COMMUNICATIONS of the ACM

APRIL 2008 VOLUME 51, NUMBER 4

THE PSYCHOLOGY OF SECURITY

Why do good users make bad decisions?

BUILDING CRITICAL TIES FOR GLOBAL TEAMWORK

THE BUSINESS OF OPEN SOURCE

DESIGNING A LEARNING MANAGEMENT SYSTEM

FAITH-BASED SECURITY

THE PROVENANCE OF ELECTRONIC DATA

DISK IS THE NEW RAM

Association for Computing Machinery

CSCW08

November 8-12, 2008
Hilton San Diego Resort
San Diego, California, USA

CALL FOR PAPERS

The 2008 ACM Conference on Computer Supported Cooperative Work

Get your CSCW Submissions Ready!

CSCW is the premiere conference on the technical and social aspects of communication, coordination, competition and collaboration. The conference's topics continue to expand as we increasingly use technologies to live, work and play with others. For complete details about CSCW's multiple participation venues, please review the Call for Participation on our website www.cscw2008.org.

Venues of Participation

The conference offers many opportunities, some old and some new, for you to participate and collaborate.

Venues of Participation	*Submission Deadline*
Papers & Notes	18 April 2008
Workshops	2 May 2008
Panels	2 May 2008
Student Volunteers	31 May 2008
Doctoral Colloquium	18 July 2008
Interactive Posters	18 July 2008
Demonstrations	18 July 2008
Videos	18 July 2008

Information

Questions and requests for information should be sent to ***publicity@cscw2008.org***

Also, see our website ***www.cscw2008.org***

CHIMIT 08

A Turning Point in IT

Symposium on

Computer Human Interaction for Management of Information Technology

November 14/15, 2008 San Diego, CA

Dates

Papers Submission
April 7th, 2008

Posters and Experience Reports
May 30th, 2008

Invitation to Participate

CHIMIT is the leading forum for discussing topics on IT management with a focus on people, business, and technology. Researchers and practitioners are invited to share issues, solutions, and research drawing upon fields such as human-computer interaction, human factors, computer systems, and management and service sciences.

Topics

Original unpublished contributions are sought in areas including but not limited to:

Workspace Studies
- Ethnographic studies of IT work in context
- Patterns of work for various IT processes

Processes and Practices
- Development and use of processes in IT
- Impact of business decisions on IT

Organizational Knowledge
- Studies of collaboration and coordination
- Knowledge management and training

Design
- Design of human-centered IT systems
- Architectural considerations for user experience

Tools and Techniques
- Collaborative system administration workspaces
- Visualizations of complex system behavior

Automation
- Automation/Policy languages
- Human interfaces to automation

acm

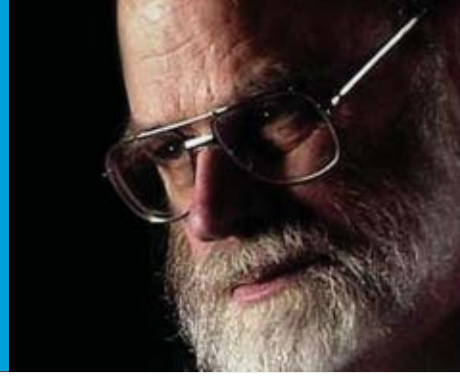
In cooperation with USENIX

www.chimit08.org

November 14/15, 2008 | San Diego, CA

Tribute to Honor Jim Gray

May 31, 2008
University of California, Berkeley



A Tribute Honoring Jim Gray:
Legendary computer science pioneer, known for his groundbreaking work as a programmer, database expert, engineer, and his caring contributions as a teacher and mentor.

General Session

Zellerbach Hall, UCB
9:00am – 10:30am

Speakers:

Shankar Sastry
Joe Hellerstein
Pauline Boss
Mike Olson
Paula Hawthorn
Mike Harrison
Pat Helland
Ed Lazowska
Mike Stonebraker
David Vaskevitch
Rick Rashid
Stuart Russell

All are welcome.
Registration is not required.

Technical Session

Wheeler Hall, UCB
Please see website for session times.

Presenters:

Bruce Lindsay
John Nauman
David DeWitt
Gordon Bell
Andreas Reuter
Tom Barclay
Alex Szalay
Curtis Wong
Ed Saade
Jim Bellingham

All are welcome.
Registration is required, see below.

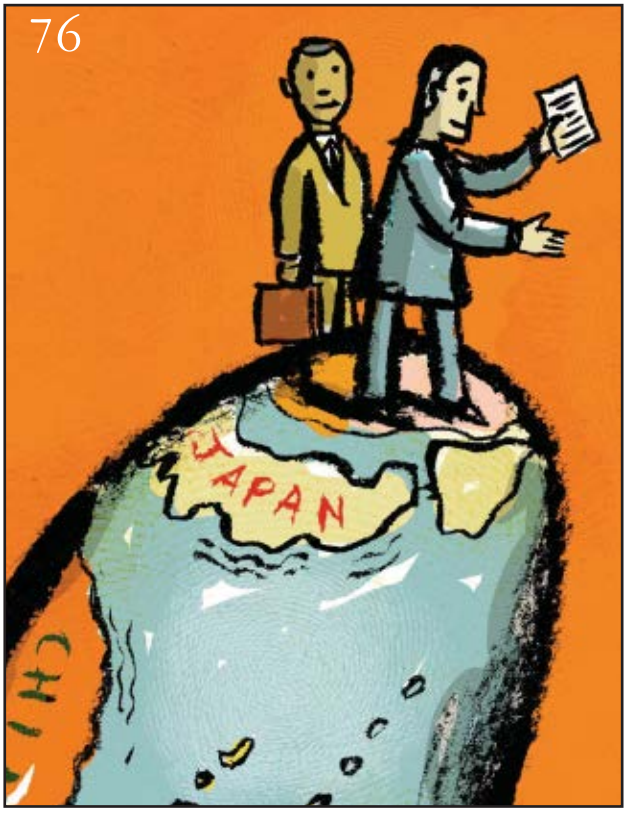
Technical Session registration and additional information:

http://www.eecs.berkeley.edu/ipro/jimgraytribute

Table of Contents

APRIL 2008

Articles



Columns

Departments

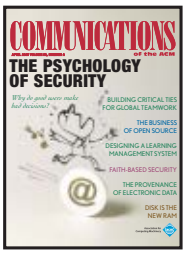
COVER ILLUSTRATION: SERGE BLOCH

eLearn MAGAZINE

Education and Technology in Perspective

elearnmag.org

Editorial Pointers



System security, as covered in these pages many times, is the ultimate team effort. It takes more than specialized equipment and protective strategies to maintain a system's operations. It takes users to adopt these measures and apply them whenever necessary. On Team Security, the user is the weakest player.

Ryan West, a design researcher at Dell, Inc., has spent years examining the principles of human behavior that govern how users think about security in daily situations. His research sheds light on why users so often undermine security "by accident." Designers of security systems must understand how users make decisions regarding security. Indeed, the most elegant design interface is useless if users fail to heed the warnings or follow the rules. West provides key concepts and spells out ways to improve users' security behavior.

Also in this issue, Bodin, Gordon, and Loeb offer valuable insight for anyone responsible for managing risk in information security. As they note, defining risk is hardly an easy task. To help in this regard, they introduce a new metric to evaluate investment proposals for enhanced information security.

Data may provide a treasure trove of information, but often finding the true gems within depends on our trust in its veracity. Moreau et al. argue data must be accompanied by a provenance that reflects, among many things, where the data originated and where it's been. In addition, Whitten et al. examine the role of IT in health care, not only as it affects the way health care professionals work, but also the way patients receive and perceive their care.

Despite the popularity of the Learning Management System (LMS) as a faculty support tool, it continues to struggle for acceptance. Yueh and Hsu share their experience at National Taiwan University, illustrating how a university can increase faculty usage through better LMS design. And Liao and Chung ask what service-quality attributes must Internet banks offer to induce consumers to switch to online transactions and keep using them? They insist the potential exists for Internet banking to be much more important than it already is, but will require that financial institutions improve their service quality.

We have witnessed a wave of studies of online auction fraud over the past year, most disputing the reigning myth that less than 0.01% of complaints to eBay allege auction fraud. Gregg and Scott suggest the problem of online auction fraud may be far worse than numbers indicate. And Oshri, Kotlarsky, and Willcocks contend F2F meetings may be invaluable for project teams dispersed globally, but managers must prioritize activities before and after these meetings to help team members stay connected.

Finally, on page 27, ACM is pleased to announce the 2007 Distinguished and Senior Members.

Diane Crawford

Editor

DOI: 10.1145/1330311.1330311

COMMUNICATIONS of the ACM

A monthly publication of the ACM Publications Office

ACM
2 Penn Plaza, Suite 701
New York, NY 10121-0701 USA
(212) 869-7440 FAX: (212) 869-0481

Group Publisher: Scott Delman

Editor: Diane Crawford
Managing Editor: Thomas E. Lambert
Senior Editor: Andrew Rosenbloom
Editorial Assistant: Zarina Strakhan
Copyright: Deborah Cotton

Art Director: Caren Rosenblatt
Production Manager: Lynn D'Addesio

Advertising
ACM Advertising Department
2 Penn Plaza, Suite 701, New York, NY 10121-0701
(212) 869-7440; Fax: (212) 869-0481
Director of Media Sales:
Jonathan M. Just: jonathan.just@acm.org

For the latest media kit—including rates—contact:
Graciela Jacome: jacome@acm.org

Contact Points
CACM editorial: crawford_d@acm.org
Copyright permission: permissions@acm.org
Calendar items: calendar@acm.org
Change of address: acmcoa@acm.org

Communications of the ACM
(ISSN 0001-0782) is published monthly by the ACM, 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

Printed in the U.S.A.

Association for Computing Machinery

Advancing Computing as a Science & Profession

COMMUNICATIONS OF THE ACM • *A monthly publication of the ACM Publications Office*

ACM, 2 Penn Plaza, Suite 701, New York, NY 10121-0701 USA (212) 869-7440 FAX: (212) 869-0481

The 1st ACM SIGGRAPH Conference and Exhibition in Asia
www.siggraph.org/asia2008

New Horizons

ACM SIGGRAPH launches the premiere SIGGRAPH Asia in Singapore

Programs include:

- Papers
- Sketches and Posters
- Courses
- Art Gallery
- Computer Animation Festival
- Educators Program
- Emerging Technologies
- Exhibition

Calling all creative researchers, artists, digital innovators and animators!

This is your opportunity to present your stellar work or attend the 1st ACM SIGGRAPH conference and Exhibition in Asia.

Queries?

Contact Conference and Exhibitions Management at asia2008@siggraph.org or Tel: +65 6500 6700

SIGGRAPHASIA2008

Conference and Exhibition on Computer Graphics and Interactive Techniques

Singapore, 10-13 December 2008

Held in

UNIQUELY Singapore
visitsingapore.com

ACM, Uniting the World's Computing Professionals, Researchers, Educators, and Students

Dear Colleague,

At a time when computing is at the center of the growing demand for technology jobs worldwide, ACM is continuing its work on initiatives to help computing professionals stay competitive in the global community. ACM delivers resources that advance computing as a science and profession.

As an ACM member you have access to leading-edge resources including publications and conferences covering the entire computing field. Whether you are pursuing scholarly research, building systems and applications, or managing computing projects, ACM offers opportunities to advance your interests.

MEMBER BENEFITS INCLUDE:

- Access to ACM's **new Career & Job Center** offering a host of exclusive career-enhancing benefits
- **Free e-mentoring services** provided by MentorNet®
- **Full and unlimited access to 2,500 online courses** from SkillSoft®
- **Full and unlimited access to 600 online books** from Safari® Books Online, featuring leading publishers, including O'Reilly (Professional Members only)
- **Full and unlimited access to 500 online books** from Books24x7®
- A subscription to ACM's flagship monthly magazine, ***Communications of the ACM***
- The option to subscribe to the full **ACM Digital Library**
- The **Guide to Computing Literature**, with over one million searchable bibliographic citations
- The option to connect with the **best thinkers in computing** by joining **34 Special Interest Groups** or **hundreds of local chapters**
- **ACM's 40+ journals and magazines** at special member-only rates
- ***TechNews***, ACM's tri-weekly email digest delivering stories on the latest IT news
- ***CareerNews***, ACM's bi-monthly email digest providing career-related topics
- ***MemberNet***, ACM's e-newsletter, covering ACM people and activities
- **Email forwarding service & filtering service**, providing members with a free acm.org email address and high-quality **Postini** spam filtering
- And much, much more!

ACM's worldwide network of more than 87,000 members range from students to seasoned professionals and includes many of the leaders in the field. ACM members get access to this network and the advantages that come from their expertise to keep you at the forefront of the technology world.

Please take a moment to consider the value of an ACM membership for your career and your future in the dynamic computing profession.

Sincerely,

Stuart I. Feldman

Stuart I. Feldman
President
Association for Computing Machinery

Association for Computing Machinery

Advancing Computing as a Science & Profession

Association for Computing Machinery

Advancing Computing as a Science & Profession

membership application & *digital library* order form

Priority Code: ACACM28

You can join ACM in several easy ways:

Online
http://www.acm.org/join

Phone
+1-800-342-6626 (US & Canada)
+1-212-626-0500 (Global)

Fax
+1-212-944-1318

Or, complete this application and return with payment via postal mail

Special rates for residents of developing countries:
http://www.acm.org/membership/L2-3/

Special rates for members of sister societies:
http://www.acm.org/membership/dues.html

Please print clearly

Name

Address

City | State/Province | Postal code/Zip

Country | E-mail address

Area code & Daytime phone | Fax | Member number, if applicable

Purposes of ACM

ACM is dedicated to:
1) advancing the art, science, engineering, and application of information technology
2) fostering the open interchange of information to serve both professionals and the public
3) promoting the highest professional and ethics standards

I agree with the Purposes of ACM:

Signature

ACM Code of Ethics:
http://www.acm.org/serving/ethics.html

choose one membership option:

PROFESSIONAL MEMBERSHIP:

- ❑ **ACM Professional Membership: $99 USD**
- ❑ **ACM Professional Membership plus the ACM Digital Library: $198 USD ($99 dues + $99 DL)**
- ❑ **ACM Digital Library: $99 USD (must be an ACM member)**

STUDENT MEMBERSHIP:

- ❑ **ACM Student Membership: $19 USD**
- ❑ **ACM Student Membership plus the ACM Digital Library: $42 USD**
- ❑ **ACM Student Membership PLUS Print *CACM* Magazine: $42 USD**
- ❑ **ACM Student Membership w/Digital Library PLUS Print *CACM* Magazine: $62 USD**

All new ACM members will receive an ACM membership card.
For more information, please visit us at www.acm.org

Professional membership dues include $40 toward a subscription to *Communications of the ACM*. Member dues, subscriptions, and optional contributions are tax-deductible under certain circumstances. Please consult with your tax advisor.

RETURN COMPLETED APPLICATION TO:

Association for Computing Machinery, Inc.
General Post Office
P.O. Box 30777
New York, NY 10087-0777

Questions? E-mail us at acmhelp@acm.org
Or call +1-800-342-6626 to speak to a live representative

Satisfaction Guaranteed!

payment:

Payment must accompany application. If paying by check or money order, make payable to ACM, Inc. in US dollars or foreign currency at current exchange rate.

❑ Visa/MasterCard ❑ American Express ❑ Check/money order

❑ Professional Member Dues ($99 or $198) $ _____

❑ ACM Digital Library ($99) $ _____

❑ Student Member Dues ($19, $42, or $62) $ _____

Total Amount Due $ _____

Card # Expiration date

Signature

What Is It About Being a Girl That Avoids IT?

I applaud the goals of the research reported in "Women and Men in the IT Profession" (Feb. 2008) by Vicki R. McKinney et al. Unfortunately, the conclusions fell somewhat short of their goals; that is, it seems that women and men already in IT share similar socialization, experience, and attitude. Missing from the study was a non-IT control group. It is not surprising that there are few differences between women and men in IT. What about differences between women and men not in IT? Or between girls and boys who have not yet made a career choice? Discovering these differences would shed more light on the question of why more women don't enter the profession in the first place.

Steve McConnell
Bellevue, WA

Authors' Response:
McConnell raises excellent questions about career choices and what influences the decision to enter IT (input). The National Science Foundation funded us to study women who are already IT professionals (throughput) and other researchers to study input issues in the IT work force. Our focus on throughput delivered surprising insight into current IT professionals.

Vicki R. McKinney,
Darryl D. Wilson,
Nita Brooks,
Anne O'Leary-Kelly,
Bill Hardgrave

Peripherals As Important As Processors

Gordon Bell's article "Bell's Law for the Birth and Death of Computer Classes" (Jan. 2008) focused on processor technology, saying "The evolutionary characteristics of disks, networks, displays, user-interface technologies, and programming environments will not be discussed here." But, in fact, peripheral devices are just as important as processors in computing.

The earliest "hobby" personal computers used paper tape, but it was the floppy disk that made PCs practical for business use. Programs like Runoff and FancyFont allowed limited forms of publishing on chain and dot-matrix printers, but it was the laser printer that made WYSIWYG word processing generally useful and put PCs in offices the world over. Multimedia needs fast CPUs but wouldn't be practical without relatively inexpensive multigigabyte hard drives. A simple cell phone might get by without a display, but it's the LCD display that makes smart phones possible.

Tom Moran
Saratoga, CA

Celebrate Weiss's Contributions, Too

My congratulations to all involved in producing the outstanding 50th anniversary issue (Jan. 2008). However, my own article, "The Battle of the Covers," fell short in at least one significant regard—not mentioning the key role Eric Weiss played in taking the helm as the first chair of the Publications Board (I was the second). He established the framework in many ways for all who followed, taking on the task with his usual patience, dedication, good judgment, and equally good humor. His support of *Communications* during those early years was crucial.

M. Stuart Lynn, Editor-in-Chief
January 1969–March 1973

Please address all Forum correspondence to the Editor, *Communications of the ACM,* 2 Penn Plaza, Suite 701, New York, NY 10121-0701; email: crawfordd@acm.org.

DOI: 10.1145/1330311.1330313

PAUL WATSON

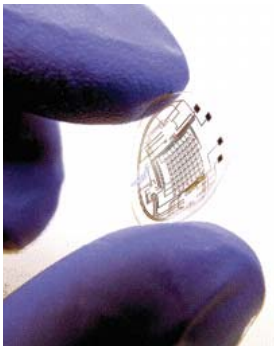
News Track

Text-matching Copycats

A new computerized look at the biomedical research literature has turned up tens of thousands of articles in which entire passages appear to have been lifted from other papers. In fact, researchers estimate there may be as many as 200,000 duplicates among some 17 million papers in the leading life sciences and biomedical research database Medline (medline.cos.com). *Scientific American* reports researchers from the University of Texas Southwestern Medical Center in Dallas used a text-matching algorithm to compare seven million Medline abstracts against matching entries flagged by the database's software as being closely related. The researchers set their own software tool, called eTBLAST, to identify pairs that were more than 45% identical. The search turned up more than 70,000 hits, which the researchers and three assistants then checked manually. In 79 cases (and counting), duplicates with different authors had no obvious legitimate explanation. The group set up a public Web site, Déjà vu (http://discovery. swmed.edu/dejavu/), to document the findings. The researchers estimate that about 50,000 of the eTBLAST hits will turn out to be either plagiarized or multiple listings. The next step, they say, is for journals to investigate.

Bionic Eyes

Engineers at the University of Washington have for the first time used manufacturing techniques at microscopic scales to combine a flexible, biologically safe contact lens with an imprinted electronic circuit and lights. There are many possible uses for virtual displays, reports UWeek.org. Drivers or pilots could see a vehicle's speed projected onto a windshield. Videogame companies could use the contact lenses to completely immerse players in a virtual world without restricting their range of motion. And for communications, people could surf the Net on a midair virtual display that only they would be able to see. While the prototype contact lens does not correct the wearer's vision, the technique could also be used on corrective lenes. Ideally, installing or removing the bionic eyes would be as easy as popping in a contact lens.



University of Washington

Swipe-and-Ride

San Francisco's transit system is the first in the U.S. to test a systemwide cell phone payment program that allows riders to pass through the turnstiles with a wave of a phone. The $200,000 pilot project, which ends its testing phase this month, uses a wireless chip that lets people pay by passing their phone over a wireless reader. The Bay Area Rapid Transit (BART) has been using the contact-free technology in its EZ Rider pilot program, allowing riders to pay at the turnstiles by waving a plastic card with a wireless chip. The latest test puts a similar chip inside a phone, eliminating the need for additional cards. BART is also working with fast-food franchise Jack in the Box to allow trial participants to pay for food with their cell phones. Users load up to $48 on the chip from a credit or debit card account via BART's Web site (www.bart.gov). This "near-field communication" technology, in wide use throughout Asia, will likely continue to proliferate in the U.S., based on preliminary results of the BART test.

News Track

China's Netizens on Rise

The Chinese government has announced its Internet population soared to 210 million people, putting it on track to surpass the U.S. online community this year as the world's largest. According to government officials, China is only five million behind the U.S. online, a figure consistent with some U.S. estimates. But China still lags the U.S. in several respects. China's online penetration rate is placed at 16%, the point Americans hit in the mid-1990s. About 75% of U.S. adults are now online; penetration is higher when teens are included. Internet penetration in China holds a different meaning, however, where cyber cafes serve as the main entry to the Web for many people. Still, say officials from both sides, China's online growth is significant.

Technology Influencers

Intel recently organized a panel of experts, including academics, journalists, and independent third parties, to vote for the 45 most influential figures in technology over the last 150 years. The top 10 vote grabbers are:

T. Berners-Lee

1. **Tim Berners-Lee** (World Wide Web founder)
2. **Sergey Brin** (Google co-founder)
3. **Larry Page** (Google co-founder)
4. **Guglielmo Marconi** (Inventor of the radiotelegraph system)
5. **Jack Kilby** (Inventor of the integrated circuit and calculator)
6. **Gordon Moore** (Intel co-founder)
7. **Alan Turing** (Pioneer in deciphering German code in WWII)
8. **Robert Noyce** (Intel co-founder)
9. **William Shockley** (Co-inventor of the transistor)
10. **Don Estridge** (Led development of the IBM computer)

For the full list of technology influencers, which includes Bill Gates (#31), Steve Jobs (#14), and Vint Cerf (#13), see http://blogs.telegraph.co.uk/technology/technotes/jan08/mostinfluentialtechies.htm.

Between Ads and Friends

The MySpace generation wants less space devoted to online advertising. In fact, the ads on social networks like MySpace and FaceBook have become so widespread—and annoying—that users are beginning to opt out. *BusinessWeek* reports the average amount of time users spend on social networking sites fell 14% in four months, with MySpace slipping from a peak of 72 million users last October to 68.9 million last December. Besides slowing user growth and declining time spent on these sites, users appear to be less responsive to ads. If advertisers can't figure out how to reverse these trends, social networking could end up as a niche market in the cyber ad world, slashing valuations across Silicon Valley.

Smart Badges

In other news (and forms) of social networking technology, smart conference badges might be able to help people venture out, form new connections, and gain insight into how they interact with others at such events. *Technology Review* reports MIT researchers tracked the social interactions of a select group of attendees at a conference using a smart badge incorporating an infrared sensor, wireless radio, accelerometer, and microphone to log the bearer's behavior. The data from the sensors was wirelessly transmitted to a computer that produced a real-time visualization of the event's social graph. The project illustrates the increasing popularity of sociometrics, a discipline in which sensors collect fine-grain data during social interactions and software makes sense of it. Similar tags from Intel are being used to help monitor the health and behavior of the elderly. Rick Borovoy, co-founder and CTO of MIT's spin-off company nTag, contends this form of "reality mining" creates a sense of community and identity. "It's a way to subtly intervene and disrupt conventional networking patterns." C

DOI: 10.1145/1330311.1330314

Send items of interest to cacm@acm.org

Faith-Based Security

A tongue-in-cheek look at serious security issues.

IT security has received increased attention primarily, but not exclusively, due to the increased threat from viruses, worms, password crackers, Trojan horses, and a cornucopia of other types of malware and exploits. As a consequence of this increased attention, a variety of security models have been proposed. Security in depth (SID) is one such example. Winn Schwartau's time-based security is another. In this column, I offer another modest example extrapolated from popular culture: faith-based security, aka "no network left behind."

Security Models

By their very nature, security models are usually out of date. Security modeling is akin to driving forward while looking through the rearview mirror since security systems are primarily reactive. The problem is illustrated by zero-day exploits where the first appearance of an exploit coincides with the first appearance of a vulnerability. One of the grand challenges in future digital security is to figure out how to model the unknown in anticipation of post-modern exploits, such as zero-day attacks and so-called "super worms."

Security models also tend to be obtuse. Though "security in depth" is a common phrase in IT circles, few could define it precisely. The phrase has been used to describe everything from cascaded network defenses and layered intrusion prevention/detection systems to differentiated password-control policies. About the only common theme I can detect is that security-in-depth seems to be used interchangeably with "more is better."

The Security in Depth Fallacy

There is an interesting fallacy in informal logic called the principle of vacuous alternatives. It goes something like this: Take any sentence. If the negation of that sentence seems preposterous, then the original sentence is likely vacuous. As an example, consider "I believe in justice." The negation, "I don't believe in justice," seems like an absurd remark. It's not that it's nonsensical. Rather, it has no conversational contribution to make as it's difficult to imagine how any reasonable person could

HAL MAYFORTH

disagree with it. Vacuous propositions behave like semantic tautologies.

Such is the case with security in depth. Have you ever heard an IT professional champion the cause of "superficial security," "shallow security," or "myopic security?" Not likely. This is the primary reason why security in depth is so poorly understood. Its vagueness quickly gives way to vacuousness on inspection.

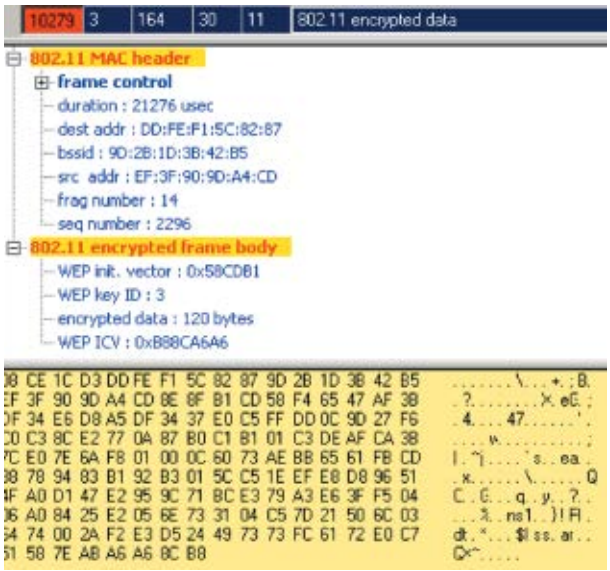


Figure 1. The WEP initialization vector is communicated in cleartext (for example, 0x58CDB1).

Security Through Obscurity

I admit that a prima facie case could be made for security in depth even in the naive sense of "more is better." When I propose adding a new vitamin to my diet, my internist tells me "At this point there is no physiological evidence that suggests that this substance is harmful to humans, so knock yourself out." As with my vitamins, a random application of security applications and systems is unlikely to do any more harm than lure one into a false sense of security and perhaps slow things down a bit. And like the vitamins, when carefully and judiciously applied and evaluated in a controlled experimental setting, even naive security in depth can be of some value.

Such is not the case with our third model: security through obscurity (STO). No prima facie case may be made here. The general premise of STO is that inviolability is a consequence of the enigmatic. This is same sort of reasoning that helped the Imperial Japanese Navy and German Wehrmacht become the global powers they are today. The Japanese Purple and JN-25 codes and the German Enigma cipher system were assumed to be inviolate precisely because of their hidden complexity. As far back as the 1880s, Auguste Kerckhoffs proposed that no cryptographic system that purports to be secure should be predicated on the assumption that no one would ever figure out how it worked—rather the emphasis should be robustness of the procedure and key strength. Both Axis powers failed to comprehend the weakness of STO. This also speaks in favor of the robustness of open source software.

Despite our intuitions, many software systems have adopted STO to their cost. To illustrate: Windows buffer overflows, such as the IDQ.DLL overflow in the Code Red Worm, were entirely predictable to anyone who knew how the Windows ISAPI extensions worked. This was a design defect that produced a buffer overflow and ran the malware with elevated privileges since IDQ.DLL runs within Inetinfo.exe as local administrator. It was assumed no one would notice the inadequate bounds and error checking built into the operating system. We'll place this in STO category I: failure to write secure code. Conceptually similar vulnerabilities, like format string attacks (printf) in Unix and SQL compromises in Windows (IIS/RDS), would also fall into our first category.

Another example is the entire suite of 802.11 security vulnerabilities. In this case, the defect was actually built into the standards. Nowhere is this more evident than with the wired equivalent privacy (WEP) protocol.

WEP has many "issues" that go beyond our current interest. However, one stands out as a paradigm case of a mistake carried through to perfection: the sloppy implementation of the RC4 symmetric, stream cipher. The faulty WEP algorithm was a part of the original IEEE 802.11 protocol

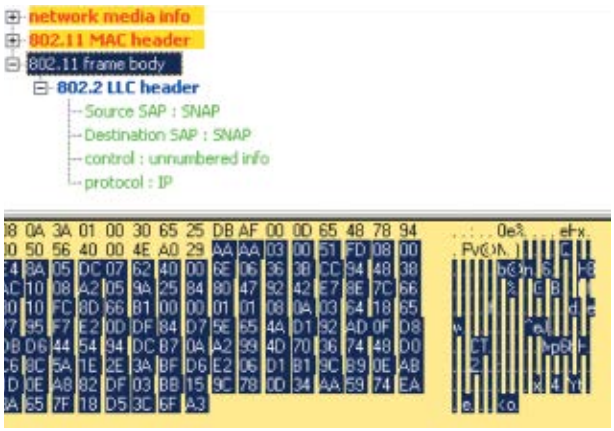


Figure 2. The 802.11 frame body always begins with a SNAP header (for example, AA).

specification.

Generally, WEP works like this. The RC4 algorithm uses the pseudorandom generation algorithm (PRGA) to produce a key-stream of bits that are XORed with the plaintext to create the ciphertext. Key-change is accomplished by adding an Initialization Vector (IV) that makes each packet key unique. The IV is concatenated with the WEP key to form the WEP seed.

The properties of the IV are interesting:

1. The IV is only 24 bits long;
2. The IV is always prepended to the WEP key;
3. The IV is always transmitted in cleartext (see Figure 1);
4. Some IVs are "weak" in the sense that they suggest information about the key—the first bytes of a typical WEP packet are typically the snap header 0xAA (see Figure 2);
5. The IEEE standards were so ambiguous that many vendors used sequential IV generators that begin with 00:00:00 and wrap with FF:FF:FF; and
6. The key-generation algorithm itself is hobbled because the most significant bit of each key is always 0; thus it only produces unique keys for seeds 00:00:00:00 through 00:7F:7F:7F.

The community of FMS (after Fluher, Mantin, and Shamir) attack analysts reacted immediately. In short order a flurry of successful WEP-cracking tools were developed (WEPAttack, WepCrack, Aircrack, WepLab, WEPWedgie) all made possible by the faulty implementation of RC4. A virtual cottage industry was made possible because the original WEP security standard followed the STO model. We will put the WEP vulnerability into our new STO Category II: botched implementations.

One might think the frailty of WEP would have triggered a total rethinking of WiFi security. Such is not the case. While WEP's successor, Wireless Protected Access (WPA), did strengthen the integrity-checking algorithm and key management, it basically just added another layer of obscurity over the sloppily designed WEP in the form of a shell over the RC4 algorithm. Deployed by the Wi-Fi Alliance in 2002, WPA didn't really eliminate the key-management problem inherent in WEP, but rather proliferated the number of keys involved. WPA uses a pairwise master key (PMK) to generate additional keys that are combined with sender MAC address, packet sequence number, the wireless Service Set ID, and SSID length as grist for the hashing mill (PKCS #5 v. 2.0). Let's think about this. If an underlying procedure is faulty, does it become less faulty if we use it over and over and over again? WPA relied on STO, just like its predecessor. Predictably, within a year of release, a successful WPA attack was discovered. Shortly therafter, the WPA-cracking utility coWPAtty was released that reverse engineers the PMK from the SSID, SSID length, and sequence number MAC address, and WiFi security was back at the starting block.

Neither was the Extensible Authentication Protocol immune. Cisco's version of EAP, LEAP, deserved the term lightweight. LEAP's major fault was that it relied on the MS-CHAPv2 hashing algorithm for authentication. MS-CHAPv2 does not use "salt," so the same plaintext value will always produce the same hashed value. This makes EAP-LEAP vulnerable to dictionary and replay attacks. Once again, the defense of EAP-LEAP ultimately relied on no one finding out how the system works. Auguste Kerckhoffs could

have predicted this without ever seeing a computer.

My final example came to my attention in the past few weeks. MIFARE is a proprietary encryption technique for RFID (radio frequency identification) developed by Philips and Siemens in the late 1990s. MIFARE is an attempt to cryptographically secure the now-ubiquitous RFID space that relies on RF transmission for communication between transmitter and receiver.

Following the common theme, the security of the proprietary MIFARE system is predicated on the belief that no one will discover how it works. And, as one might predict, some MIFARE circuits were reverse engineered down to the gate level. The result was the discovery that the random number generation that drove the encryption resulted from a 16-bit key linear feedback shift register based on a master key and a time signature. With RFID sniffing via an open PICC (proximity integrated contactless chip) card and a logic analyzer, it is possible to discern patterns in the challenge-response authentication procedure that can be used in a replay attack, and from there it is possible to recover the key from the value of the unique identifier and the observed behavior of the shift register in the authentication process. We'll create STO category III for this MIFARE vulnerability: turning chip designers loose with CAD/CAM software without adequate education and training.

URL PEARLS

When it comes to digital security systems, secrecy is indeed the mother of dysfunction. The security vulnerabilities described in this column were real and betray only the slightest hint of literary hyperbole. For those interested in the details, two of the security-through-obscurity examples were covered in previous columns: the Code Red Worm was discussed in December 2001; and Wireless Infidelity appeared in December 2004 and again in August 2005. The RFID MIFARE exploit was presented at the 24th Chaos Communication Congress last December (see events.ccc.de/congress/2007); a video of the presentation by Karsten Nohl and Henryk Plotz is available at video.google.com/videoplay?docid=4252367680974396650&hl=en. C

Faith-Based Security

Examples of failed STO could fill a weighty tome. I've mentioned three. These examples highlight the consequences of building deficiencies into the design of things or at least unwittingly including them. The flaws would likely have been detected and reported had the code, system, or chipset been carefully analyzed during impartial peer review by qualified professionals.

But I don't want to leave this critical view of deficiencies at the feet of naive SID or STO. I'm looking for first principles here.

I'll refer to the common elements between them under the general rubric of faith-based security—in the most secular sense of this popular phrase. The only thing these two security models have going for them is the unsupportable and unjustified faith that they are reliable. These are manifestations of the technologist succumbing to the self-deception that secrecy and tight lips will cover all design misjudgments.

I propose that faith-based security enter our vocabulary as the default model of IT security. Let's get the faith-based orientation of naive security in depth and STO up front where it belongs. Think of the advantages. If an auditor asks why we decided to place our Web server on the inside of our enterprise firewall, we report that we have faith in our Internet comrades. Faith is a predicate of propositional attitude, like belief, want, and desire. If someone says they have faith in something, one can't say "No you don't," at least not until someone comes up with a method to read thoughts. The auditor doesn't have faith, we do have faith; half-empty, half-full. You get the idea.

Since the integrity of a faith-based security implementation is by definition taken on faith, we hold the position that whatever policies and procedures discovered by an auditor were actually intended. So what if our corporate mailer is running on an operating system that hasn't been supported since perestroika—we have faith in good old "digital iron." After all, when was the last time you read about some hacker

compromising OS/2 or Multix? So the primary remote access to our file server is TFTP; our spin is that any protocol that old is "time-tested." So our password security policy requires LAST-NAME followed by YEAR; we emphasize that we have a rule for password expiration built right into our password security policy.

No baselines to measure, no checklists to distract us, no concern over best practices, no specific objectives to define. COBIT? Out the window. FISCAM? Who needs it? SOX, HIPAA, GLB? No thank you.

So the next time someone challenges your organization's security model, rather than beating around the bush, making excuses, blaming budgetary woes, faulting management's lack of vision, or chastising vendors, think outside the box. State up front that your security model is faith-based and take a swerve around all the minutiae. Treat these details like all of those log files you haven't reviewed since you upgraded to NT Service Pack 2. Build in backward "time basing" to the ultimate IT apocalypse—the implosion of the commercial Internet. After that, who will care about digital security anyway? C

Hal Berghel is associate dean of the Howard R. Hughes College of Engineering at the University of Nevada-Las Vegas, the director of the Center for Cybersecurity Research (ccr.i2.nscee.edu), and co-director of the Identity Theft and Financial Fraud Research and Operations Center (www.itffroc.org).

DOI: 10.1145/1330311.1330315

Coming Next Month in COMMUNICATIONS OF THE ACM

Web Searching in a Multilingual World
How Intuitive is Object-Oriented Design?
Words for Pictures for Dual Channel Processing
Emerging Trends in M-Government
Taming Heterogeneous Agent Architectures
Improving the Change Management Process
Coordination in Emergency Response Management
Reducing Internet Auction Fraud

Also: Meet the candidates running for ACM's general election

The Best Place to Find the Perfect Job... Is Just a Click Away!

No need to get lost on commercial job boards. The ACM Career & Job Center is tailored specifically for you.

JOBSEEKERS

- Manage your job search
- Access hundreds of corporate job postings
- Post an anonymous resume
- Advanced Job Alert system

EMPLOYERS

- Quickly post job openings
- Manage your online recruiting efforts
- Advanced resume searching capabilities
- Reach targeted & qualified candidates

NEVER LET A JOB OPPORTUNITY PASS YOU BY!

START YOUR JOB SEARCH TODAY!

http://www.acm.org/careercenter

Association for Computing Machinery

Advancing Computing as a Science & Profession

POWERED BY JOBTARGET

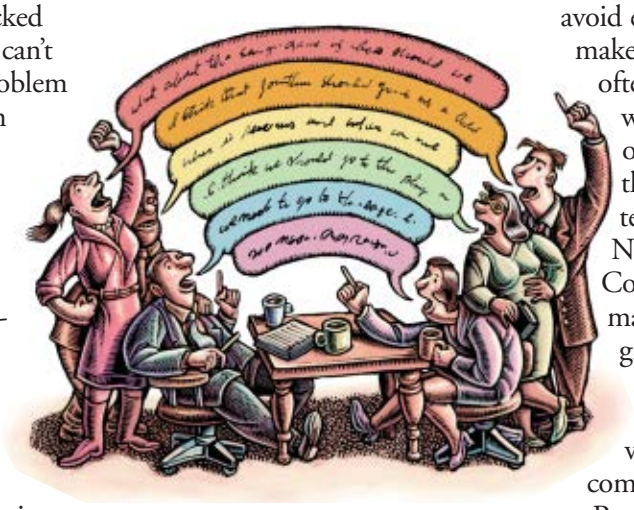
Peter J. Denning and Peter Yaholkovsky

Getting to "We"

Solidarity, not software, generates collaboration.

Messes are large, complex, seemingly intractable situations that no one can find a way out of. The most tangled messes are called "wicked problems" because people can't even agree on what the problem is and because the solution will almost surely entail a disruptive innovation [2, 9]. Collaboration is essential for resolving messes. Can our impressive array of "collaboration technologies" help those trying to solve messy problems?

This is not an easy question. The messiness of the problems is usually nontechnical in origin. Lewis Perelman cites infrastructure renewal as a messy problem involving the clash of "green" and "blue" agendas [8]. Green represents the sustainability movement, which aims at environmental protection and resource efficiency; its main concerns include energy-neutral designs for buildings and other infrastructure. Blue represents the security movement, which aims to protect against attacks and disasters; its main concerns include critical infrastructure. The various players do not agree on the relative importance of the two perspectives. Each perspective reaches different conclusions about infrastructure renewal and best use of resources.



Can our technologies help the players to develop a larger, more encompassing perspective, a sort of "blue-green space" rather than two opposing ends of a continuum? [3, 8] Such technologies might appear as major challenges. Blue and green advocates tend to avoid each other. When they do make contact, their interactions often do not go well, ending with legal battles, such as the one in California between the U.S. Navy (wanting to test new sonar systems) and National Resources Defense Council (wanting to protect marine wildlife). Often the groups form political movements that try to "win" by gathering votes and preventing losers from wresting compromises.

Recent experience at the grass roots is more optimistic. People are tired of failed public projects in parks, development, affordable housing, climate change, and infrastructure renewal. They are turning to facilitated processes that guide them to collaboration. Prominent examples include Appreciative Inquiry [1], Straus Method [10], and Charrettes [7].

LISA HANAEY

The sad news is that most of our "collaboration technologies" are not able to support such collaboration processes. The good news is that with a clear understanding of the essence of the collaboration process, we can design technologies that can help.

Defining Collaboration

Collaboration generally means working together synergistically [6]. If your work requires support and agreement of others before you can take action, you are collaborating.

Coordination and cooperation are weaker forms of working together; neither requires mutual support and agreement. Coordination means regulating interactions so that a system of people and objects fulfills its goals. Cooperation means playing in the same game with others according to a set of behavior rules. In this discussion, we use collaboration for the highest, synergistic form of working together.

Four levels of working together are listed in the table here along with examples of supporting groupware tools. We have listed tools at the highest levels at which they can consistently deliver the expected results. For example, chat is an information-sharing technology but it does not guarantee that participants will cooperate or coordinate on anything. An operating system is a coordination technology and a multiplayer game is a cooperation technology but neither guarantees that its players will synergistically achieve a larger goal.

Category	Purpose	Groupware Examples
Information Sharing	Exchanging messages and data	blog chat content streaming corporate directories database sharing discussion board document sharing email file servers instant messaging live presentation PC access recording remote blackboard RSS screen sharing version control systems remote VoIP VPN
Coordination	Regulating elements and players for harmonious action	auction systems classroom management concurrency control decision support interactive voice recognition Internet protocols network meetings online payments operating system project management shopping cart service-oriented architecture support center telescience (remote lab) workflow management
Cooperation	Playing together in the same game under agreed "rules of interaction" (including games of competition)	collaboratory creation nets discussion forum multiplayer games newsgroup Second Life socially beneficial games wiki (Wikipedia)
Collaboration	Creating solutions or strategies through the synergistic interactions of a group of people	Appreciative Inquiry Brainstorming Charrettes Consensus workshop Straus Method

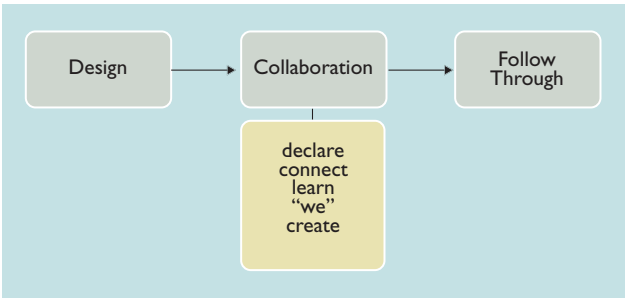
Levels of joint action and associated tools.

Although the information-sharing technologies do not guarantee cooperation, coordination, or collaboration, their users sometimes develop impressive systems of practice. For example, the Faulkes Telescope is a facility that provides free access to robotic telescopes and an education program to encourage teachers and students to engage in research-based science education (see http://faulkes-telescope.com). John Hagel and John Seely Brown see this as a fine example of a creation net, a (possibly collaborative) community that learns and invents together. Creation nets can be adopted and managed by organizations seeking to be more innovative [5]. Thus, a community practice can be harnessed and imitated even if no technology embodies it.

It is apparent from the items listed in the table that most "collaboration tools" do not guarantee their users will collaborate on anything. Only a few tools actually qualify as collaboration technologies. The five collaboration tools listed are processes that at best are partially automated.

If we are to achieve the extent of collaboration we keep calling

Structure of messy problem solving.



for, and support collaboration with automated tools, we require a deeper understanding of how collaboration works.

Collaboration Is Not Our First Choice

When faced with a messy problem, most people do not automatically fall into a mode of collaboration. Our colleague, Nancy Roberts, has confirmed this from her work and uses it to teach a class on "coping with wicked problems" [9].

Roberts begins the class by posing a wicked problem and asking everyone to devise a solution to it. When they come together, the group judges no solution satisfactory. Their proposals typically involve getting an appropriately high authority to make and enforce key declarations. For example, a green infrastructure is best achieved by establishing a new cabinet-level "infrastructure czar" who can set sustainability goals, create timetables for their completion, and inflict punishments on those who do not comply.

After this failure, Roberts asks the students to try again. Once again, when they come together, the group judges no proposed solution satisfactory. This time their proposals involve various forms of competition: the best prevails in some sort of contest. For example, the green and blue advocates both present their cases to the public, who vote on referenda to adopt one scheme after a period of debates and campaigning.

Roberts sends the students back to try a third time. In their frustration over their recalcitrant instructor they start meeting as a group. They discover they can invent solutions that take care of multiple concerns. They find a solution to the wicked problem.

Roberts notes that the students eventually got to collaboration, but not before they had exhausted the alternatives of authoritarianism and competition. These two approaches do not work because they do not show each member of the group how individual concerns will be addressed. Roberts concludes, "People fail into collaboration."

We are not saying that authoritarian solutions or competition solutions never work. Of course they do. They tend not to work for wicked problems. Our familiarity with them draws us to them first. Roberts is saying that when we encounter a wicked problem, our best bet is to look for a collaborative solution.

The situation in the U.S. after Hurricane Katrina in August 2005 followed this pattern. The wicked problem was to restore infrastructure in a region where most of the residents had permanently fled after the storm knocked out all power, communications, water, transportation, food distribution, sewage, and waste removal. The President's first proposal (FEMA takeover) was authoritarian. Local authorities asserting regional rights rebuffed that approach. Thereafter, the situation devolved into numerous competitions (including disputes and finger-pointing) between federal and local jurisdictions. Two years after the disaster, the region remained gridlocked by local rivalries, fewer than half the residents had returned, disaster reimbursements were held up by enormous tangles of red tape, and very little rebuilding had even started. Most of the progress that was made came from the grass-roots level, such as businesses, churches, voluntary associations, and neighbors.

So the political system tried and failed at authoritarianism and competition and got stuck, while the grass roots fell into collaboration and made progress. The political system, in its desire to manage everything, did little to empower the grass roots.

Two aspects of our contemporary culture may be further disincentives for collaboration. One is a belief that we can win in every negotiation by standing our ground [4]. This belief leaves little

room for a "we." The other is a belief in "hero celebration": we look for a hero in every successful group and give the credit to the hero alone. Who will collaborate if they think "we" will be stolen?

Clearly it will take some work and practice on our part to understand how collaboration works and how to achieve it.

Structure of Collaboration

The problem-solving process for a messy problem has three main stages: design, collaboration, and follow-through (see the figure here). Collaboration is fostered through a facilitated workshop. Variations of this process appear in Appreciative Inquiry [1], Straus Method [9], and Charrettes [6]. The design stage identifies all the interested parties and fruitful questions for them to explore. The facilitated workshop leads the participants through a five-stage process, described below. During the follow-through, teams organized at the workshop do their parts to implement the solution. The five stages of collaboration are:

1. Declare: The group's leader or organizer declares a question for the group to consider. The question emphasizes new possibilities rather than current deficits. Each group member declares acceptance of the need or desire to work together on the issue, and openness to the perspectives of the others. Without the buy-in of everyone in the group, egos can get in the way and hijack the process.

2. Connect: The members take time to become present and engaged with each other. They explain what concerns bring them to the gathering. They state their aspirations, what is at stake for each of them, and why they see a need for collaboration. They look for and acknowledge connections such as mutual friends, business interests, or education.

3. Listen to and learn all perspectives: Now the group speaks and listens, as openly as possible, to the concerns motivating each member on the issue. The goal is to expose all the concerns and learn how and why each matters to some member. Members tell stories showing how concerns affect their worlds. For example, "Low-wattage light bulbs matter to me. My company replaced a thousand incandescent bulbs and saved $5,000 on our electric bill in the first year. That's a lot of cash for our little company." The listening must be open and inclusive—seeking to gather many different perspectives, and avoid any initial judgment that one is better than another. Conversation is for clarification—not justification or argument. Comments beginning "What if ..." and "I wish ..." fit, but not "That won't work." This stage is complete when no one has any further ideas to express; everyone appreciates that the group has multiple concerns to consider; many may see a common core of concerns the group can work with.

4. Allow a "we" to develop: Members of the group continue the conversation about what matters for as long as necessary until they develop the *experience* of a "we." The early sign of group identity and solidarity is members making tentative proposals that recognize, respect, and even own the interests and concerns of the other members. The later sign is reconfiguration of concerns—for example, someone concerned for authoritarian, protective, anti-terrorist government might reconfigure into a concern for strong, safe, resilient community. The facilitator keeps the proposals tentative and the mood exploratory. The conversation will evolve into a shared feeling that we are all in the same mess together, and by staying together we can resolve the mess. The mess may start to unravel as the members become aware of and take care of their interlocking concerns. Occasionally, the mess will evaporate in the light of the reconfigured concerns of "we."

5. Create together: Now the group engages with the actual work of creating projects. Some will be variations of the tentative earlier proposals, others new. To win group support, projects must address multiple concerns. Members offer to lead projects; other interested parties join the project teams. The facilitator guides members with doubts about a proposed project to question in a "we" mood of exploration, clarifying objectives and exploring consequences. For example, instead of saying, "This project will be too expensive," the member could ask, "How will we get the resources to do this? In my experience they will be considerable. Can we refor-

mulate in a less expensive way?" As proposals are discussed and modified in this way, the group will identify the highest priorities and gravitate toward a small number of possibilities. These can then be tuned for more effective action. The group's final agreement on projects to take forward cements its solidarity and service to a larger cause.

One of the facilitator's main duties is to manage the group's mood: it should be open and appreciative throughout. Openness encourages everyone to contribute ideas and disclose concerns. Appreciativeness invites creativity. The contrasting mood of problem-fixing tends to be narrow; it focuses on what's wrong rather than what could be; it discourages group solidarity [1]. The facilitator also displays all new points learned, proposed, or created on shared computers or wall posters. This form of group memory helps everyone recall ideas belonging to the group as a whole [10].

Consider a scenario of a group of green and blue infrastructure advocates deciding to collaborate together despite the clash between their perspectives. Their discussion might evolve as follows. They discover that some of their members are motivated green because beloved family members succumbed to lung diseases. They discover that others are motivated toward security because their businesses have been robbed at gunpoint and because one of their companies went out of business in a blackout. They discover that all of them are hesitant to back a centralized government solution because of the government's poor track record; they do not want to risk locking in a bad solution. They start speculating about grassroots solutions that make it desirable and fashionable to be both green and secure. They agree on committees and working groups that will sponsor contests for well-designed energy-efficient products and stimulate research into personal home power plants that don't depend on the grid being operational all the time.

Limitations of This Structure

How far does the collaboration process scale? We know that it works for workshop-size groups (approximately 50–200 people). It extends to larger communities if the workshop represents them well and if the sponsors can support the project teams created by the collaborating group. What about messy problems that affect millions of people? How do we bring about enough collaboration to influence so many?

This of course is the central question in efforts to deal with large-scale wicked problems such as sustainable infrastructure or global warming. We don't yet know how to make the collaboration process scale up to enlist millions of people in a solution. Currently, problems of such scale tend to be resolved by strong leaders who combine technology with political and media operations to inspire collaboration. For example, Candy Lightner and Cindy Lamb established Mothers Against Drunk Driving (MADD) as an international movement. U.S. Senator George Mitchell established the "Mitchell Principles" that created a workable framework for dialogue that ultimately led to the peace agreement in Northern Ireland. Amory Lovins, who focuses on technical facts and avoids moral judgments, has helped clients as diverse as Wal-Mart and the U.S. Department of Defense deal with energy issues.

Conclusion

Collaboration occurs when a community creates a solution to a messy problem that takes care of all their concerns at the same time. Collaboration is an ideal achieved far less often than it is invoked. It is often confused with information sharing, cooperation, or coordination. Most of our "collaboration technologies" are actually tools for information sharing. We have a few tools for cooperation and coordination, and very few for collaboration.

Scaling up the known collaboration processes to country or world sizes will require significant advances in collaboration tools and networking. Their designs will be based on deep knowledge of the practices now used by the human facilitators of today's processes.

You can use the five-step collaboration process anytime a small-scale collaborative solution is needed. You do not need the full process with workshop. The full process is most useful for achieving collaboration within a large, more diverse community.

Collaboration does not mean

that you give up or compromise your dearest concerns. It means designing a solution that recognizes your concerns. The process often leads to a reconfiguration of everyone's concerns. The hallmark of successful collaboration is the experience of solidarity and new energy: a "we." C

References

1. Barrett, F. and Fry, R. *Appreciative Inquiry.* Taos Institute, 2005.
2. Denning, P. Mastering the mess. *Commun. ACM 50*, 4 (Apr. 2007), 21–25.
3. Denning, P. Flatlined. *Commun. ACM 45*, 6 (June 2002), 15–19.
4. Fisher, R., Patton, B. and Ury, W. *Getting to Yes: Negotiating an Agreement Without Giving In, Second Edition.* Mifflin, 1992.
5. Hagel, J. and Brown, J.S. Creation nets: Harnessing the potential of open innovation. Working paper (2006); johnseelybrown.com.
6. London, S. Collaboration and Community. An essay prepared for Pew Partnership for Civic Change (Nov. 1995); www.scottlondon.com/reports/ppcc.html.
7. National Charrette Institute; www.charretteinstitute.org.
8. Perelman, L. Infrastructure risk and renewal: The clash of blue and green. Working paper PERI Symposium (2008); www.riskinstitute.org/PERI/SYMPOSIUM.
9. Roberts, N.C. Coping with wicked problems. In L. Jones, J. Guthrie, and P. Steane, Eds., *International Public Management Reform: Lessons From Experience.* Elsevier, London, 2001.
10. Straus, D. and Layton, T. *How to Make Collaboration Work.* Berrett-Koehler publishers, 2002.

Peter J. Denning (pjd@nps.edu) is the director of the Cebrowski Institute for Information Innovation and Superiority at the Naval Postgraduate School in Monterey, CA, and a past president of ACM.
Peter Yaholkovsky (peter.yaholkovsky@attglobal.net) is an executive consultant in Grass Valley, CA.

DOI: 10.1145/1330311.1330316

Call for Nominations for Advanced Member Grades In the ACM

ACM has three distinct member grades to recognize the professional accomplishments of our members:

Senior Member recognizes those ACM members, with at least 10 years of professional experience, that have demonstrated performance and accomplishment that set them apart. The list of recipients is found on: http://awards.acm.org/homepage.cfm?awd=159

Distinguished Engineer, Scientist, or Member recognizes those ACM members, with at least 15 years of professional experience that have made significant accomplishments or achieved a significant impact on the computing field. The list of recipients is found on:http://awards.acm.org/homepage.cfm?awd=157

Fellow is ACM's most prestigious member grade recognizing the top 1% of ACM members for their outstanding accomplishments in computing and information technology and/or outstanding service to ACM and the larger computing community. The list of recipients is foundon: http://fellows.acm.org/homepage.cfm?srt=all

Criteria

Senior Member

- Five years continuous Professional membership in ACM
- Ten years of professional experience
- Demonstrated performance that sets the member apart from peers
- Three endorsements from colleagues (not necessarily ACM members) in the field

Distinguished Engineer, Scientist, or Member

- Five years continuous Professional membership in ACM
- Fifteen years of professional experience
- Significant accomplishment in, or a significant impact on, the computing field
- Four endorsements from colleagues in the field. Two of these endorsements must be from ACM Members. It is recommended, but not required, that at least two of these endorsements be from ACM Fellows. Ideally, one of the four endorsements will be from a current or past employer or client.

Fellow

- Five years continuous Professional membership in ACM
- No specific requirement for years of professional experience
- Outstanding accomplishments in computing and information technology and/or outstanding service to ACM and the larger computing community
- Five to eight endorsements

Call for Nominations

from current ACM Professional Members—ideally ACM Fellows.

Nomination Procedures

All nominations for advanced ACM member grades must be made through the ACM Web site:

Senior Members are self-nominating (www.acm.org/seniormember)

Distinguished Engineers, Scientists, Members can be self-nominating or may be nominated by a current ACM Professional Member http://amg.acm.org/public/distinguishedmember/nomination.cfm)

Fellows must be nominated by an ACM Professional Member (http://amg.acm.org/public/fellows/nomination.cfm)

Notes:

- In meeting the requirements for professional experience, educational experience is credited as follows:
  - 3 years if the candidate holds a baccalaureate degree
  - 4 years if the candidate holds a master's degree
  - 5 years if the candidate holds a doctorate
- For all grades, candidates must have been an ACM Professional Member for at least five years immediately preceding the final date for submission of the respective nomination.
- Although there is a natural progression implied within these three grade levels, this progression is not compulsory, i.e., if a candidate meets the requirements of the membership grade it is not necessary to advance from one grade level to the next.
- Endorsers for Senior Member and Distinguished Engineer, Scientist, or Member must attest that:
  - They know the candidate and their work
  - The candidate has accurately described their achievements
  - The accomplishments outlined in the nomination meet the endorsers' best understanding of the criteria for Senior and Distinguished Member.

Deadlines

Senior Member nominations and endorsements must be received by May 31, 2008. Nominations are on a quarterly basis: May 31, 2008; Aug. 31, 2008; Nov. 30, 2008; Feb. 28, 2009.

Distinguished Engineer, Scientist, Member nominations and endorsements must be received by July 31, 2008.

Fellow nominations and endorsements must be received by Sept. 9, 2008.

Recognition

ACM Senior Members and Distinguished Members will receive a certificate and a specially annotated ACM membership card. There will be an announcement on the ACM Web site and in *Communications of the ACM* listing the names of the Senior Members and Distinguished Members.

ACM Fellows will receive a certificate, a specially annotated ACM membership card and an ACM Fellow lapel pin. Their names will be listed in an issue of *Communications of the ACM* and a letter of recognition will be sent to the chief executive at the Fellow's place of employment. Formal induction ceremonies and presentation of Fellow certificates and pins will take place at the next annual ACM Awards Banquet.

Please send any questions you may have about the Senior Member, Distinguished Member or Fellows Programs to: Senior@acm.org; Distinguished@acm.org; Fellow@acm.org; or Rosemary McGuinness (mcguinness@acm.org).

DOI: 10.1145/1330311.1330317

ACM Honors Distinguished and Senior Members

ACM has three distinct member grades to recognize the professional accomplishments of its members. The list of those members recognized as ACM Fellows in 2007 was published in the March 2008 issue of *Communications* (p. 22). Here, we list those members named senior members and distinguished engineer, scientist, or member in 2007.

The *Distinguished Engineer, Scientist, or Member* grade level recognizes those ACM members with at least 15 years of professional experience and five years of continued ACM Professional membership that have made significant accomplishments or achieved a significant impact on the computing field.

The *Senior Member* grade level recognizes those members with at least 10 years of professional experience and five years of continuous ACM Professional membership who have demonstrated performance that sets them apart from their peers.

DISTINGUISHED ENGINEERS

Andrea L. Ames, *IBM Corporation*
John R. Douceur, *Microsoft Research*
Richard Furuta, *Texas A&M University*
Greg Ganger, *Carnegie Mellon University*
Toshio Nakatani, *IBM Research, Tokyo*
Raj Rajkumar, *Carnegie Mellon University*
Stephen M. Trimberger, *Xilinx, Inc.*

DISTINGUISHED SCIENTISTS

Michael G. Burke, *IBM T.J. Watson Research Center*
Siddhartha Chatterjee, *IBM T.J. Watson Research Center*
Nikil Dutt, *University of California, Irvine*
Matthew B. Dwyer, *University of Nebraska-Lincoln*
Kathleen Fisher, *AT&T Labs*
Lane A. Hemaspaandra, *University of Rochester*
Jennifer C. Hou, *University of Illinois at Urbana Champaign*
David J. Kasik, *The Boeing Company*
John Riedl, *University of Minnesota*
Mary Beth Rosson, *Pennsylvania State University*
Michael S. Schlansker, *Hewlett Packard*
Subhash Suri, *University of California, Santa Barbara*
Fei-Yue Wang, *Chinese Academy of Sciences; The University of Arizona*

SENIOR MEMBERS

George K. Adam, *Technological Educational Institute of Larissa, Greece*
Gail-Joon Ahn, *University of North Carolina at Charlotte*
Anthony Aiuto, *Integrated Computer Solutions*
Halundun Akpinar, *Marmara University*
James A. Alves-Foss, *University of Idaho*
Scott Ambler, *IBM*
Sihem Amer Yahia, *Yahoo! Research*
Paul Anderson, *GrammaTech, Inc.*
Martin F. Arlitt, *HP Labs/University of Calgary*
Ronald T. Azuma, *HRL Laboratories*
Eduard Babulak, *Fairleigh Dickinson University, Vancouver*
Ashok Banerji, *Jones International University, India*

ACM Honors

Bill Bartgis, *SPAWARSYSCEN Norfolk*
Dirk Bartz, *University of Leipzig*
Azer Bestavros, *Boston University*
Jun Bi, *Tsinghua University*
Harvey Bingham, *Bingham Associates*
Ronald D. (Shawn) Blanton, *Carnegie Mellon University*
Athman Bouguettaya, *Virginia Tech*
Ron Brightwell, *Sandia National Laboratories*
Ian Brown, *Oxford Internet Institute, Oxford University*
François Bry, *University of Munich*
Eric W. Burger, *Cantata Technology, Inc.*
Martin Carlisle, *US Air Force Academy*
Catherine L. Carter, *University of Maryland*
Curtis A. Carver, Jr., *US Military Academy, West Point*
Goutam Chakraborty, *Iwate Prefectural University, Japan*
Naehyuck Chang, *Seoul National University*
Richard (Mickey) Cheatham, *IBM*
Yen-Kuang Chen, *Intel Corp.*
Jingde Cheng, *Saitama University*
Kak Wah Chiu, *Dickson Computer Systems, Hong Kong*
Jong Hyuk Choi, *IBM T.J. Watson Research Center*
K.R. Chowdhary, *JNV University, Jodhpur, India*
Panos K. Chrysanthis, *University of Pittsburgh*
Jen-Yao Chung, *IBM T.J. Watson Research Center*
Chris Clifton, *Purdue University*
Stephen G. Corbesero, *Moravian College*
Priya Dakshinamoorthy, *Software Architects, Inc.*
Akshay Darbari, *Tata Elxsi Ltd., Bangalore*
Joseph G. Davis, *The University of Sydney*
Anthony H. Dekker, *DSTO*
Xiaotie Deng, *City University of Hong Kong*
Mieso K. Denko, *University of Guelph*
Steven J. DeRose, *National Center for Biotechnology Information, NIH*
Murthy Devarakonda, *IBM T.J. Watson Research Center*
John F. Dooley, *Knox College*
Margaret J. Dunham, *SMU*
Mohamed Y. Eltoweissy, *Virginia Tech*
Tom Enderes, *Terawave Communications*
Michael E. Ensminger, *PAR3 Communications*
Jeremy Epstein, *Software AG, Inc.*
Babak Falsafi, *Carnegie Mellon University*
Michael E. Farmer, *University of Michigan-Flint*
Bassam S. Farroha, *Johns Hopkins University*
Yishai Feldman, *IBM Haifa Research Lab*
Antonio Fernández, *Universidad Rey Juan Carlos*
Barry B. Flachsbart, *Missouri University of Science and Technology*
Karol Früehauf, *INFOGEM AG*
Richard Furuta, *Texas A&M University*
Corrado Giustozzi, *Innovia Security*
Jack Goldberg, *Goldberg Associates*
James J. Grimm, *InfoTrax Systems, LLC*
David P. Grove, *IBM Research*
Daniel Guinier, *OSIA*
Vijay K. Gurbani, *Bell Laboratories/Lucent Technologies*
Martin P. Haeberli
John A. Hamilton, Jr., *Auburn University*
Haidar M. Harmanani, *Lebanese American University*
Timothy L. Harris, *Microsoft Research, Cambridge, UK*
Christopher G. Healey, *North Carolina State University*
John S. Heidemann, *UCS/Information Sciences Institute*
David K. Hemsath, *IBM Corporation*
Christian Hess, *Supreme Court of Justice, Costa Rica*
Michael M.T. Ho, *City University of Hong Kong*
James P. Hobbs, *Intel Corporation*
Vasant G. Honavar, *Iowa State University*
Christian Horn, *Broadcast Learning Ltd., Ireland*
Pao-Ann Hsiung, *National Chung Cheng University*
Huosheng Hu, *University of Essex*
Yu Charlie Hu, *Purdue University*
Galen C. Hunt, *Microsoft Research*
Keith Instone, *IBM*

Distinguished Members

T. Pattabhiraman, *Conversay*
Jian Pei, *Simon Fraser University*
David M. Pennock, *Yahoo! Research*
Frank Pfenning, *Carnegie Mellon University*
Kenneth Pier, *Socialtext, Inc.*
Darrell R. Pitzer, *ExxonMobil Process Research*
Beth A. Plale, *Indiana University*
Thomas E. Potok, *Oak Ridge National Laboratory*
Parthasarathy Ranganathan, *Hewlett-Packard Labs*
G.S.V. Radha Krishna Rao, *Cognizant Technology Solutions*
Wolf-Dieter Rase, *Bundesamt für Bauwesen und Raumordnung*
Donald J. Reifer, *RCI*
Yong Rui, *Microsoft China R&D Group*
David J. Russomanno, *University of Memphis*
Kathleen Ryall, *MERL*
David J. Rypka, *DJR Consulting*
Domenico Saccá, *University of Calabria*
Paolo Santi, *Istituto di Informatica e Telematica del CNR*
Toshinori Sato, *Kyushu University*
Steffen Schaefer, *IBM*
Robert S. Schloss, *IBM Research*
Eljakim Schrijvers, *Eljakim Information Technology bv*
Clifford A. Shaffer, *Virginia Tech*
Mark A. Shand, *Let It Wave*
Jun Shen, *University of Wollongong*
Sandeep Kumar Shukla, *Virginia Polytechnic and State University*
Kevin Skadron, *University of Virginia*
Lars Arne Skår, *Miles AS, Norway*
Ann E. Kelley Sobel, *Miami University*
Mike Speciner, *MIT Lincoln Laboratory*
Vugranam C. Sreedhar, *IBM T.J. Watson Research Center*
John R. Steensen, *Spatial Dynamics Corporation*
Ileana Streinu, *Smith College*
Rosaline Y. Tam, *Richwap Company Limited, Hong Kong*
Randall Tamura, *Boingo Wireless*
M. Rita Thissen, *RTI International*
Michael Gary Thomason, *University of Tennessee-Knoxville*
Walter F. Tichy, *University of Karlsruhe*
Russell Craig Treadwell, *Perot Systems Corporation*
Marilyn Tremaine, *Rutgers University*
Matthew Turk, *University of California, Santa Barbara*
Marco G. Valtorta, *University of South Carolina*
Michael VanHilst, *Florida Atlantic University*
Gregg T. Vesonder, *AT&T Labs-Research*
Ken Wadland, *Cadence Design Systems*
David R.R. Webber, *XML eBusiness*
Bruce F. Webster, *Webster and Associates*
Michael Weintraub, *Verizon Technology*
Richard E. Wendt, III, *UT M.D. Anderson Cancer Center*
Lawrence W. West, *Columbia College*
Michael D. Wilson, *CCLRC (Rutherford Appleton Laboratory Chilton, UK)*
Steven Wilton, *University of British Columbia*
Jenny D. Wirtschafter, *Hypnos Entertainment*
Tilman Wolf, *University of Massachusetts-Amherst*
Konrad S. Wrona, *SAP Research*
Kesheng Wu, *Lawrence Berkeley National Laboratory*
Cheer-Sun Yang, *West Chester University*
Guangxin Yang, *Siemens Corporate Technology*
Ming-Hsuan Yang, *Honda Research Institute*
Yau-yuen Yeung, *Hong Kong Institute of Education*
Michelle X. Zhou, *IBM T.J. Watson Research*
Zhiying Zhou, *Tsinghua University*
Zhigang Zhu, *City College of New York*

DOI: 10.1145/1330311.1330318

Daniel Kunkle and Gene Cooperman

Solving Rubik's Cube: Disk Is the New RAM

Substituting disk for RAM, disk-based computation is a way to increase working memory and achieve results that are not otherwise economical.

Disk-based computation represents a major new use of disks, in addition to the three historical uses: file systems, databases, and virtual memory. We recently demonstrated the importance of this fourth case by showing progress on a 25-year-old conjecture: determine how many moves suffice to solve Rubik's Cube. We chose Rubik's Cube because it has long served as a computationally challenging problem in which practitioners from a variety of disciplines have tested the efficacy of their techniques.

Our working group coined the term "disk-based computation" to describe our five-year effort to make use of parallel disks in scientific computation, including the many disks already available in a computational cluster. In doing so, the humble disk is elevated to a status normally reserved for RAM. RAM equivalence gives an application several orders of magnitude more working space for the same financial price. Such parallel disk-based methods are often based on lower-level external memory algorithms (such as those surveyed in [3]).

Our work reached the mainstream media in 2007 when we showed that Rubik's Cube can be solved in 26 moves or less [1]. At its heart, our computation simply enumerates and stores possible configurations of the puzzle. But, with more than 4.3×10^{19} possible configurations, proving that 26 moves suffice requires many terabytes of main memory. It was only our insight that "disk is the new RAM" that enabled us to overcome this memory barrier.

Rubik's Cube is an example of a large enumeration problem for which disk-based computation may lead to breakthroughs in many different problem domains, including group theory, hardware and software verification, coding theory, and constraint satisfaction. In them, one has an initial state, a method to produce neighboring states, and a need to store all reachable states. New powerful multicore computers are beginning to allow us to generate neighboring states faster than ever before. However, the ability to do so often means we also reach the limits of RAM more quickly than ever before.

Limiting ourselves to 4GB of main memory per computer is an arbitrary restriction not required by current technology. We are all conditioned by decades of history to regard disk as a hopelessly slow cousin to RAM. However, a simple back-of-the-envelope calculation shows this does not have to be so. The bandwidth of commodity disks is on the order of 100MB/s. A computer cluster with 50 disks provides 50 times the aggregate bandwidth, or 5GB/s, which is close to the bandwidth of commodity RAM. Thus 50 local disks provide the moral equivalent of a single extremely large RAM subsystem.

Viewed this way, a 50-node scientific computing cluster would be able to perform like a powerful parallel computer endowed with a single 10TB RAM subsystem. Justifying the use of distributed

LISA HANEY

Despite the fact that RAM stands for random access memory, we would almost never use the "new RAM" (disk) in random-access mode.

disks as a multi-terabyte main memory requires a small amount of math, as well as several somewhat larger caveats. A typical scientific computing cluster includes 200GB of often-unclaimed disk space per computer. A 50-node cluster provides 10TB of disk. As a nice side benefit, in today's commodity computer market, this 10TB of idle local disk space is essentially free.

How can we treat 10TB of disk space as if it were RAM? The answer depends on consideration of disk bandwidth, disk latency, and network bandwidth:

Thesis. Because 50 disks provide approximately the same bandwidth as a single RAM subsystem, the local disks of a computer cluster can be regarded as if they were a single very large RAM subsystem;

Caveat 1. Disk latency is much more limiting than disk bandwidth. Therefore, despite the fact that RAM stands for random access memory, we would almost never use the "new RAM" (disk) in random-access mode. The old-fashioned RAM already serves as our random-access cache;

Caveat 2. The new RAM is distributed across the local-area network. The aggregate network bandwidth of a cluster (even gigabit Ethernet) may not fully support the ideal 5GB/s aggregate bandwidth of the new RAM. Parallel algorithms must therefore be restructured to emphasize local access over network access. (This restriction is familiar to practitioners, who have long been aware of the impossibility of accessing traditional remote RAM at full speed over the network.)

Testbed

The details of the Rubik's Cube computation illustrate the benefits of disk-based computation. Whereas people usually solve Rubik's Cube in four or five stages, each involving fewer than one million combinations, the large main memory of disk-based computation allows a programmer to provide a two-stage solution where the largest subproblem involves 10^{14} combinations.

A person might first solve the top layer of the Cube (with nine smaller cubies, or individual box-like segments), then the bottom layer, and finally the remaining middle pieces. Solving the bottom and middle layers requires the use of macro moves, or sequences of moves that preserve the previous layers.

The programmer solves each of the two subproblems by performing a breadth-first search over all possible configurations, starting with the solved state. For the smaller of the two subproblems (10^5 configurations), this is easy.

For the larger of the two subproblems (10^{14} configurations), we first used the symmetries of Rubik's Cube to reduce it to 10^{12} configurations. We then analyzed several possible algorithms, settling on the final version, enumerating the 10^{12} configurations in 63 hours with the help of 128 processor cores and 7TB of disk space.

The primary difficulty in trying to extend a naive enumeration algorithm to execute on disk is how to efficiently perform duplicate detection, that is, to determine when a newly generated state has been seen before. This is typically done using a hash table or some other data structure that relies on random access. In the disk-based version, we avoid random access by delaying duplicate detection and collect many new states we check for duplicates in a later phase.

A brief description of the methods we considered when solving Rubik's Cube illustrates the kinds of

data structures and algorithms we have found useful in disk-based computation. The first method is based on external sort—a well-known disk-based sort that avoids random access at the cost of performing several passes through the data. New states discovered during the breadth-first search are saved to disk without checking for duplicates. When an entire level of the search is completed, the new states are externally sorted and merged into a sorted list containing all previously discovered states.

In this way, we eliminate random-access data structures, using sorted lists in their place. Eliminating random access comes at the cost of having to maintain the sorted order of the lists. Further, this method requires that we save all known states. For our Rubik's Cube computation, storing all configurations would require 11TB, not counting the buffer space for newly generated states.

The second method avoids storing all seen states and also removes the need for expensive external sorting operations. Instead of explicitly storing the known states, we use a disk-based table to record the previously discovered states. To avoid random access, we split this table into contiguous pieces such that each piece fits into RAM. When performing duplicate detection, we load one piece of the table into RAM at a time and remove duplicate states that correspond to that portion of the search space.

Even though this method avoids storing explored states, it still requires the storage of the open list of new states from which duplicates have not been removed. For our Rubik's Cube computation, the open list has a maximum size of 50TB. To avoid this limitation, we use a technique we call `implicit open list` to encode the open states using a hash table, rather than an explicit list. This allows us to complete the computation using just 7TB of disk space.

Organizing Principle

A unified framework is required to broaden the appeal of disk-based computation beyond Rubik's Cube. Our team is now searching for an organizing principle that will allow for the construction of a software library or language extension that does for disk-based computation what numerical libraries have done for numerical analysis. As an initial step, we have begun a comparative analysis of eight different techniques for disk-based enumeration [2]. This analysis is based on the methods we used for Rubik's Cube, along with our solutions to several model problems in computational group theory.

The search cuts across many areas of computer science. For example, in systems and architecture, how can we design disk-based computations to balance the use of CPU, RAM, network, and disk? In theory and algorithms, what class of computations can be converted to efficient disk-based computation? In software engineering and programming languages, how can we separate disk-specific data structures and algorithms from problem-specific concerns? By answering such questions, we will advance the use of disk-based computation, enabling solutions to problems requiring even petabytes of memory. C

References

1. Kunkle, D. and Cooperman, G. Twenty-six moves suffice for Rubik's Cube. In *Proceedings of the 2007 International Symposium on Symbolic and Algebraic Computation* (Waterloo, Ontario, Canada, July 29–Aug. 1). ACM Press, New York, 2007, 235–242.
2. Robinson, R., Kunkle, D., and Cooperman, G. A comparative analysis of parallel disk-based methods for enumerating implicit graphs. In *Proceedings of the 2007 International Workshop on Parallel Symbolic Computation* (London, Ontario, Canada, July 27–28). ACM Press, New York, 2007, 78–87.
3. Vitter, J. External memory algorithms and data structures: Dealing with massive data. *ACM Computing Surveys 33,* 2 (June 2001), 209–271.

Daniel Kunkle (kunkle@ccs.neu.edu) is a Ph.D. candidate in computer science in the College of Computer and Information Science at Northeastern University, Boston, MA.

Gene Cooperman (gene@ccs.neu.edu) is a professor in the College of Computer and Information Science at Northeastern University, Boston, MA., where he is also the director of the Institute for Complex Scientific Software and the head of the High Performance Computing Laboratory.

DOI: 10.1145/1330311.1330319

BY RYAN WEST

THE PSYCHOLOGY OF SECURITY

Why do good users make bad decisions?

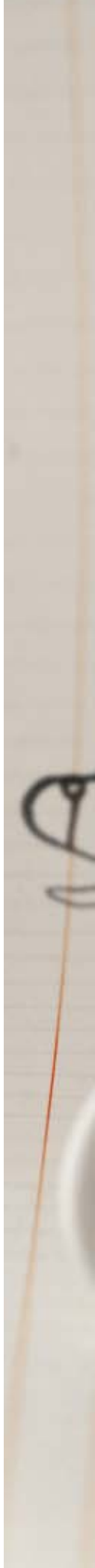
"... [the system] must be easy to use and must neither require stress of mind nor the knowledge of a long series of rules..."

AUGUSTE KERCKHOFFS ON THE DESIGN OF CRYPTOGRAPHIC SYSTEMS (*La cryptographie militaire, 1883*)

The importance of the user in the success of security mechanisms has been recognized since Auguste Kerckhoffs published his treatise on military cryptography, *La cryptographie militaire*, over a century ago. In the last decade, there has been tremendous increase in awareness and research in user interaction with security mechanisms.

Risk and uncertainty are extremely difficult concepts for people to evaluate. For designers of security systems, it is important to understand how users evaluate and make decisions regarding security. The most elegant and intuitively designed interface does not improve security if users ignore warnings, choose poor settings, or unintentionally subvert corporate policies. The user problem in security systems is not just about user interfaces or system

ILLUSTRATIONS BY SERGE BLOCH



People tend to believe they are less vulnerable to risks than others. People also believe they are less likely to be harmed by consumer products compared to others. It stands to reason that any computer user has the preset belief that they are at less risk of a computer vulnerability than others.

interaction. Fundamentally, it is about how people think of risk that guides their behavior. There are basic principles of human behavior that govern how users think about security in everyday situations and shed light on why they undermine security by accident.

This article offers a brief introduction to research on risk, uncertainty, and human decision making and how they relate to users making security decisions, and provides a few key concepts and possibilities in how they may be used to improve users' security behavior.

Non-acceptance of security tools is recognized as a major problem facing the information security world [5]. Research in the usability of security mechanisms has exploded over the last decade and an excellent trove of research papers is cataloged by the *HCISec Bibliography* hosted atwww.gaudior.net/alma/biblio.html. Among the studies listed there is a mountain of evidence that mechanisms for encryption, authorization, and authentication can be difficult for people to understand or use [1, 9] and that people often fail to recognize security risks or the information provided to cue them [3, 4]. Accordingly, researchers have promoted the need for user-centered design throughout the development process and warn that usability testing security systems only at the end of the process does not guarantee a usable or acceptable system [7, 11, 12].

However, there is more to this than interaction with technology. Human decision making has been a topic of study in social sciences from economics to psychology for over a century. The net sum of that research suggests that individuals are often less than optimal decision makers when it comes to reasoning about risk. However, we have predictable and exploitable characteristics in our decision-making process. Understanding these principles and how users come to make decisions about security may suggest places where we can improve the outcome of the decisions.

Users do not think they are at risk. First of all, people tend to believe they are less vulnerable to risks than others. Most people believe they are better than average drivers and that they will live beyond average life expectancy [6]. People also believe they are less likely to be harmed by consumer products compared to others. It stands to reason that any computer user has the preset belief that they are at less risk of a computer vulnerability than others. It should come as no surprise that, in 2004, a survey from AOL and the National Cyber Security Alliance reported that roughly 72% of home users did not have a properly configured firewall and that only one-third had antivirus virus signatures updated within the past week.[1]

Even as security measures improve, users will remain at risk. There is evidence that individuals maintain an acceptable degree of risk that is self-levelling, known as *risk homeostasis*.[2] Applied to security, it suggests that as users increase their security measures, they are likely to increase risky behavior. For example, the user who has just installed a personal firewall may be more likely to leave his machine online all the time.

Users aren't stupid, they're unmotivated. In social

[1]America Online and the National Cyber Security Alliance. AOL/NCSA Online Safety Study, 2004; www.staysafeonline.info/news/safety_study_v04.pdf.
[2]G.J.S. Wilde. *Target Risk 2: A New Psychology of Safety and Health.* PDE Publications, Toronto, Ontario, 2001.

From Windows Explorer: UI #1
1. Right click on folder in public share (invokes UI #2)
2. Click on Properties in context menu (invokes UI #3)
3. Click on Sharing tab (invokes UI #4)
4. Click Share… (invokes UI #5)
5. Enter the User or Group name to share with
6. Click Add (automatically sets permission level to "Reader" which sets ACEs for Read, Read & Execute, and List Folder Contents)
7. Click Share (invokes UI #6)
8. Click Done (returns to UI #3)
9. Click Close (returns to UI #1)

Table 1. Nine steps and six UIs are required to set file permissions on a public share in Windows Vista. It takes four steps just to find the settings.

cognition, the term is *cognitive miser*. Humans have a limited capacity for information processing and routinely multitask. As a result, few tasks or decisions receive our full attention at any given time. To conserve mental resources, we generally tend to favor quick decisions based on learned rules and heuristics. While this type of decision making is not perfect, it is highly efficient. It is efficient in the sense it is quick, it minimizes effort, and the outcome is good enough most of the time. This partially accounts for why users do not reliably read all the text relevant in a display or consider all the consequences of their actions.

Safety is an abstract concept. When evaluating alternatives in making a decision, outcomes that are abstract in nature tend to be less persuasive than outcomes that are concrete [2]. This is key to understanding how users perceive security and make decisions. Often the pro-security choice has no visible outcome and there is no visible threat. The reward for being more secure is that nothing bad happens. Safety in this situation is an abstract concept. This, by its nature, is difficult for people to evaluate as a gain when mentally comparing cost, benefits, and risks.

Compare the abstract reward (safety) garnered from being more secure against a concrete reward like viewing an attachment in instant messaging or Web content that requires a browser add-on and the outcome does not favor security. This is especially true when a user does not know what his or her level of risk is or believes they are at less risk than others to start. Returning to the principle of the cognitive miser, the user is also more likely to make a quick decision without considering all of the risks, consequences, and options.

Feedback and learning from security-related decisions. The learning situation created by many common security and risk decisions does not help either. In a usual learning situation, behavior is shaped by positive reinforcement when we do something "right." We do something good, we are rewarded. In the case of security, when the user does something good, the reinforcement is that bad things are less likely to happen. There is seldom an immediate reward or instant gratification, which can be a powerful reinforcer in shaping behavior.

In another common learning situation, behavior is shaped by negative reinforcement when we do something "wrong." We do something bad, we suffer the consequences. In the case of security, when the user does something bad, the negative reinforcement may not be immediately evident. It may be delayed by days, weeks, or months if it comes at all. Cause and effect is learned best when the effect is immediate and the anti-security choice often has no immediate consequences. This makes learning consequences difficult except in the case of spectacular disasters.

Evaluating the security/cost trade-off. While the gains of security are generally abstract and the negative consequences are stochastic, the cost is real and immediate. Security is integrated into systems in such a way that it usually comes with a price paid in time, effort, and convenience—all valuable commodities to users.

For example, in the simplest case—restricting access to a public share in Microsoft's Windows Vista to a group of users—requires about nine separate steps and six distinct user interfaces (see Table 1). While each step seems small, they add up a real cost to users. In deciding what to do, users weigh the cost of the effort against the perceived value of the gain (safety/security) and the perceived chance that nothing bad would happen either way.

Making trade-offs between risk, losses, and gains. Given that security gains are often intangible, the costs known, and the negative consequences involve probabilities, we can look at several known factors at play when people evaluate risks, costs, and benefits.

Users are more likely to gamble for a loss than accept a guaranteed loss. First of all, people react to risk differently depending on whether they think they are primarily gaining something or losing something. Tversky and Kahneman [8] showed that people are more likely to avoid risk when alternatives are presented as gains and take risks when alternatives are presented as losses. For example, consider the following scenario where a person has to decide between two options presented as gains:

Scenario 1:
A) Gain $5 at no risk

B) Gain $10 if a coin toss lands heads up

When Tversky and Kahneman used a similar scenario, 72% of those surveyed chose the sure bet offered by option A because there was less risk and the outcome was guaranteed. Now consider a similar scenario presented as a choice between two losses:

Scenario 2:
A) Lose $5 guaranteed
B) Lose $10 if a coin toss lands heads up

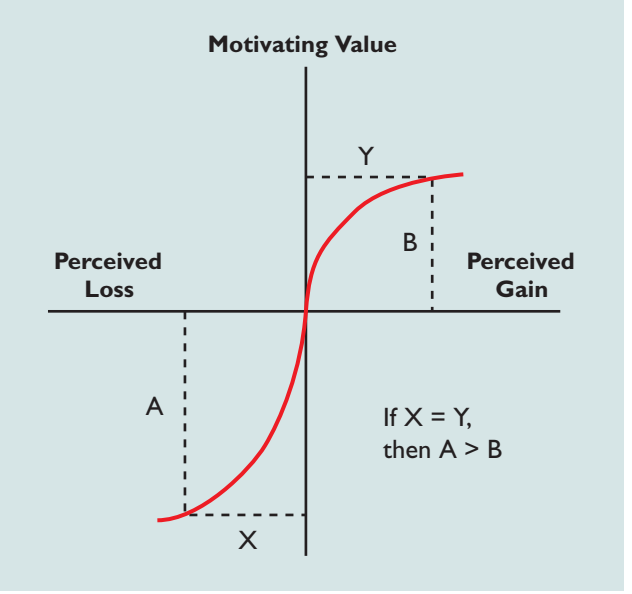


Figure 1. Losses carry more value compared to gains when both are perceived as equal. For non-zero values, if value of loss (X) = value of gain (Y), then motivation of loss (A) > motivation of gain (B) (Adapted from Tversky and Kahneman [8]).

When Tversky and Kahneman framed their scenario as a choice between losses, 64% of the respondents chose option B. People tended to focus on the chance to not lose anything offered in B compared to the sure loss guaranteed by option A.

When evaluating a security decision, the negative consequences are potentially greater of course, but the probability is generally less and often unknown. The principle holds true. When there is a potential loss in a poor security decision compared to the guaranteed loss of making the pro-security decision, the user may be inclined to take the risk. For example, consider the choice between two losses in a common security decision involving the download and installation of a digital certificate and ActiveX control from an unknown source. In this scenario, the primary goal is to view the Web page content:

Scenario 3:
A) Do not install digital certificate and ActiveX control from unknown source and do not view the content of the Web page (fail on primary goal), guaranteed.
B) Install digital certificate and ActiveX control from unknown source, view the Web page (accomplish primary goal), and take a chance that something bad happens.

Like Scenario 2, some users will chance that nothing bad will happen in order to achieve their primary goal than accept the task failure guaranteed by option A. Furthermore, if there are no immediate and obvious negative consequences incurred by option B, the user learns it is an acceptable decision and is more likely to repeat it in the future. The everyday security decisions end users make, like opening file attachments, are often presented in the form of losses as in Scenario 3.

People do not perceive gains and loss equally. This suggests that while a system designer may consider the cost of security effort small, the loss could be perceived as worse than the greater gain in safety. Put simply, the user must perceive a greater magnitude of gain than of loss.

Security as a secondary task. People tend to focus more on the losses that will affect their immediate goal than the gains when making decisions under time pressure [12]. Users are often called on by the system to make a security decision while they are in the middle of an activity. In these cases, the user is often motivated to get on with the primary task as quickly as possible and, therefore, less likely to make a decision that further interrupts that task. In cases where users are prompted to install software updates, scan a file for viruses before opening, and so forth, users are less likely to comply when in the middle of another task, especially if in a hurry.

Figure 2. Can you spot the security message? Message dialogs often look similar enough that no message stands out as more important that than others.

Losses perceived disproportionately to gains. People do not perceive gains and losses equally. Tversky and Kahneman [8] showed that when individuals perceive a gain and a loss to have the same value, the loss is more motivating in the decision (see Figure 2). In short, this means that a loss of $100 is more adverse than a gain of $100 is attractive to a decision maker.

This suggests that while a system designer may consider the cost of security effort small, the loss could be perceived as worse than the greater gain in safety. Put simply, the user must perceive a greater magnitude of gain than of loss.

Improving Security Compliance and Decision Making

Using the principles at work in security decision making, there are several avenues that may improve user security behavior.

Reward pro-security behavior. There must be a tangible reward for making good security decisions. Some suggest that corporate IT organizations would be encouraged to adopt stronger security practices if insurance companies offered lower premiums to those who protect themselves by certain measures [5]. Likewise, end users must be motivated to take pro-security actions.

Increasing the immediate and tangible reward for secure actions may increase compliance. One form of reward is to see that the security mechanisms are working and that the action the user chose is, in fact, making them safer. This makes safety a visible gain when evaluating gains and losses in a security decision.

A good example of this is when an antivirus or antispyware product finds and removes malicious code. In these cases, the security application often issues a notification that it has found and mitigated a threat. This is an effective way for a security system to prove its value to the user by showing there was a risk and that the system protected them. By returning to the access control scenario for file sharing, it would be possible to report attempts at unauthorized access to the file owner.

Figure 3. Can you spot the security message? (Part 2) Well-designed security messages have distinct visual and auditory properties that make them stand apart from all other message dialogs and indicate the criticality of the message.

Improve the awareness of risk. As discussed earlier, people often believe they are at less risk compared to others. One way to increase security compliance is to increase user awareness of the risks they face. This could be achieved through user training and education in general but should also be built into systems to support specific events.

One classically deficient area in the security of systems is messages and alerts. Security messages often resemble other messages dialogs (Figure 2). As a result, security messages may not stand out in importance and users often learn to disregard them.

To avoid the response bias problems faced by most message dialogs, security messages should be instantly distinguishable from other message dialogs. Security messages should look and sound very different (illustrated in Figure 3). This helps mitigate the blasé attitude with which users attend to the information. Once the message dialog has the user's attention, they are more likely to read

and consider the choices given to them.

Catch corporate security policy violators. Increasing the awareness of risk could also mean increasing the likelihood that a corporate user is caught violating security policy. Having a corporate security policy that is not monitored or enforced is tantamount to having laws but no police. If the security systems have good auditing capabilities and are watched by event monitoring systems, users who make poor security decisions could be "caught" in a way. This would serve as an immediate negative consequence by itself. Like automated systems at traffic lights that snap pictures and issue violations to drivers that run red lights, users who make poor security decisions could receive automated email notifications of their actions and the corporate policy or safe computing practice. In general, the best deterrent to breaking the rules is not the severity of consequences but the likelihood of being caught.

Reduce the cost of implementing security. Obviously, if users need to take additional steps to increase their level of security, they will be less likely to do so. As the cost of implementing security increases, the overall value of the decision decreases. To accomplish a task, users often seek the path of least resistance that satisfies the primary goal. It should be common knowledge that in making the secure choice the easiest for the user to implement, one takes advantage of normal user behavior and gains compliance.

Another way to reduce the cost of security is, of course, to employ secure default settings. Most users never change the default settings of their applications. In this way, one increases the cost to make non-secure decisions in terms of time and effort. While good default settings can increase security, system designers must be careful that users do not find an easier way to slip around them. For example, users who are directed by their IT departments to use strong passwords across multiple systems are more likely to write them down [1].

Conclusion

Core to security on an everyday basis is the compliance of the end user, but how do we get them to make good decisions when they are often the weakest link in the chain? Users must be less motivated to choose anti-security options and more motivated to choose pro-security options. Obviously, no one would suggest training end users with USB devices that deliver an electric shock or food pellet reward based on their actions. But, generally speaking, we can increase compliance if we work with the psychological principles that drive behavior.

The ideal security user experience for most users would be none at all. The vast majority would be content to use computers to enrich their lives while taking for granted a perfectly secure and reliable infrastructure that makes it all possible. Security only becomes a priority for many when they have problems with it. However, now, and in the foreseeable future, users are in the control loop. We must design systems with an understanding that, at some point, must make a decision regarding security. The question is, what will they decide? C

References

1. Adams, A. and Sasse, A.S. Users are not the enemy. *Commun. ACM 42*, (1999) 40–46.
2. Borgida, E., and Nisbett, R.E. The differential impact of abstract vs. concrete information on decisions. *J. Applied Social Psychology 7* (1977) 258–271.
3. Dhamija, R., Tygar, J.D., and Hearst, M. Why phishing works. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Montreal, Quebec, Canada, Apr. 22–27, 2006). R. Grinter, T. Rodden, P. Aoki, E. Cutrell, R. Jeffries, and G. Olson, Eds. ACM, New York, 581–590.
4. Downs, J.S., Holbrook, M., and Cranor, L.F. Behavioral response to phishing risk. In *Proceedings of the Anti-Phishing Working Groups 2nd Annual Ecrime Researchers Summit* (Pittsburgh, PA, Oct. 4–5, 2007). ACM, New York, 37–44.
5. Greenwald, S.J., Olthoff, K.G., Raskin, V., and Ruch, W. The user non-acceptance paradigm: INFOSEC's dirty little secret. *New Security Paradigms Workshop*, 35–43. ACM, New York.
6. Slovic, P., Fischhoff, B., and Lichtenstein, S. Facts versus fears: Understanding perceived risks. *Judgment under Uncertainty: Heuristics and Biases.* D. Kahneman, P. Slovic, and A. Tversky, eds. Cambridge University Press, New York, 1986, 463-489.
7. Smetters, D.K. and Grinter, R.E. Moving from the design of usable security technologies to the design of useful secure applications. *New Security Paradigms Workshop*. ACM, New York, 2002, 82–89.
8. Tversky, A. and Kahneman, D. Rational choice and the framing of decisions. *J. Business 59* (1986), 251–278.
9. Whitten, A. and Tygar J.D. Why Johnny can't encrypt: A usability evaluation of PGP 5.0. In *Proceedings of the 8th USENIX Security Symposium* (1999). USENIX Association, Berkeley, CA, 169–184.
10. Wright, P. The harassed decision maker: Timer pressure, distractions, and the use of evidence. *J. Applied Psychology 59*, (1974), 555–561.
11. Yee, K.P. User interaction design for secure systems. *Proceedings of the 4th International Conference on Information and Communications Security.* Springer-Verlag, London, 2002.
12. Zurko, M.E. and Simon, R.T. User-centered security. *New Security Paradigms Workshop*. ACM, New York, 27–33.

Ryan West (ryan.west@acm.org) has conducted academic research in risk and decision making and applied research in areas ranging from medical mistakes to computer security. He currently works as a design researcher at Dell, Inc., Austin, TX.

DOI: 10.1145/1330311.1330320

The Business of OPEN SOURCE

Tracking the changing competitive conditions of the software industry.

In his discourse comparing various economic systems, Schumpeter [5] declares it is new products, new markets, and new forms of production and distribution that impel the creative destruction engine of free enterprise. Entrepreneurs strategically weave an organizational design of customer value, product offering, and production and distribution technologies that enables them to compete with, and often displace, existing organizations. Customers decide whether to accept the new firm's offerings based on their perceptions of value.

Open source software (OSS) appears to be creative destruction in action: all three of the components that fuel the destructive fire are evident. There is an abundance of new and innovative products emerging from the OSS community. The zero-cost licensing structure of most open

By Richard T. Watson, Marie-Claude Boudreau, Paul T. York, Martina E. Greiner, and Donald Wynn, Jr.

source projects has opened up the acceptance of these products into a number of previously untapped markets. The Internet has created an environment in which software distribution costs are approaching zero. Products freely and rapidly flow across borders. There is no packaging—no shelf-space requirements. OSS is not confined to one economic system. It overcomes both the tyranny of distance [1] and oppression of borders. OSS also espouses new methods of software production that utilize the public as the production mechanism and allows for coordinated, location-agnostic access to the raw materials for these new products.

To assess if OSS has the potential to revolutionize the development and distribution of software, we must first understand how the entities involved in the development of such software are organized. Because different business models are not equal in their capacity to create value, we must analyze each particular blend of customer, product, and production and distribution mechanism. After presenting five models underlying the software development business, we focus our attention on the one that has perhaps the most disruptive potential.

The Business Models

We distinguish five models of software production or distribution: proprietary, open community, corporate distribution, sponsored OSS, and second-generation OSS. Whereas the first two constitute the extremes of the closed-open continuum, the other three are hybrids of closed and open models.

Proprietary and Open Communities. Proprietary and open communities both have their origins in the early days of computing, when some people freely exchanged code while others recognized there were customers for their programs and accordingly sold executable versions of their products while carefully securing the source.

The proprietary model has dominated the marketplace for decades. Firms employ programmers to develop software and customers purchase it. The code is considered a major intellectual resource, and traditional software firms protect their code from outside eyes by erecting physical and legal firewalls between their code and the outside world. Proprietary firms rely heavily on both copyright law—to ensure that "leaked" source code cannot legally be used in a competing product—and patent law—to protect their intellectual property from duplication. While the code is most often sold for license fees, proprietary firms can and do distribute their products as freeware. It is not the price that distinguishes proprietary software but rather the public's inability to view and modify the source code.

At the other extreme is the open community model, which involves the development and support of software by volunteers with limited or no commercial interest. This model dominates the OSS movement in terms of number of projects. Many of them can be located through large, Internet-based project management and source code repositories such as SourceForge, which hosts over 170,000 software projects.[1] While the majority of these projects involve only one or two developers and have a small number of users, many have a vast base of both developers and users and have produced products that provide unique functionality or offer compelling alternatives to commercial products.

Corporate Distribution. Based on the high level of adoption for many OSS products, it seems apparent that quality products are being produced through the open community model. However, some entrepreneurs recognize that identifying appropriate products, interacting with open communities for support, and developing the required support skills can be challenging for many potential OSS customers. As a result, firms, such as RedHat, SpikeSource, and OpenOSX, have emerged to create value (and generate revenue) by identifying best-of-breed OSS projects, improving distribution methods for these products, and providing complementary services in order to make these OSS products more accessible to a broader market.

Sponsored Open Source. Corporations and foundations sponsor some OSS projects. For example, the Apache Software Foundation fosters the development of the Apache server and over 50 other OSS projects. Some corporate sponsors directly contribute development resources to OSS projects. IBM is a high-profile example of a corporation contributing developers to Apache's Web server. In some cases, sponsored OSS projects have been initiated by corporations releasing previously closed code and encouraging their employees to continue to work on the now open project. Eclipse, an integrated software development environment, was released as OSS by IBM, whose developers are still primary contributors to the project.

Second-Generation Open Source. Second-genera-

[1] As of late February 2008, SourceForge hostsed 170,539 projects.

tion open source (OSSg2)—also known as professional open source—firms are essentially a hybrid between corporate distribution and sponsored OSS. As with the corporate-distribution model, OSSg2 companies typically generate the bulk of their revenues by providing complementary services around their products [3]. Like sponsored projects, OSSg2 firms provide the majority of the development resources required to create and maintain their products. However, unlike most corporate-distribution companies, OSSg2 firms generally do not sell licenses for their products,[2] and unlike most sponsored projects, OSSg2 firms typically own or tightly control the software code and can exploit their intimate knowledge of the code to provide higher-quality service than could potential competing service providers. As the leading OSSg2 firms (including JBoss,[3] MySQL, Trolltech, and Sleepycat[4]) are privately held or have been acquired, we do not have data on their profitability. However, based on interviews with the CEOs of the four firms mentioned here, it appears they are cash-flow positive while growing rapidly.

We contend that OSSg2 firms have a very promising business model that could emerge as a dominant model for OSS development in the coming years. Here, we examine four leading OSSg2 companies, highlighting three important benefits of their business models.

Evaluating the OSSg2 Business Model

We studied four companies that are among the OSSg2 leaders. In order of business longevity, these are Trolltech, MySQL, Sleepycat, and JBoss. Three important characteristics of the OSSg2 model exhibited by these firms that lead to specific benefits are: accountability (and the benefit of reduced liability problems); talent base (and the associated benefits for code quality and support); and ecosystem (and the associated benefits of trialability and quality assurance). These benefits should improve the value proposition to customers for OSSg2 products and are central to our contention that OSSg2 is a threat to traditional software firms. To quote Marc Fleury, former CEO of JBoss: "We (OSSg2 companies) are proving that professional open source can do it better and faster and cheaper than our traditional competitors."[5] How the OSSg2 model addresses three specific strategic risks is discussed later in this article.

OSSg2 Leaders. Trolltech was founded in Norway in 1994 and currently has more then 4,400 customers. It manages two software products: Qt, a cross-platform application development library, and Qtopia, an application platform built for embedded Linux. A second OSSg2 leader, MySQL, was founded in Sweden in 1995. In mid-2007, MySQL's OSS relational database had 11 million active installations. MySQL is an attractive alternative to higher-cost relational systems from commercial vendors. A third leader is Sleepycat Software, a U.S. company founded in 1996. Its flagship product, Berkeley DB, is an OSS-developer database that boasts over 200 million deployments. Finally, JBoss Inc., a U.S. company founded in 2001, provides middleware through its JEMS (JBoss Enterprise Middleware System) portfolio of products. Three of these products are currently market leaders: JBoss AS (a J2EE-compliant application server), Hibernate (an object-relational mapping solution), and Tomcat (a Java Servlet container). JBoss's former CEO, Fleury, who coined and trademarked the "Professional Open Source" label, has greatly influenced the OSSg2 business model [6].

There are differences among these OSSg2 companies. First, Trolltech, MySQL, and Sleepycat are based on a dual-license strategy offering both commercial and OSS licensing options. Customers may use a product without paying a license fee; however, if they

> Because different business models are not equal in their capacity to create value, we must analyze each particular blend of customer, product, and production and distribution mechanism.

[2]As discussed here, some OSSg2 firms offer a proprietary license for organizations not wishing to comply with the terms of the OSS licensing model.
[3]JBoss was acquired by RedHat, Inc. in April 2006.
[4]Sleepycat was acquired by Oracle, Inc. in February 2006.
[5]All uncited quotes are based on personal interviews.

augment the original source code and do not wish to release the modifications under an OSS license, they must buy a commercial license. Mike Olson, former CEO of Sleepycat, acknowledges that the dual licensing strategy is a "great judo trick for competing with proprietary vendors." JBoss is based on a Lesser General Public License (LGPL) license and only receives revenues from services including software support, training, and consulting. A second difference is that, whereas Trolltech, MySQL, and Sleepycat own the source code underlying their products (which allows them to offer a dual-licensing scheme), JBoss does not own the code of the software products it services. Nevertheless, as an OSSg2 firm, it controls the code more tightly than companies based on the other OSS business models. For example, the extent of its contribution to its three leading products is 85% for JBoss AS, 95% for Hibernate, and 60% for Tomcat [4].

OSSg2 Characteristics Improve Customer Value. Three key traits of OSSg2 firms provide specific benefits to their customers and can thus improve their value proposition.

Accountability. All four OSSg2 companies we studied indemnify their paying customers from any legal liability associated with their products (potential patent or copyright infringements). The indemnity provision provides a necessary level of security for potential adopters of OSSg2 products who are still apprehensive about OSS. This accountability may do more than just bring OSSg2 companies to parity with proprietary software vendors. Sleepycat's former CEO, Mike Olson, asserts the risks of patent infringements and copyright problems are lower for an OSSg2 company: "Anyone that wants to can look at my software. If there was a claim pending, if I had stolen something, it is overwhelming likely that it would have been seen by now. […] No proprietary vendor's customer has that degree of assurance. If there has been intellectual property misappropriated in that product, it is a secret and it may still be lurking" [7].

From Olson's perspective, OSSg2 companies offer greater peace of mind than proprietary firms, because patent or copyright infringements should be uncovered relatively early—reducing the impact the copyright infringements may have on adopting customers' systems.

Talent base. Each OSSg2 company retains talented coders, wherever they are located, to maintain and support its software products. Indeed, all four OSSg2 leaders insist they recruit from among the world's best and most productive programmers, drawing not only from the immense pool of first-generation OSS contributors, but also from a growing collection of emerging talent. MySQL and JBoss allow their programmers to live wherever they wish. In addition, recruitment is different. Typically, those employed by OSSg2 companies have an established record of contributing code and identifying bugs as volunteers prior to their hiring. They have demonstrated their understanding of the code base and their ability to fit within the OSS development culture. This is an important competitive advantage because it means OSSg2 companies reduce hiring risks without significant up-front recruiting and training costs.

> Open source programs have moved beyond the desktops of code hackers and are now in production in a growing number of corporate IS departments.

Trolltech's employees (approximately 230) come from more than 20 different countries; they were recruited almost exclusively through the OSS community. Trolltech has learned that great developers want to work with each other. When asked about the criteria for hiring, CEO Havaard Nord emphasized that what really counts is "code, code, and code…merits…formal education is less important." Trolltech's employees are the company's most valued assets. The founders and the employees—owning two-thirds of the shares—control Trolltech. Outside investors have majority ownership and control of many software companies. Only in rare cases does Trolltech get outside contributions for its products. When this happens, either the submitting contributor is hired (if coding quality and knowledge of the product have been demonstrated) or the firm gets ownership of the code. As a result, Nord claims Troll-

tech's customer base is "extremely happy with the code," thanks to the company's careful approach to recruiting and retaining its high-skill employee base. Fleury insists that employees are JBoss's greatest asset as well: "I treat my elite developers like royalty. I overpay them. I cover my lead developers in stock. Many of them walk around with an executive package, which is rarely the case, if ever, in traditional software companies."

This focus on hiring the best programmers results in a quality of code that is at least commensurate with that of proprietary development while maintaining the benefit of "mass innovation" [4] shared by all OSS products. Similarly, the support and education offered by OSSg2 companies meet industry expectations because of the quality of the personnel.

Ecosystem. There is an encompassing ecosystem that evolves around OSSg2 companies that typically includes all the entities that gain from the OSSg2 companies' presence in the market (support services, authors, educators, publishers, partners, user communities, and so forth). This translates into multiple Web sites, email lists, newsgroups, conferences, and published materials providing up-to-date information about OSSg2 products and their applications. OSSg2 companies typically benefit greatly from their ecosystem without much strain on their resources. Mårten Mickos, CEO of MySQL, emphasizes that MySQL tries, with minimum involvement, to make its ecosystem thrive: "We try to be open about our intentions so it's easy for others to plan their business and their life around us. We try to move the obstacles of getting our product, distributing our product, using our product. […] We just make sure the friction is as low as possible."

Potential OSSg2 customers can download and test a complete software product extensively before making an adoption decision. Because the ecosystem provides an effective pre-sales support apparatus, potential customers receive a significant advantage in the form of trialability that is limited neither in time nor functionality.

The ecosystem can also provide for an efficient, external quality-assurance mechanism above and beyond what may be carried out in-house, as Mickos points out: "When we release a new version, within 24 hours 35,000 people have downloaded and tested it. That's fantastic. Not even Microsoft has 35,000 QA engineers. […] Just based on statistics, we know that there are enough people out there who certainly test all relevant features, without our specific instruction" [7].

The OSSg2 model thus has a significant advantage in leveraging an important ecosystem that is willing to work on its behalf.

How OSSg2 Addresses Risks. OSSg2 has an adroit answer to dealing with the major risks facing all software firms. Every firm faces three strategic risks: demand, efficiency, and innovation [2].

Demand risk and pricing strategy. Wal-Mart and Dell have altered the structure of the retailing and computer industries through their low-cost strategies. Similarly, OSSg2 firms push the cost of software acquisition to the lower limit. Assuming requirements are met by an OSSg2 product, cost-driven IS departments will be attracted by zero acquisition costs. Extensive trialability, discussed earlier, also contributes to mitigate demand risk. For OSSg2 firms, as with both Wal-Mart and Dell, revenue losses from low-cost strategies are largely offset by increased operational efficiencies.

Efficiency risk and the Internet. OSSg2 firms gain from efficiencies associated with their Internet-based infrastructures. Many employees work remotely, software is downloaded rather than packaged and distributed physically, and high trialability obviates many traditional marketing costs. Consequently, OSSg2 firms tend to have a lower cost structure than traditional firms and thus enjoy efficiency differentials over proprietary software competitors.

Innovation risk and open source. When code is open, many coders can inspect it, and faults often will be detected more rapidly than when only a handful review it. Furthermore, those who can see the code can suggest improvements and submit code changes. As with all OSS communities, the developers and supporting community members for OSSg2 projects are drawn from all areas of the world, an immense talent pool from which OSSg2 community members can be recruited on the basis of talent and contribution, unfettered by physical location. This ready supply of programmers ensures innovative ideas can be contributed to the OSSg2 community from both traditional sources and sources previously untapped by traditional software firms. This phenomenon directly attacks innovation risk.

Conclusion

The open source movement is challenging the status quo in the software marketplace. Open source programs have moved beyond the desktops of code hackers and are now in production in a growing number of corporate IS departments. OSS is ampli-

fying the demand, efficiency, and innovation risks that traditional software organizations face and is driving a period of creative destruction that has the potential to permanently alter the competitive landscape within the software industry. OSSg2 firms offer a significant customer value proposition and have effective strategies that should aid their prospects for long-term survivability. However, during this period of creative destruction, we also recognize that the market is constantly changing, traditional firms are experimenting with adjustments to their strategies to address the stresses that OSSg2 is placing on their business models, and new models are emerging that will blur the lines between the categories we have outlined in this article. This makes the business of open source both extremely fascinating and highly consequential. C

References

1. Cairncross, F. *The Death of Distance: How the Communications Revolution Will Change Our Lives*. Orion, London, 1997.
2. Child, J. Information technology, organizations, and the response to strategic challenges. *California Management Review 30*, 1 (1987), 33–50.
3. Fitzgerald, B. The transformation of open source software. *MIS Quarterly 30*, 3 (2006), 587–598.
4. Goetz, T. Open source everywhere. *Wired 11*, 11 (Nov. 2003).
5. Schumpeter, J. *Capitalism, Socialism, and Democracy*. Fakenham and Reading, London, 1943.
6. Watson, R.T., Wynn, D., and Boudreau, M.-C. JBoss: The evolution of professional open source software. *MIS Quarterly Executive 4*, 3 (2005), 329–341.
7. Wittig, C. and Inkinen, S. MySQL open source database in 2004. Stanford Graduate School of Business, 2004.

Richard T. Watson (rwatson@terry.uga.edu) is the J. Rex Fuqua Distinguished Chair for Internet Strategy in the Terry College of Business at the University of Georgia, Athens.
Marie-Claude Boudreau (mcboudre@terry.uga.edu) is an associate professor in the Terry College of Business at the University of Georgia, Athens, GA.
Paul T. York (ptyork@uga.edu) is a Ph.D. student in the Terry College of Business at the University of Georgia, Athens, GA.
Martina E. Greiner (mgreiner@uga.edu) is a Ph.D. student in the Terry College of Business at the University of Georgia, Athens, GA.
Donald Wynn, Jr. (wynndona@notes.udayton.edu) is an assistant professor in the Department of Management Information Systems, Decision Sciences and Operations Management at the University of Dayton, OH.

DOI: 10.1145/1330311.1330321

Measuring Consumer Satisfaction in Internet Banking: A Core Framework

What service-quality attributes must Internet banks offer to induce consumers to switch to online transactions and keep using them?

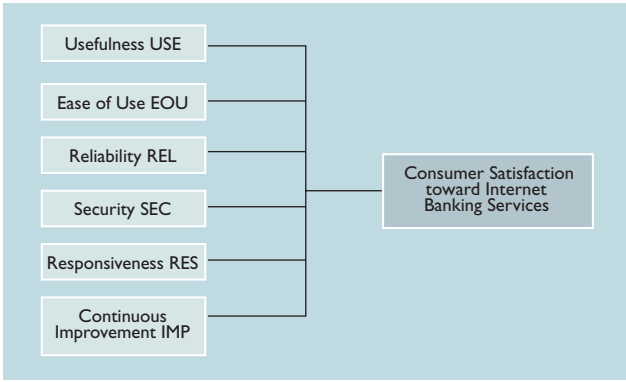
We apply Herbert Simon's seminal idea of bounded rationality to construct a framework for measuring consumer satisfaction with Internet banking in terms of a core subset of attributes. This construction facilitates decision-cost-effective thinking and applications on the part of the e-bank's operations and IT managers to enhance customer service quality and boost market share in this expanding but increasingly competitive business area. Strong analytical and empirical grounds are offered to support such an approach. The managerial implication follows that when planning to expand or contract Internet operations, e-banks must first focus on attributes in the core subset, along with their benefits and costs.

An increasing number of banks worldwide offer facilities that allow customers to access accounts and execute transac-

By Ziqi Liao and Michael Tow Cheung

tions through the Internet. Unlike traditional banking, these facilities do not provide face-to-face contact in what is essentially a one-to-one service relationship [5]. For Internet banking to compete effectively against traditional brick-and-mortar banking, service quality in other directions must be relatively higher. Among the challenges to market development in Internet banking [4] is the requirement that managers and strategists identify, measure, and compare the key determinants (such as usefulness, reliability, and security) of service quality.

Given the large number of variables that can potentially affect service quality and the high decision costs if enhancement is sought in each and every dimension, the idea of bounded rationality suggests that the opportunity set should be made as small as possible, that is, its size should be "satisficed" in the sense expounded by Simon. To this end, we suggest an approach under which service-quality attributes are reduced to a core subset through analytical considerations, after which the resulting core framework is tested for empirical relevance. We show in terms of survey data that all quality attributes entering the core subset have a statistically significant effect on consumer satisfaction with Internet banking, as against quality attributes partitioned outside the core subset.



Schematic of the core framework.

In the literature, service quality is generally understood to depend on reliability, security, responsiveness, competency, courtesy, communication, credibility, access, empathy, and intangibles [8]. Under the Servqual protocol for quantifying service quality, determinants are distilled into basic categories involving reliability, responsiveness, assurance, empathy, and intangibles [7]. In studies where the standard Technology Acceptance Model (TAM), Servqual, and transaction cost analysis are used to measure consumer attitudes toward B2C e-commerce [3], empirical significance has been established for the perceived usefulness and ease of use under both the TAM and the quality dimensions of Servqual.

In Internet banking, the TAM and Servqual attributes that might potentially affect service quality present an *embarrass des richesse*. If enhancement is sought in each and every dimension, then according to the theory of bounded rationality, such a situation can actually work against managerial efficiency. Through similar reasoning, the decision costs arising from such a large number of variables are readily reduced if the opportunity set is rationally made smaller. We therefore propose an approach under which, by reference to the research support established in the literature, the TAM and Servqual variables potentially affecting consumer satisfaction with Internet banking are reduced to a core subset. This approach yields a framework containing six service-quality attributes—usefulness (USE), ease of use (EOU), reliability (REL), security (SEC), responsiveness (RES), and continuous improvement (IMP)—along with their reduced-form relationship to consumer satisfaction in Internet banking services (CSIBS) (see the figure here). Since the consumption or investment decisions underlying changes to individual cash balances are given under the framework's other-things-being-equal conditions, we can defer consideration of the time-asymmetry effects that characterize plans implemented through e-banking, as against plans retracted through e-banking [2]. Our core framework is therefore applicable to Internet banking whatever the direction of monetary transactions.

Given the framework's reduced-form structure, it is possible to introduce statistical analysis to test any choice of attributes in terms of empirical relevance. If a particular core framework is found to be valid on empirical, in addition to statistical, grounds, it can be applied to support decision-cost-effective and empirically prioritized management in Internet banking (such as in market development).

Structural Properties

Under the bounded-rationality approach, whether a given service-quality attribute enters our framework is first determined by the general research support it enjoys in the literature and the extent to which it is applicable to Internet banking. We then subject any choice of the core subset to tests for empirical validity. In particular, we draw attention to concepts introduced under the fundamental TAM and Servqual paradigms and apply them to service-quality assessment and consumer satisfaction with Internet banking. We then obtain a core framework containing six perception-based constructs, together

with six directly testable hypotheses that characterize the resulting consumer-satisfaction function in terms of empirically meaningful properties.

We first generalize from the TAM literature and propose that service quality in Internet banking and resulting consumer satisfaction depend on individual perceptions with regard to usefulness and ease of use. The empirical importance of these considerations to consumer attitudes toward Internet banking was investigated and established in [5]. Combining these results and applying them to the core framework, we obtain the hypotheses:

H1. Perceived usefulness (USE) is a positive determinant of CSIBS; and
H2. Perceived ease of use (EOU) is a positive determinant of CSIBS.

Reliability—a basic category in the Servqual protocol—has been found to be an empirically important determinant of service quality in many situations [12]. In Internet banking, concern over reliability would tend to focus on whether information access and transaction processes are expected to be operationally consistent and accurate. Applying these results to the core framework yields the hypothesis:

H3. Perceived reliability (REL) is a positive determinant of CSIBS.

Under Servqual modeling, security is understood in physical and financial terms, as well as in terms of privacy and the protection of data against unauthorized disclosure, modification, and destruction. In particular, privacy enters the analysis in the sense of individuals and organizations determining for themselves when, how, and to what extent personal and sensitive data is to be transmitted to others [9]. In Internet banking, security has been found to be a matter of intense concern, especially with regard to the acquisition and dissemination of personal and sensitive data. Perceptions regarding this aspect of service quality are generally operationalized in the form of transaction security, as represented directly by the safe and accurate transfer of funds and payment-credit information and indirectly by transaction risk [5]. These observations suggest the hypothesis:

H4. Perceived security (SEC) is a positive determinant of CSIBS.

In Servqual modeling, service responsiveness is generally captured in terms of the vendor's ability to supply information with minimal time lag to make available problem-solving mechanisms, as well as provide guarantees when difficulties emerge [12]. As applied to e-service quality, responsiveness has been operationalized and studied in terms of promptness and efficiency [6]. These observations suggest an extension of Servqual modeling to the case of Internet banking in terms of the hypothesis:

H5. Perceived responsiveness (RES) is a positive determinant of CSIBS.

The Servqual idea of continuous improvement was proposed to depict service quality in relation to the vendor's expected ability to meet changing consumer needs and requirements [10]. Such an attribute would be fundamental to competitive advantage in business areas characterized by rapid technological and institutional change (such as Internet banking), especially with regard to product-service innovation and enhancement to increase demand. Applying these ideas and results to the core framework suggests the hypothesis:

H6. Continuous improvement (IMP) is a positive determinant of CSIBS.

Methodology and Results

Our research methodology involved the standard areas of questionnaire design, survey implementation, and quantitative analysis. Our questionnaire was designed to allow Likert-scale measurement of the core framework's perception-based constructs and service-quality attributes: consumer satisfaction with Internet banking, usefulness, ease of use, reliability, responsiveness, security, and continuous improvement. In 2005, we dispatched 500 questionnaires to individuals with experience in Internet banking in Hong Kong. A research sample of 182 meaningful replies was obtained.

We first performed a Cronbach α test to determine the internal consistency of data obtained from multiple-item measurement of {USE, EOU, REL, RES, SEC, IMP}. The α values we obtained ranged from 0.796 to 0.907, indicating satisfactory internal consistency with reference to the standard criterion of ≥ 0.7 (see Table 1). Correlation coefficients ranging from 0.457 to 0.758 indicate the existence of significant relationships (at the 0.01 level) among {USE, EOU, REL, RES, SEC, IMP} in the data, thereby supporting the combination of such attributes under linear modeling of the core framework.

The core framework's reduced-form structure allowed us to exploit the optimal properties of ordinary least squares in further data analysis. A regression with CSIBS as dependent variable and USE, EOU, REL, SEC, RES, and IMP as independent variables suggests that, given linear modeling assumptions, the consumer-satisfaction function implied by the present choice of core subset is statistically meaningful. In particular, we found that $R^2 = 0.783$, $F = 109.867$, df = (6, 175), $p < 0.001$, and that the regression coefficients for all six core attributes are statistically significant (see Table 2). Properties of the consumer-satisfaction function, as hypothesized under H1–H6, are therefore supported by the data.

Perception-based Attribute	Items Under Likert Scaling	Cronbach α
Usefulness (USE)	8	0.825
Ease of Use (EOU)	12	0.907
Reliability (REL)	6	0.796
Security (SEC)	6	0.897
Responsiveness (RES)	6	0.876
Continuous Improvement (IMP)	5	0.815
Consumer Satisfaction toward Internet Banking Services (CSIBS)	4	0.806

Table 1. Data reliability test.

Attribute	OLS Coefficients b_k	t	Sig.
Constant	0.277	1.323	0.187
USE	0.100	2.222	0.028
EOU	0.138	2.479	0.014
REL	0.146	3.042	0.003
SEC	0.177	3.407	0.001
RES	0.116	2.253	0.026
IMP	0.290	4.365	0.000

Unstandardized constant coefficient $b_{CONST} = 0.277$, $t = 1.323$, $p = 0.187$

Table 2. Regression results.

According to a standard result in statistics, the constant term in a linear regression equation captures autonomous effects on the dependent variable. In the present exercise, this can be interpreted as representing the empirical influence of service-quality variables not included in the core subset, in the sense of partitioning a universal set of quality attributes into a subset containing {USE, EOU, REL, SEC, RES, IMP} and a complement subset of other attributes. (Excluded variables having nothing to do with service quality would be factored into the regression equation's error term.) The fact that the constant term was found to be statistically nonsignificant (in Table 2, the coefficient $b_{CONST} = 0.277$, $t = 1.323$, $p = 0.187$) indicates that these "left-out" service-quality attributes do not, even in the aggregate, significantly affect consumer satisfaction with Internet banking. This result, together with the fact that we found all six regressors to be statistically significant, suggests that the approach employed to construct the core framework is justified, both empirically and analytically.

	USE	EOU	REL	SEC	RES	IMP
USE		1.380	1.460	1.770	1.160	2.900
EOU			1.058	1.283	0.841	2.101
REL				1.212	0.795	1.986
SEC					0.655	1.638
RES						2.500
IMP						

Table 3. Estimated marginal rates of substitution.

Since hypotheses H1–H6 are supported by the data, our core framework can be applied to identify and evaluate strategies in Internet-banking management. First consider the fundamental strategic-managerial problem of market development. Given the positive impact of perceived usefulness, it would be possible to enhance consumer satisfaction and demand by increasing the variety of banking and financial services offered over the Internet. From a micro-level analysis of the survey data, we discovered that respondents consider ease of navigation particularly important when judging ease of use. This finding suggests that the upgrading of e-banking Web sites should be planned with this function in mind. Given the problems posed by counterfeit bank Web sites and the resulting disincentive effects on demand [11], our findings with regard to security and reliability supply a compelling reason to allocate more resources to combat fraudulent banking over the Internet.

The positive impact of reliability highlights the importance of satisfying customer expectations with regard to error-free accounting and service implementation. It is particularly important for operations and IT managers not to forget this desideratum in the midst of popular efforts by Internet banks to compete by offering rewards and discounts. It has been suggested [9] that as customers become more accustomed to online transactions, their concern over security would ease [9]. If Internet banks consistently demonstrated competence and a commitment to enhancing information safety and privacy protection, both the demand side and supply side of the market would benefit.

Since responsiveness enhances consumer satisfaction when transacting online, initiatives by Internet banks to increase promptness and attentiveness in e-communications should improve demand. Finally, the positive impact of continuous improvement suggests that in the

midst of increasing standardization of financial products and services, demand can be expected to react favorably to innovation designed to anticipate the changing needs of customers in technologically diverse market segments (such as online asset trading).

For a quantitative comparison of efficiency along different strategic directions in market development, we follow [1] and calculate marginal rates of substitution (MRS) from the empirical results in Table 2. Assuming that a linear approximation of the consumer satisfaction function is valid, we can apply the standard formula estimating $MRS_{ij}=b_j/b_i$ to obtain the data in Table 3, determining in particular $MRS_{USE,EOU}=b_{EOU}/b_{USE}=0.138/0.100=1.380$ and $MRS_{USE,REL}=b_{REL}/b_{USE}=0.146/0.100=1.460$. Should a cost-benefit analysis be required to establish priorities in market development under the core framework, these calculations would supply data for one side of the decision. For example, if the difference between $MRS_{USE,EOU}=1.380$ and the (given) relative cost of enhancing service quality in the direction of USE and EOU is greater than the difference between $MRS_{USE,REL}=1.460$ and the (given) relative cost of enhancing quality in the direction of USE and REL, it would be more efficient for the bank to incrementally expand online services by exploiting the first opportunity as against the second. (In economic theory, MRS comparisons of this type can be introduced independently from output price.)

Conclusion

The potential exists for Internet banking to become significantly more important in the increasingly technology- and information-based global economy. Financial institutions must therefore deliver ever-better service quality in their online operations and products. Given that a large number of service-quality attributes can potentially affect consumer attitudes toward Internet banking, the theory of bounded rationality suggests that the high decision cost entailed in the pursuit of service-quality enhancement in each and every direction would be reduced if the opportunity set is rationally made smaller. To this end, we have proposed a framework under which service-quality attributes are reduced to a core subset on the basis of both analytical and empirical considerations. The resulting core framework can then be applied to decision-cost-effective and empirically prioritized management in Internet banking, especially with regard to market development.

Significant analytical and statistical grounds exist to justify the introduction of perceived usefulness, ease of use, reliability, responsiveness, security, and continuous improvement into the core subset. The idea of empirically testing bounded-rational model construction can also be extended to evaluate re-specification of the core subset in response to shifts in the business and/or technological environment. If bank-user perceptions and preferences are found to change with regard to certain core attributes, empirical results obtained in this exercise can be exploited by marketing managers to attract more customers to online banking. C

References

1. Cheung, M.T. and Liao, Z. Supplyside hurdles in Internet B2C e-commerce: An empirical investigation. *IEEE Transactions on Engineering Management 50,* 4 (Nov. 2003), 458–469.
2. Cheung, M.T. and Liao, Z. Time-asymmetry in business processes. *Commun. ACM 45,* 5 (May 2002), 107–108.
3. Devaraj, S., Fan, M., and Kohli, R. Antecedents of B2C channel satisfaction and preference: Validating e-commerce metrics. *Information Systems Research 13,* 3 (Sept. 2002), 316–333.
4. Liao, Z. and Cheung, M.T. Challenges to Internet e-banking. *Commun. ACM 46,* 12 (Dec. 2003), 248–250.
5. Liao, Z. and Cheung, M.T. Internet-based e-banking and consumer attitudes: An empirical study. *Information and Management 39,* 4 (Jan. 2002), 283-295.
6. McKinney, V., Yoon, K., and Zahedi, F. The measurement of Web-consumer satisfaction: An expectation and disconfirmation approach. *Information Systems Research 13,* 3 (Sept. 2002), 296–315.
7. Parasuraman, A., Zeithaml, V.A., and Berry, L.L. Servqual: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing 64,* 1 (Spring 1988), 12–40.
8. Parasuraman, A., Zeithaml, V.A., and Berry, L.L. A conceptual model of service quality and its implications for future research. *Journal of Marketing 49,* 4 (Fall 1985), 41–50.
9. Udo, G.J. Privacy and security concerns as major barriers for e-commerce: A survey study. *Information Management & Computer Security 9,* 4 (2001), 165–174.
10. Yang, Z., Peterson, R.T., and Hung, L. Taking the pulse of Internet pharmacies. *Marketing Health Services 21,* 2 (Summer 2001), 5–10.
11. Yousafzai, S., Pallister, J., and Foxall, G. A proposed model of e-trust for electronic banking. *Technovation 23,* 11 (Nov. 2003), 847–860.
12. Zeithaml, V.A., Parasuraman, A., and Malhotra, A. Service quality delivery through Web sites: A critical review of extant knowledge. *Journal of the Academy of Marketing Science 30,* 4 (Fall 2002), 362–375.

Ziqi Liao (zqliao@hotmail.com) is an associate professor in the Department of Finance and Decision Sciences at Hong Kong Baptist University, Hong Kong, China.

Michael Tow Cheung (mcheung@econ.hku.hk) is an associate professor in the School of Economics and Finance at the University of Hong Kong, Hong Kong, China.

DOI: 10.1145/1330311.1330322

By Luc Moreau, Paul Groth, Simon Miles, Javier Vazquez-Salceda, John Ibbotson, Sheng Jiang, Steve Munroe, Omer Rana, Andreas Schreiber, Victor Tan, and Laszlo Varga

THE PROVENANCE OF ELECTRONIC DATA

It would include details of the processes that produced electronic data as far back as the beginning of time or at least the epoch of provenance awareness.

Provenance is well understood in the study of fine art where it refers to the documented history of some art object. Given that documented history, the object attains an authority that allows scholars to understand and appreciate its importance and context relative to other works. Art objects that lack a proven history may be viewed with skepticism by those who study them.

If the provenance of data produced by computer systems could be determined, then users would be able to understand how documents had been assembled, how simulation results were determined, and how financial analyses were carried out. Computer applications should thus

ILLUSTRATION BY PAUL WILEY


98743.57
98743,5774B
44343.1897D
74891,5487
74473,1189
10443.218
63981,487A
22189,1747A
provenance:
(i) the fact of coming from some particular source or quarter; origin, derivation; (ii) the history or pedigree of a work of art, manuscript, rare book, etc.; concretely, a record of the ultimate derivation and passage of an item through its various owners.

Electronic data does not typically contain the historical information that would help end users, reviewers, or regulators make the necessary verifications.

be transformed, making them provenance-aware, so the data's provenance may be retrieved, analyzed, and reasoned over.

The *Oxford English Dictionary* defines provenance as: "(i) the fact of coming from some particular source or quarter; origin, derivation; (ii) the history or pedigree of a work of art, manuscript, rare book, etc.; concretely, a record of the ultimate derivation and passage of an item through its various owners." Hence, we can regard provenance as the derivation from a particular source to a specific state of an item. The description of such a derivation may take different forms or emphasize different properties according to a user's personal interest. For instance, for a work of art, provenance usually identifies its chain of ownership; alternatively, the actual state of a painting may be understood better by studying the various restorations it has endured.

The dictionary definition also identifies two distinct ways to view provenance: the source (or derivation) of an object and the record of the derivation. A computer-based representation of provenance is crucial for users who want to analyze, reason, and decide whether or not they trust electronic data.

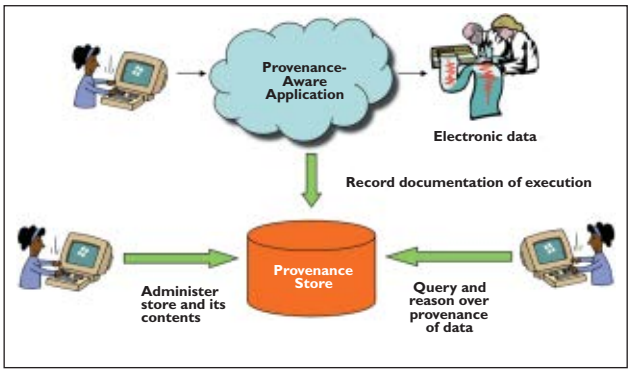


Figure 1. Provenance life cycle.

Here, we introduce the provenance life cycle, summarizing key principles underpinning existing provenance systems. We then examine an open data model for describing how applications are executed; in this context, provenance is seen as a user query over such descriptions. We illustrate the vision of provenance-aware applications through a concrete example in health-care management, contrasting it with existing systems.

The scientific and business communities [6] both embrace a service-oriented architecture (SOA) that allows the dynamic discovery and composition of services. SOA-based applications are increasingly dynamic and open but must satisfy new requirements in both e-science and business. In an ideal world, e-science end users would be able to reproduce their results by replaying previous computations, understand why two seemingly identical runs with the same inputs produce different results, and determine which data sets, algorithms, or services were involved in their derivation.

In e-science and business, some users, reviewers, auditors, and even regulators must verify that the process that led to some result complies with specific regulations or methodologies; further, they must prove the results were derived independently from services or databases with given license restrictions; and they must also establish that the data was captured at the source by instruments with some precise technical characteristics.

While some users must perform such tasks today, they are unable to do so or do it only imperfectly, because the underpinning principles have not been investigated, and systems have not been designed to support such requirements. A key observation is that electronic data does not typically contain the historical information that would help end users, reviewers, or regulators make the necessary verifications. Hence,

there is a need to capture extra information, or process documentation, describing what actually occurred at execution time. Process documentation is to electronic data what a record of ownership is to a work of art. Provenance-aware applications create process documentation and store it in a provenance store offering long-term persistent, secure storage of process documentation (see Figure 1). This role accommodates a variety of physical deployments; for instance, a provenance store can be a single, autonomous service or (to be more scalable) a federation of distributed stores.

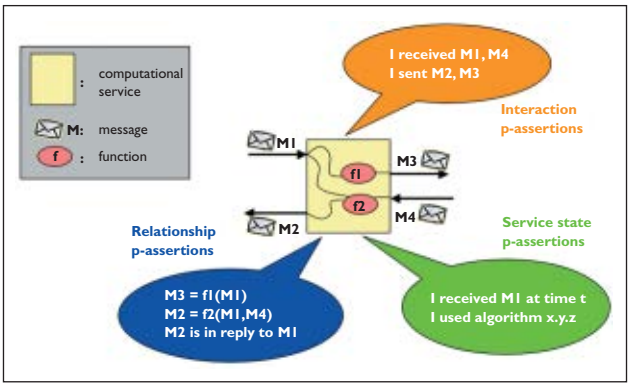


Figure 2. Categories of p-assertions made by a computational service.

When process documentation is recorded, the provenance of data results can be retrieved by querying the provenance store and analyzed to suit the user's needs. The provenance store and its contents might also need to be managed, maintained, or curated.

Open Model for Process Documentation

Process documentation for many applications cannot be produced in a single, atomic burst but must be interleaved continuously with execution. This makes it necessary for designers to be able to distinguish a specific item documenting part of a process from the whole process of documentation. We view the former—a p-assertion—as an assertion made by an individual application service involved in the process. Thus, the documentation of a process consists of a set of p-assertions made by the services involved in the process.

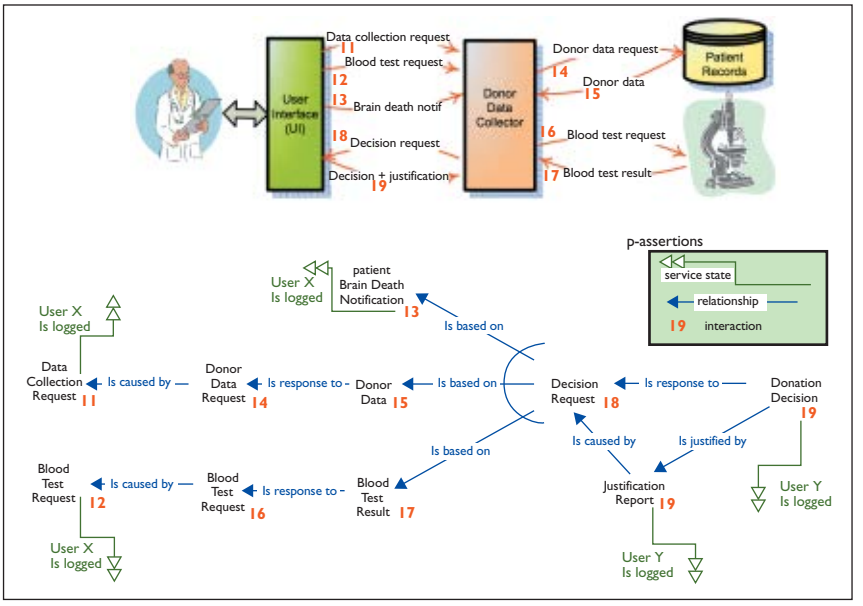


Figure 3. Provenance directed acyclic graph of a donation decision.

In order to minimize its effect on application performance, documentation must be structured so it can be constructed and recorded autonomously by services on a piecemeal basis. Otherwise, should synchronization be required among these services to agree on how and where to document execution, application performance might suffer dramatically. To satisfy this design requirement, we've identified various kinds of p-assertions we expect applications to adopt in order to document their execution. Figure 2 outlines a computational service sending and receiving messages and creating p-assertions that describe its involvement in such activity.

In SOAs, interactions consist of messages exchanged between services. By capturing all interactions, one can analyze an execution and verify its validity or compare it with other executions. Therefore, process documentation includes interaction p-assertions, or descriptions of the contents of a message by a service that has sent or received it.

Whether a service returns a result directly or calls other services, the relationship between its outputs and inputs is not generally explicitly represented in the messages themselves but is understood through analysis of the service's business logic. To promote openness and generality, we make no assumptions about the technology (such as source code and workflow language) used by services to implement their business logic. Rather, we require services to provide information in the form of relationship p-assertions, or descriptions asserted by a service as to how it obtained output data sent in an interaction by applying some function or algorithm to input data from other interactions. (In Figure 2, output message M3

Process documentation is to electronic data what a record of ownership is to a work of art.

was obtained by applying function f1 to input M1.)

With the two kinds of p-assertions—interaction and relationship—process documentation as a whole is greater than the sum of its individual parts. Indeed, while p-assertions are simple pieces of documentation produced by services autonomously, interaction and relationship p-assertions together capture an explicit description of the flow of data in a process. Interaction p-assertions denote data flows between services, whereas relationship p-assertions denote data flows within services. These flows capture the causal and functional data dependencies in execution and, in the most general case, constitute a directed acyclic graph (DAG) (see Figure 3). For a specific data item, the data-flow DAG indicates how it is produced and used and is thus a core element of provenance representation, though not the only one.

Beyond the flow of data in a process, internal service states may be needed to understand nonfunctional characteristics of execution (such as the performance or accuracy of services) and therefore the nature of the results they compute. Hence, a service-state p-assertion is documentation provided by a service about its internal state in the context of a specific interaction. Service-state p-assertions are varied; they may include the amount of disk and CPU time used by a service in a computation, the local time when an action occurred, the floating-point precision of the results it produced, or application-specific state descriptions.

In order for provenance-aware applications to be interoperable, it is critical that the process documentation they respectively produce be structured according to a shared data model. Therefore, the novelty of our approach is the openness of the proposed model of documentation [7] conceived as independent of application technologies [8]. These characteristics together allow process documentation to be produced autonomously by application services and expressed in an open format over which provenance queries may be expressed.

Querying the Provenance of Electronic Data

Provenance queries are user-tailored queries over process documentation aimed at obtaining the provenance of electronic data. In this context, the data item of interest to the user must first be characterized. Indeed, since data is indeed mutable, its provenance, or history, can vary according to the point in execution from which a user wishes to find it. A provenance query must be able to identify a data item with respect to a given documented event (such as sending or receiving a message).

The full detail of everything that ultimately caused a data item to be what it is could be quite large; for example, the full provenance of an experiment's results almost always includes a description of the process that produced the materials in the experiment, along with the provenance of any materials used in producing these materials and the devices and software (and their settings) used in the experiment. Should documentation be available, the full provenance would ultimately include details of processes leading back to the beginning of time or at least to the epoch of provenance awareness.

Users must be able to express the scope of their

interest in a process through a provenance query, essentially performing a reverse graph traversal over the data flow DAG and terminating according to the query-specified scope; the query output is a DAG subset. Scoping can be based on types of relationships, intermediary results, services, or subprocesses [7].

In Health Care Management

To illustrate our approach, we explore a health care management application. The Organ Transplant Management (OTM) system under development by the Catalan Transplant Organization, Catalonia, Spain, manages all the activities pertaining to organ transplants across multiple Catalan hospitals and their regulatory authority, the government of Catalonia, Spain [1]. OTM consists of a complex process involving the surgery itself, along with such activities as data collection and patient organ analysis that must comply with a set of regulatory rules. OTM is supported by an IT infrastructure that maintains records that allow medical personnel to view (and edit) a given patient's local file within a given institution or laboratory. However, the system does not yet connect records or capture the dependencies among them or allow external auditors or patients' families to analyze or understand how decisions are made.

By making OTM provenance-aware, powerful queries impossible without provenance-awareness functionality can now be supported (such as find all doctors involved in a decision, find all blood-test results involved in a donation decision, and find all data that led to a decision). Such functionality can be made available not only to the medical profession but also to regulators and families.

Here, we limit ourselves to a simplified subset of the OTM workflow—the process leading to the decision of whether or not to donate an organ. As a hospitalized patient's health declines and in anticipation of a potential organ donation, an attending doctor requests the full health record for the patient and sends a blood sample for analysis. Through a context-sensitive menu-driven user interface (UI), the attending doctor submits the requests that are then passed to a software component (the donor data collector) responsible for collecting all expected results. If brain death is observed and logged into the system and if all requested data and analysis results are obtained, the system asks the doctor to decide about the donation of an organ. The decision, or the outcome of the doctor's medical judgment based on the collected data, is explained in a report submitted by the doctor as the decision's justification.

Figure 3 (top) outlines the components involved in this scenario and their interactions. The UI sends requests (I1, I2, I3) to the donor data collector service, which gets data from the patient records database (I4, I5), along with analysis results from the laboratory (I6, I7), and finally requests a decision (I8, I9).

To make OTM provenance-aware, designers are augmenting OTM with the ability to produce an explicit representation of the process taking place, including p-assertions for all interactions (I1–I9), relationship p-assertions capturing dependencies between data items, and state p-assertions. Figure 3 (bottom) outlines the DAG representing a donation decision's provenance, which consists of relationship p-assertions produced by provenance-aware OTM. DAG nodes denote data items, whereas DAG edges (in blue) represent relationships (such as data dependencies, like "is based on" and "is justified by," and causal relationships, like "in response to" and "is caused by"). Each data item is annotated by the interaction in which it occurs. Further, the UI asserts a service-state p-assertion for each of its interactions about the users logged into the system.

Authorized users can then issue provenance queries that navigate the provenance graph, pruning it according to the querier's needs; for example, from the graph, we can derive that users X and Y are both causing a donation decision to be reached. Figure 3 includes only a limited number of components, but in real-life examples involving vast amounts of documentation, users—doctors, patients, or regulatory authorities—benefit from a powerful and accurate provenance-query facility.

Existing Systems

The approach we've explored here is derived from an extensive requirement analysis [8] that resulted in a complete architectural specification [7] used as the basis for writing an open specification of data models and interfaces. The open approach allows the documentation of complex distributed applications, possibly involving multiple technologies (such as Web services, command-line executables, and monolithic executables). It also allows the expression of complex provenance queries to identify data and scoping processes independent of the technologies being used.

The Virtual Data System [4] and myGrid [10] are execution environments for scientific workflows that provide support for provenance. They focus on producing documentation from a workflow enactor's viewpoint using data models compatible with p-assertions. They assume their respective workflow lan-

guage, allowing them to obtain compact process documentation. By adopting an open data model for process documentation, like the one we've advocated here, such systems could be integrated into heterogeneous applications that seamlessly execute provenance queries.

The database community has also investigated provenance [2, 5] but adopted different assumptions; for instance, it assumes the existence of a query language for which queries may be reversed to identify the origin of results. As in our approach, different kinds of provenance (such as why and where [2]) are viewed as being of value as specific instances of provenance queries.

The Provenance Aware Storage System developed at Harvard University [9] is designed to automatically produce documentation of execution by capturing file system events in an operating system. Like all other approaches, capturing small-grain documentation involves scalability and performance challenges, so deriving information at a suitable level of abstraction for the user is often difficult.

Conclusion

The IT landscape, which once exclusively involved closed monolithic applications, today involves applications that are open and composed dynamically while being able to discover results and services on the fly. Users must know whether they have confidence in their applications' electronic data; it must therefore be accompanied by its provenance that describes the process that led to its production.

To achieve this vision, we've proposed an open approach through which applications, irrespective of technology, document their execution in an open data model that can then be used to run provenance queries tailored to user needs. In the same way scholars can appreciate works of art by studying their documented history, users would be able to gain confidence in electronic data thanks to provenance queries. C

References

1. Alvarez, S., Vazquez-Salceda, J., Kifor, J., Varga, L., and Willmott, S. Applying provenance in distributed organ transplant management. In *Proceedings of the International Provenance and Annotation Workshop Vol. 4145 of Lecture Notes in Computer Science* (Chicago, May 3–5). Springer, Heidelberg, 2006, 28–36.
2. Buneman, P., Khanna, S., and Tan, W.-C. Why and where: A characterization of data provenance. In *Proceedings of Eighth International Conference on Database Theory Vol. 1973 of Lecture Notes in Computer Science* (London, Jan. 4–6). Springer, Heidelberg, 2001, 316–330.
3. Burbeck, S. *The Tao of E-business Services. Technical Report.* IBM Software Group, Oct. 2000; www.ibm.com/developerworks/webservices/library/ws-tao/.
4. Clifford, B., Foster, I., Voeckler, J.-S., Wilde, M., and Zhao, Y. Tracking provenance in a virtual data grid. *Concurrency and Computation: Practice and Experience* (2007); dx.doi.org/10.1002/cpe.1256.
5. Cui, Y., Widom, H., and Wiener, J. Tracing the lineage of view data in a warehousing environment. *ACM Transactions on Database Systems 25,* 2 (June 2000), 179–227.
6. Foster, I., Kesselman, C., Nick, J., and Tuecke, S. Grid computing: Making the global Infrastructure a reality. In *The Physiology of the Grid: An Open Grid Services Architecture for Distributed Systems Integration.* Wiley Series in Communications Networking and Distributed Systems. John Wiley & Sons, Chichester, England, 2003, 217–249.
7. Groth, P., Jiang, S., Miles, S., Munroe, S., Tan, V., Tsasakou, S., and Moreau, L. *D3.1.1: An Architecture for Provenance Systems. Technical Report.* University of Southampton, Southampton, U.K., Feb. 2006; eprints.ecs.soton.ac.uk/12023/.
8. Miles, S., Groth, P., Branco, M., and Moreau, L. The requirements of recording and using provenance in e-science experiments. *Journal of Grid Computing 5,* 1 (Mar. 2007), 1–25.
9. Seltzer, M., Holland, D., Braun, U., and Muniswamy-Reddy, K.-K. Passing the provenance challenge. *Concurrency and Computation: Practice and Experience* (2007); dx.doi.org/10.1002/cpe.1233.
10. Zhao, J., Goble, C., Stevens, R., and Turi, D. Mining Taverna's semantic web of provenance. *Concurrency and Computation: Practice and Experience* (2007); dx.doi.org/10.1002/cpe.1231.

Luc Moreau (L.Moreau@ecs.soton.ac.uk) is a professor of computer science in the School of Electronics and Computer Science at the University of Southampton, Southampton, U.K..

Paul Groth (pgroth@isi.edu) is a post-doctoral researcher in the Information Science Institute at the University of Southern California, Marina del Rey, CA.

Simon Miles (simon.miles@kcl.ac.uk) is a lecturer in the Department of Computer Science at King's College London, London, U.K.

Javier Vazquez-Salceda (jvazquez@lsi.upc.edu) is a post-doctoral researcher in the Computer Science Department at the Universitat Politecnica de Catalunya, Barcelona, Spain.

John Ibbotson (john_ibbotson@uk.ibm.com) is a senior software engineer at IBM U.K.'s Hursley Development Laboratory, Winchester, U.K.

Sheng Jiang (sj@ecs.soton.ac.uk) is a post-doctoral researcher in the School of Electronics and Computer Science at the University of Southampton, Southampton, U.K..

Steve Munroe (sj.munroe@uk.ibm.com) is an IT consultant/technical team lead at IBM United Kingdom, Ltd., Global Business Services, Winchester, U.K.

Omer Rana (o.f.rana@cs.cardiff.ac.uk) is a reader in computer science at Cardiff University and the Deputy Director of the Welsh eScience Center, Cardiff, Wales, U.K.

Andreas Schreiber (Andreas.Schreiber@dlr.de) is a research scientist and head of the Distributed Systems and Component Software Department at the German Aerospace Center, Cologne, Germany.

Victor Tan (vhkt@ecs.soton.ac.uk) is a post-doctoral researcher in the School of Electronics and Computer Science at the University of Southampton, Southampton, U.K.

Laszlo Zsolt Varga (laszlo.varga@sztaki.hu) is a senior scientific associate and head of the System Development Department at the Hungarian Academy of Sciences, Budapest, Hungary.

DOI: 10.1145/1330311.1330323

DESIGNING A LEARNING MANAGEMENT SYSTEM TO SUPPORT INSTRUCTION

The goal of an LMS, devised by a growing number of universities, is to offer faculty instructional support. The actual use of these programs, however, suggests that support is elusive. An experience at National Taiwan University illustrates how a university can increase faculty usage through better LMS design.

As educational technology becomes more prevalent in higher education, teaching is no longer restricted to face-to-face (F2F) instruction. For university courses, the combination of e-learning and F2F teaching increases accessibility, flexibility, and choices for interactivity [10]. This leap in instructional productivity can be accomplished with a Learning Management System (LMS), which is often used as the platform to support e-learning and hybrid online F2F courses. Traditional instructional activities such as presenting information, managing course materials, and collecting and evaluating student work can be completed online using an LMS. Recently, a growing number of

By Hsiu-Ping Yueh and Shihkuan Hsu

Before investing time and money to develop technically advanced tools, it is necessary to investigate the needs of the faculty.

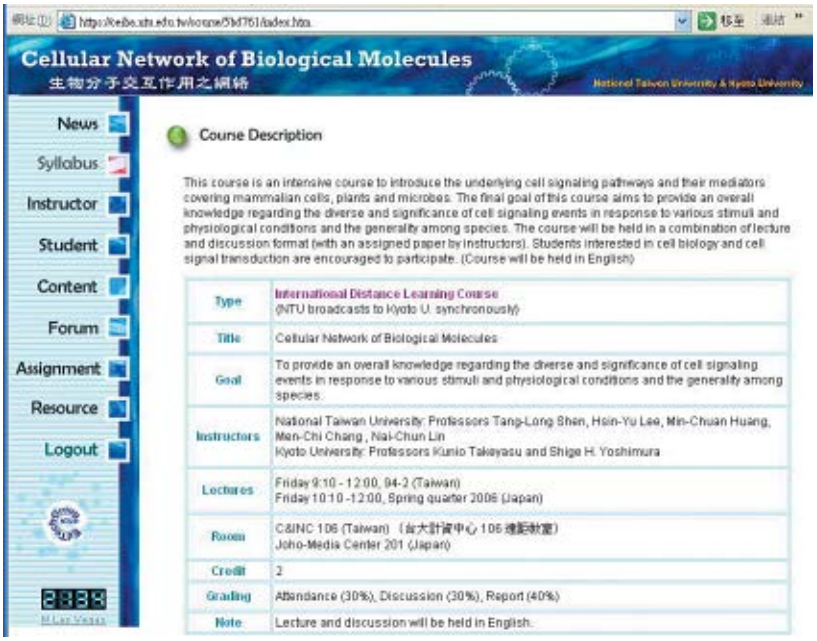


Figure 1. A sample English CEIBA page from a biology course.

universities have employed LMSs to support their courses [9]. Some universities have even developed their own LMS to better integrate with their existing instructional resources or just to cut costs.

Many LMS products are commercially available, such as Blackboard (www.blackboard.com), Desire2Learn (www.desire2learn.com/), ANGEL|LMS (www.angellearning.com/products/LMS/default.html), and Intralearn™ LMS (www.intralearn.com/Products/intralearn.aspx). Sometimes the terms "Course Management Systems" (CMS) or "Learning Content Management Systems" (LCMS) are used to indicate similar systems.

An LMS provides an array of tools and functions to support teaching and learning, usually including course management tools, online group chat and discussion, homework collections and grading, and course evaluation. Some LMS features are more technically sophisticated, such as holding virtual office hours, reminding students about the deadlines, and dividing students into groups for online projects [12]. Other programs can separately archive content for use in multiple courses. Some programs allow teachers to create ePortfolios to collect and store student's journals, projects, and tests [3]. As more LMS products are developed, new technically sophisticated functions are created.

The variety of functions and features of LMS should provide more choices and increase the use of the system. Studies about the actual use of LMS programs reveal that some functions are used more often than others [1, 7, 11]. Woods, Baker, and Hopper conducted a survey of 862 faculty members at 38 institutions who used the Blackboard Learning Management System. They found that few faculty members used LMS functions to assess students or to promote community [11]. Most faculty used instructional functions, such as publishing syllabi, sending email, and providing readings. The communicative and interactive features were largely unused. In Grant's qualitative study, some faculty members relied on Blackboard CourseInfo to post scanned material in the absence of the copying services [7].

The results of actual LMS use at universities suggest it is important to examine the teaching needs of the faculty before designing such a system. If the functions and features do not suit faculty needs, or the technical complexity is too difficult, the use of such functions and features is limited. Before investing time and money to develop technically advanced tools, it is necessary to investigate the needs of the faculty.

What makes an LMS popular among a faculty? Can faculty members with little technical computing knowledge become proficient at using an LMS system? The LMS development experience at National Taiwan University (NTU) presents an instructive case that answers these questions.

Design and Development of the NTU LMS

A team at NTU's Computer and Information Networking Center designed and developed its own LMS in 1995 and called it the CEIBA system (https://ceiba.ntu.edu.tw/). The main CEIBA interface is in Chinese. An English interface is available and English content construction is possible for faculty who wishes to use it, especially for those who offer international courses (see Figure 1). Initially, it was created as a system for faculty to place course supplements online. In 2001, an educational technology support team was formed to redesign the CEIBA system as an instructional management system. The total number of courses using CEIBA has grown from 100 in 1999 to 2,300 in 2005, and then reached 4,100 in 2007. This number does not include graduate seminars, physical education, or service courses that may also use CEIBA. The total number of faculty members who placed courses online also has grown from 60 in 1999 to 1,246 in 2007.

CEIBA (version 4) was redesigned to focus on the teaching aspects of using an LMS. User support was increased to help faculty members overcome the technological barriers of using an LMS.

Instructive design. CEIBA teaches users about instructional design. The system was based on instructional design traditions in educational technology from scholars such as Gagné, Briggs, and Wager [6]. While providing tools for online instruction, the LMS informs faculty members about instructional design steps such as setting goals, making the structure explicit, encouraging interaction, and including evaluation. In addition, CEIBA enhances faculty knowledge about the courses and students. The LMS assists professors with the following functions:

- *Course syllabus*: To build a CEIBA course Web site, a faculty member goes into a course introduction page, where there are course titles, course objectives, course evaluation, and grade assignment. These choices force the faculty member to lay out the information about the course before the course starts.
- *Course schedule*: After completing the course introduction page, faculty members advance to a weekly outline page. They type in the first date, and the rest of the 17 weeks of weekly class sessions appear automatically. A professor can enter the weekly topics and go into the weekly course pages that are linked automatically to the topics.
- *Class roster*: CEIBA connects to the registrar's office and retrieves information from the student records. The faculty automatically receives updated student records data throughout the term. Professors can print out the class list, and can send email to individuals, small groups, or the entire class.
- *Student homework*: CEIBA allows students to submit homework online to professors. The LMS has an option to allow sharing documents with other students. With this feature, students can show homework with a professor's comments to other students.

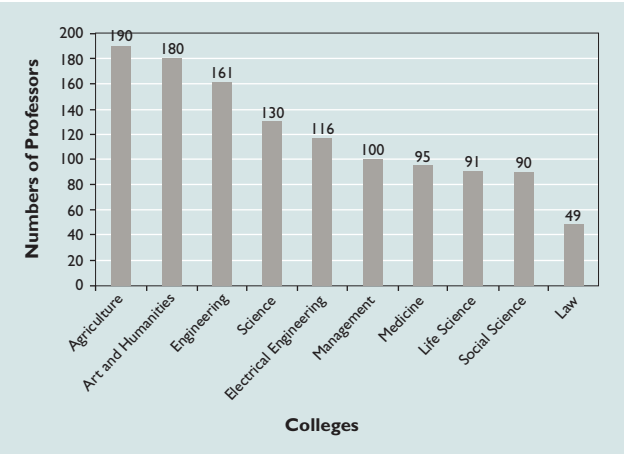


Figure 2. NTU professors using CEIBA between 2000 and 2007 by college.

Inclusive design. CEIBA accommodates both novices and experts. The LMS has features that allow experts to quickly bypass step-by-step pages designed for novices. CEIBA was designed to prevent experts from getting frustrated by features for novices, while shielding novices from the complexity of technical systems of advanced functions. The LMS offers the following:

- *Course creation*: Professors are given three ways to create a course. Faculty members can link to their own course Web sites, import course outlines or the entire course from previous CEIBA courses, and create new courses.
- *Content editing*: An online Web page editor is available. Although the functions of the editor are simple, the editor provides tools for novices to manipulate text, typefaces, bullets, hyperlinks, and graphics.
- *Student grouping*: CEIBA allows a class to be divided into groups. It also allows two classes to be combined to use the same interface, mainly for professors who have two or more sessions of the same class.
- *Interactive activities*: CEIBA has a course resource sharing board, an announcement board, a discussion board, and a voting board, to which the teacher can post announcements and questions.

One of the barriers limiting LMS use at universities is the fear of technology. Professors in the arts and humanities often feel they do not possess the ability nor have the time to learn to build Web-based course material.

Support personnel. A team of instructional specialists support faculty members using CEIBA. The support team conducts general workshops on how to use CEIBA, as well specialty workshops on how to use Web editors, graphic editors, and video editors. The support team answers questions submitted by email and through Web forms. The support team also provides help for individual professors who come to the office in person. For faculty members who are interested in developing multimedia material, but who do not have the equipment, software, or expertise, the support team works with them in a dedicated multimedia studio. For large introductory courses, such as Chemistry 101 and Physics 101, the support team worked with the departments to develop professional quality of videos of their lab procedures.

Category	Functions	Never used
Knowledge	Course objectives and evaluation	4%
Knowledge	Student information and roster	5%
Knowledge	FTP files to CEIBA	5%
Knowledge	Announcement boards	10%
Knowledge	Using templates to create course pages	14%
Knowledge	Email to all students	15%
Interaction	Discussion board	34%
Interaction	Homework assignment	40%
Interaction	Resource sharing	42%
Interaction	Co-teacher management	55%
Interaction	Grouping students	57%
Interaction	Homework sharing	63%
Interaction	Chat rooms	65%
Interaction	Voting	66%

Survey results of CEIBA at NTU at spring 2007.

Combining instructive design, inclusive design, and support personnel has made a big difference. After the organizational and system function changes were made, the results were noticeable. A growing number of professors started using CEIBA. A survey was conducted in June 2007 to determine CEIBA usage. Questionnaires were distributed at the end of the spring semester, and 182 out of 620 professors who used CEIBA during that semester responded.

Results of the CEIBA User Analysis

Professor participation. One of the barriers limiting LMS use at universities is the fear of technology. Professors in the arts and humanities often feel they do not possess the ability nor have the time to learn to build Web-based course material. With the redesign of LMS and the assistance provided by the support team, CEIBA usage increased greatly among the faculty without science and engineering backgrounds. Figure 2 presents the total number of professors using CEIBA between 2000 and 2007. The College of Arts and Humanities recorded the highest number of faculty using CEIBA, surpassing the number of users from the engineering department. The results suggested that arts and humanities professors are no less interested or capable of building online resources for their courses than their engineering counterparts.

Teaching methods. In terms of overall satisfaction, most of the professors ranked the richness and flexibility of CEIBA functions well above average. Over 95% of respondents felt that CEIBA was equipped with instructional and management functions that serve the user needs. Over 85% felt CEIBA was easy to use, had clear guides, and the support team was helpful and quick to solve problems. In terms of the impact of using CEIBA, about 90% of the professors felt their courses were more complete and structured after using CEIBA. Indeed, 80% of professors responded that the contents of their courses were enriched by using CEIBA, and their students' learning results have been improved.

Many professors indicated their instructional strategies and teaching styles had changed. About 80% of professors felt that their interaction with students had increased, and their teaching styles had become livelier. About 75% of the professors

responded that their knowledge about media had increased, and 60% stated that their skills in Web page construction had increased as well. Over 95% of professors predicted they will continue to use CEIBA in the future. Of the 620 professors who used CEIBA in spring 2007, about 16% were new users of CEIBA, about 55% had one to three years of experience, about 22% had four to six years of experience, and only 6% had over six years of experience.

Function avoidance. Many of the CEIBA functions are designed to increase student interaction with professors and other students. The table on the preceding page lists the frequency of the usage of interactive functions. Many professors reported that they did not use interactive functions. The results showed the functions that provide information about the course were used by over 90% of the professors who participated in the survey. About 85% to 90% of the responding professors used group email and announcement boards to disseminate information. On the other hand, functions that encourage interaction and sharing were not used as often. About 65% of professors never used chat rooms, homework sharing, or voting functions.

Conclusion

As the case of the NTU illustrates, it is possible to increase LMS usage by professors from all disciplines. The survey results confirmed previous studies that showed the most frequently used functions are not necessarily the technically advanced ones [1, 7, 11]. Rather, the functions critical to providing course information for faculty and students are used the most. As Laurillard indicated [8], university courses are still dominated by lecturing or information giving. However, instructive design, inclusive design, and personnel support for systems like CEIBA can increase users among both faculty and students.

More recent development of LMS also tends to focus on more diverse design and personalized services [4, 5]. Given the positive response from the NTU professors, one can see that it is possible to design an LMS to meet the needs of faculty members without extensive computer skills. CEIBA attracted large number of professors from arts and humanities, and was widely used across departments and colleges at NTU.

Teaching is a complicated process. Instructional support requires software designers to consider a fuller scope of instructional process. As Boyd pointed out [2], interaction and thus the cultivation of community is crucial in sustaining and expanding a professor's academic life. As much as interaction is essential in F2F instruction, it should be carefully fostered in Web-based instruction. Therefore, building interaction in class would require a lot more work than to incorporate interaction tools in a system. An instructionally supportive LMS must build on the faculty's understanding and knowledge of instruction.

References

1. Akpinar, Y., Bal, V., and Simsek, H. An e-learning content development system on the Web: BU-LMS. In *Proceedings of the Fifth International Conference on Information Technology Based Higher Education and Training*. (Istanbul, Turkey, May 31–June 2, 2004), 239–243.
2. Boyd, G Toward the webversity: Managing to clone scholars and researchers via the Web. In *Perspectives in Web Course Management*. B. Mann, Ed. Canadian Scholar's Press, Toronto, ON, 2000, 69–77.
3. Ceraulo, S. Benefits of upgrading to an LMS. *Distance Education Report 9*, 9 (May 2005), 6–7.
4. Chevrin, V., Derycke, A., and Rouillard, J. Project Ubi-Learn: An intermediation infrastructure for multi-channel accesses to future LMS. In *Proceedings of the Advanced International Conference on Telecommunications and International Conference on Internet and Web Applications and Services*. (Guadeloupe, French Southern Territories, Feb. 19–25, 2006), 7.
5. Dagger, D., O'Connor, A., Lawless, S., Walsh, E., and Wade, V.P. Service-oriented e-learning platforms: From monolithic systems to flexible services. *IEEE Internet Computing 11*, 3 (May/June 2007), 28–35.
6. Gagné, R., Briggs, L., and Wager, W. *Principles of Instructional Design, 4th Ed.* HBJ College Publishers, Fort Worth, TX, 1992.
7. Grant, M. Learning to teach with the Web: Factors influencing teacher education faculty. *The Internet and Higher Education 7*, 4 (Nov. 2004), 329–341.
8. Laurillard, D. *Rethinking university teaching: A conversational framework for the effective use of learning technologies, 2nd Ed.* Routledge/Falmer, New York, NY, 2002.
9. National Center for Educational Statistics. *Distance education at degree-granting postsecondary institutions: 2000-2001* U.S. Department of Education, Washington, DC, 2003.
10. Rosenberg, M. *E-learning strategies for delivering knowledge in the digital age*. McGraw-Hill, New York, NY, 2001.
11. Woods, R., Baker, J., and Hopper, D. Hybrid structure: Faculty use and perception of Web-based courseware as a supplement to face-to-face instruction. *Internet & Higher Education 7*, 4 (Dec. 2004), 281–297.
12. Yildirim, S., Temur, N., Kocaman, A. and Goktas, Y. What makes a good LMS: An analytical approach to assessment of LMSs. In *Proceedings of the Fifth International Conference on Information Technology Based Higher Education and Training*. (Istanbul, Turkey, May 31–June 2, 2004), 125–130.

Hsiu-Ping Yueh (yueh@ntu.edu.tw) is the associate director for the Center of Teaching and Learning Development, and an associate professor at the Department of Agricultural Extension at the National Taiwan University.

Shihkuan Hsu (skhsu@ntu.edu.tw) is an associate professor at the Center for Teacher Education at National Taiwan University, Taipei, Taiwan.

DOI: 10.1145/1330311.1330324

INFORMATION SECURITY AND RISK MANAGEMENT

Use the new PCR risk metric to find ways to enhance security, avoiding one-dimensional metrics like ALE that could risk an organization's survivability.

The economic framework explored in [3, 6, 7] is useful for evaluating information security activities. A key concept in this framework is the notion of risk management. Even though organizations try to avoid any breach of information security, they cannot make all their information 100% secure all the time. Thus, managing the risk associated with potential breaches is an integral part of resource-allocation decisions associated with information-security activities.[1] To make such decisions, the chief information security officer (CISO) needs to first be clear as to what is meant by risk.

Risk involves multiple dimensions and meanings within the context of information security. Here, we discuss three measures that capture var-

[1] See [5] for a framework for cyber risk management that incorporates insurance.

By LAWRENCE D. BODIN,
LAWRENCE A. GORDON,
and MARTIN P. LOEB

ious aspects of information security risk and propose a methodology that allows decision makers to combine them into a single composite metric—the perceived composite risk, or PCR.

We recommend using the Analytic Hierarchy Process (AHP) [8] to determine the weighting factors needed to combine risk measures into the PCR. We offer an example of how decision makers can use the PCR to evaluate proposals for enhancing an organization's information-security system. Here, we build on the AHP analysis in [1] for assisting CISOs ranking proposals intended to enhance their organizations' information security systems.[2]

Three measures that capture commonly considered facets of risk are the expected loss, expected severe loss, and standard deviation of the loss.

The expected loss is calculated by adding together the product of each loss with its respective probability.[3] The expected loss is conceptually equivalent to the popular Annual Loss Expectancy (ALE) measure (see, for example, [3]). Based on this measure, the larger the expected loss, the larger would be the risk associated with a breach of information security.

The expected severe loss focuses on the breaches that would put the survivability of the organization at risk. In order to calculate the expected severe loss, the decision maker (such as a CISO) first specifies the magnitude of a loss that, were it to occur, would threaten the organization's survivability. The expected severe loss is calculated by adding together the product of each loss that is greater than or equal to the specified threshold loss with its respective probability. Based on this metric, the larger the expected severe loss, the larger would be the risk associated with a breach of information security.

The standard deviation of loss (the square root of the variance of loss) represents the dispersion

[2]For more on the allocation of resources in information security, see [2, 4].
[3]We assume loss is a discrete random variable.

around the expected loss. It is computed by taking the square root of the product of squares of the deviation of each loss from the expected loss with the probability of that loss. Based on this metric, the larger the standard deviation, the larger would be the risk associated with a security breach. We used the standard deviation of loss rather than the variance of loss because the standard deviation of loss is measured in the same units (for example, dollars) as both the expected loss and the expected severe loss.

To illustrate the three metrics, let X be a random variable representing the loss (in millions of dollars) attributable to a breach. In a proposal (Proposal 1) for enhancing information security activities, X has the following discrete uniform distribution:

P[X=x] = .1 for x = 0, 1, 2, ..., 9.

Expected loss:

$$E[X] = \sum_{x=0}^{9} x \cdot P[X = x] = 0 \cdot [.1] + 1 \cdot [.1] + \ldots + 9 \cdot [.1] = 4.5$$

Expected severe loss:

$$E[X \mid X \geq T] = \sum_{x=8}^{9} x \cdot P[X = x] = 8 \cdot [.1] + 9 \cdot [.1] = 1.7$$

Standard deviation of loss:

$$\sigma = \sqrt{\sum_{x=0}^{9} (x - E[X])^2 \cdot P[X = x]} = \sqrt{8.25} \approx 2.872$$

X = random variable representing the loss in millions of dollars attributable to a breach
P [X=x] = probability the loss attributable to the breach equals x
x = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
T = $8 million (threshold loss)

Calculation of expected loss, expected severe loss, and standard deviation of loss in Proposal 1.

The expected loss from a breach, E[X], under Proposal 1 is equal to $4.5 million, as shown by the calculation in the figure here. In order to calculate the expected severe loss, the decision maker must first specify a threshold level. Suppose that level, denoted by T, is judged to be 8, that is, any breach that costs $8 million or more is believed to put the survivability of the organization at risk. The expected severe loss, $E[X|X \geq T]$, under Proposal 1 is equal to $1.7 million, as shown by the calculation in the figure.

The standard deviation of loss, denoted by σ, under the loss function defined for Proposal 1 is equal to $2.87 million, as shown by the calculation in the figure.

Computing Expected PCR

For a given set of information-security activities, the PCR is a linear combination of the expected loss, the expected severe loss, and the standard deviation of loss that can be attributable to a breach:

$$PCR = E[X] + [B/A]\ E[X|X \geq T] + [C/A]\ \sigma$$

where the weights A, B, and C are determined from the AHP. These weights are positive, sum to one, and reflect the relative importance of the performance metrics to the decision maker. An overview of the AHP (in an information-security-investment context) is given in [1].

Before turning to the question of how these weights are derived through AHP, consider three properties of the PCR:

- It equals the expected loss plus two penalty terms;
- The penalty term, $[B/A]\ E[X|X \geq T]$, measures an additional perceived loss due to the occurrence of a severe loss; and
- The penalty term, $[C/A]\ \sigma$, measures an additional perceived loss due to variability in predicting the loss.

The weights A, B, and C measure the emphasis the CISO wants to place on the three risk measures: expected loss, expected severe loss, and standard deviation. The weights on the three terms are 1, B/A, and C/A. Without the loss of generality, one can normalize the weights on the terms in the PCR so the weight on the expected loss, E[X], is equal to one. In that way, a decision maker who wants the PCR to equal the expected loss would set B = 0 and C = 0 in the equation defining PCR.

	Expected Loss E[X]	Expected Severe Loss E[X|X ≥T]	Standard Deviation of Loss σ	Weights
Expected Loss E[X]	1	1	2	**.4**
Expected Severe Loss E[X|X ≥T]	1	1	2	**.4**
Standard Deviation of Loss σ	1/2	1/2	1	**.2**

Table 1. Pairwise comparison matrix and weights for the example.

To illustrate the AHP method for determining the values of the weights, we consider a numerical example. Table 1 lists a pairwise comparison matrix of the three measures: expected loss, expected severe loss, and standard deviation of the loss. The pairwise comparison matrix is made up of columns 2–4 and rows 2–4 in the table. The final column lists the weights as determined by the eigenvector associated with the maximum eigenvalue for the pairwise comparison

The approach of using the expected loss due to a breach as the ranking criterion gives the CISO *a narrow analysis of the alternatives* and *may lead to misleading results.*

matrix in columns and rows 2–4 in the table (for more, see [1]).

In establishing this pairwise comparison matrix, the assumption in the example is that the expected loss (E[X]) and expected severe loss (E[X|X≥T]) are equally important criteria, both slightly more preferred than the standard-deviation-of-loss (σ) criterion. The pairwise comparisons that represent this judgment are realized by setting a_{12} = 1, a_{21} = 1, a_{13} = 2, a_{23} = 2, a_{31} = 1/2, and a_{32} = 1/2. Further, the diagonal elements, a_{11}, a_{22}, and a_{33}, are set equal to 1, since a criterion is equally important as itself.

	Losses from an information security breach (in $ millions)										
	0	1	2	3	4	5	6	7	8	9	Other values
Probability of Loss Proposal 1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	0
Probability of Loss Proposal 2	0	0	.2	0	0	.5	0	.1	.2	0	0
Probability of Loss Proposal 3	.3	.2	0	0	0	0	.05	.05	.1	.3	0
Probability of Loss Proposal 4	.0	.0	0	0	0	0	0	.45	.45	.1	0

Table 2. Probability of losses under three information security project proposals.

For a given decision maker for which AHP reveals these weights—A = 0.4, B = 0.4, and C = 0.2—here is the value of the PCR for Proposal 1:

PCR (Proposal 1) = \$4.5+[.4/.4] [\$1.7M]+[.2/.4].[\$2.872M]=\$4.5M+\$1.7M+\$1.43 6M=\$7.636M

Evaluating Four Proposals

In order to demonstrate PCR use, assume that the CISO must select from among four equal cost proposals for enhancing an organization's information security. Suppose the CISO and his/her staff have estimated the loss probabilities associated with the three proposed sets of information security activities. The estimated loss probabilities associated with each proposal are broken down into the 10 discrete amounts in Table 2.

We continue to assume that the threshold level, T, of a severe loss is \$8 million. Table 3 lists the values of the three risk measures for each of the three proposals; it also lists the value of the PCR for each proposal, assuming that A = 0.4, B = 0.4, and C = 0.2.

	Expected Loss E[X]	Expected Severe Loss E[X|X≥T]	Standard Deviation of Loss σ	Perceived Composite Risk PCR
Proposal 1	14.5	1.7	2.872	**7.636**
Proposal 2	5.2	**1.6**	1.990	7.795
Proposal 3	**4.35**	3.5	4.028	9.864
Proposal 4	7.65	4.5	**0.654**	12.477

Bold indicates column minimums

Table 3. Risk measures for the three proposals (where T=8, A=0.4, B=0.4, and C=0.2.

Some problems with using the popular metric of expected loss as a sole measure of risk are apparent by examining Tables 2 and 3. According to the expected loss metric, Proposal 3 is the preferred proposal, followed in order by Proposal 1, Proposal 2, and Proposal 4. Note that although Proposal 3 minimizes the expected loss, it also generates the seco

nd highest probability of threatening the survivability of the organization (Pr [X≥8]=0.4) and generates the highest standard deviation of loss.

Table 3 also indicates that based on the expected severe loss criterion, Proposal 2 is the preferred proposal, followed in order by Proposal 1, Proposal 3, and Proposal 4. Further, based on the standard deviation criterion, Proposal 4 is the preferred proposal, followed in order by Proposal 2, Proposal 1, and Proposal 3. Thus, a decision maker interested in minimizing the risk of a breach could rationally select Proposal 2, Proposal 3, or Proposal 4, depending on the risk metric being considered.

The PCR combines the three risk measures through a procedure that determines the decision maker's relative weighting of the risk criteria. The

Popular risk metrics (such as expected loss from a breach and the standard deviation of a loss from a breach) *capture only narrow aspects of risk.*

weights are decision-maker dependent, so the rankings based on the PCR are likely to vary from person to person. With the values of A, B, and C given by 0.4, 0.4, and 0.2, respectively, Proposal 1 is preferred to Proposal 2, which in turn is preferred to Proposal 3, which is preferred to Proposal 4. It is interesting to note that Proposal 1 has the smallest value of the PCR, even though it did not dominate any individual metric. However, if the decision maker's weights were A = 0.1, B = 0.2, and C = 0.7, then based on the PCR, Proposal 4 is preferred to Proposal 2, which is preferred to Proposal 1, which is preferred to Proposal 3.[4]

The approach of using the expected loss due to a breach as the ranking criterion gives the CISO a narrow analysis of the alternatives and may lead to misleading results. Examining these other risk measures helps determine the best proposal for implementation. Although we formed the PCR as a linear combination of expected loss, expected severe loss, and standard deviation of loss, the method of forming a single PCR type of metric from a set of criteria is a general methodology. The decision maker can use any set of criteria to form a PCR type of metric and the AHP to determine the weighting factors. In that way, no matter what aspects of risk a decision maker wishes to consider, a PCR type of metric can serve as a powerful decision-making tool.

Conclusion

Anyone responsible for information security must be able to manage risk. However, the initial step in such management—defining risk—is far from easy. Popular risk metrics (such as expected loss from a breach and the standard deviation of a loss from a breach) capture only narrow aspects of risk. Here, we've introduced a new metric—the PCR—to evaluate investment proposals for enhanced information security and recommended using AHP to determine the weights in the PCR. The PCR gives the user powerful new tools for analyzing proposals for enhancing an organization's information security system. This analysis complements [1], which detailed how to spend an information-security budget, taking into account both financial and nonfinancial aspects of proposed information security projects. C

[4]In this case, PCR(Proposal 4)=$21.227 million, PCR(Proposal 2)=$22.330 million, PCR(Proposal 1)=$28.006 million, and PCR(Proposal 3)=$39.548 million.

References

1. Bodin, L., Gordon, L., and Loeb, M. Evaluating information security investments using the analytic hierarchy. *Commun. ACM 48,* 2 (Feb. 2005), 461–485.
2. Gordon, L. and Loeb, M. Budgeting process for information security expenditures: Empirical evidence. *Commun. ACM 49,* 1 (Jan. 2006), 121–125.
3. Gordon, L. and Loeb, M. *Managing Cybersecurity Resources: A Cost-Benefit Analysis.* McGraw-Hill, New York, 2006.
4. Gordon, L., Loeb, M., and Lucyshyn, W. Sharing information on computer systems: An economic analysis. *Journal of Accounting and Public Policy 22,* 6 (Nov.-Dec. 2003), 461–485.
5. Gordon, L., Loeb, M., and Sohail, T. A framework for using insurance for cyber risk management. *Commun. ACM 46,* 3 (Mar. 2003), 81–85.
6. Gordon, L. and Loeb, M. The economics of investment in information security. *ACM Transactions on Information and System Security 5,* 4 (Nov. 2002), 438–457.
7. Gordon, L. and Loeb, M. A framework for using information security as a response to competitor analysis systems. *Commun. ACM 44,* 9 (Sept. 2001), 70–75.
8. Saaty, T. *The Analytic Hierarchy Process.* McGraw-Hill, New York, 1980.

Lawrence D. Bodin (lbodin@rhsmith.umd.edu) is Professor Emeritus in the Robert H. Smith School of Business at the University of Maryland, College Park, MD.

Lawrence A. Gordon (lgordon@rhsmith.umd.edu) is the Ernst & Young Alumni Professor of Managerial Accounting and Information Assurance in the Robert H. Smith School of Business at the University of Maryland, College Park, where he is also an affiliate professor in the University of Maryland Institute for Advanced Computer Studies.

Martin P. Loeb (mloeb@rhsmith.umd.edu) is a professor of accounting and information assurance and a Deloitte & Touche faculty fellow in the Robert H. Smith School of Business at the University of Maryland, College Park, where he is also an affiliate professor in the University of Maryland Institute for Advanced Computer Studies.

DOI: 10.1145/1330311.1330325

A TYPOLOGY *of* COMPLAINTS ABOUT EBAY SELLERS

More could be done to reduce rising online fraud rates.

Complaints are expressions of dissatisfaction stemming from a feeling of having been wronged. Complaints can express dissatisfaction with a company's customer service or allege that a company has defrauded a customer. Understanding complaints allows firms to improve their business practices to better meet customer needs. Online complaints are often recorded in reputation systems that collect, distribute, and aggregate feedback about an online business's past behavior [9]. These online complaints help consumers engaging in transactions over the Internet to "decide whom to trust, encourage trustworthy behavior, and deter participation by those who are unskilled or dishonest" [9].

DAWN G. GREGG *and* JUDY E. SCOTT

Complaint	Example	# Instances	% of Complaints 2003	% of Complaints 2005
Item won but not paid: No payment information received from seller.	"I asked 4 times, Sellers never give Name and Address, I can not send Payment."	380	5.43%	2.65%
Item won but not paid: Seller has no product to sell	"Seller after auction emailed me to tell me that they did not have them to sell."	174	2.34%	2.31%
Item won but not paid: Seller reneges on auction and/or relists item	"Out of stock, 4 days later is selling again, got it low so he out of stock!"	116	1.51%	1.96%
Item paid but not received: Non-Delivery	"I'm still waiting for these sunglasses! 2-1/2 months have gone by!"	2,716	36.19%	38.99%
Item sent: Late	"Would never buy from again, took a month to get item to me, says server got hacked"	471	6.51%	4.96%
Item sent: Overcharges for shipping	"This is a seller that charges outrageously for shipping!"	274	3.62%	4.15%
Item sent: Poorly packaged	"Item, a plate, was poorly packaged and arrived broken. Seller not responsive"	182	2.48%	2.19%
Item sent: Shipped to wrong address	"Asked to ship to address in Hawaii, was shipped to billing in California."	25	0.30%	0.58%
Total for complaints about receiving items		**4,338**	**58.39%**	**57.79%**

Table 1. Complaints about receiving items.

In 2007, an estimated $108.7 billion in goods were sold online with approximately a quarter of sales occurring at online auctions [2, 3, 10]. Online auctions provide unparalleled selection and potential value for buyers, while offering sellers a way to reach millions of buyers. However, the anonymity of online auctions gives less scrupulous sellers the opportunity to take advantage of buyers, either by intentionally misstating the quality and condition of their products or by selling products they have no intention of delivering. Both of these practices are forms of online fraud, and represent a growing problem for online consumers. Online auctions are especially prone to fraud because it is easy for businesses large and small to establish and run online auction stores. In 2006, online auction fraud was the most reported online offense, comprising 44.9% of complaints referred to the Internet Crime Complaint Center [5].

Online auction reputation systems contain feedback profiles made up of comments from transaction partners (buyers or sellers). In order to understand the complaints being left in online auction reputation systems, it is necessary to determine what problems are currently being reported as negative feedback in reputation systems, and the proportion of problems that contain allegations of fraud. This research develops a typology of complaints about sellers in online auctions that can be used to classify negative feedback posted at online auction sites. Complaints placed in eBay's reputation system in 2003 and 2005 were analyzed using the typology of complaints. The types of fraud a buyer can encounter when making a purchase at an online auction include [6]:

- *Non-delivery.* The seller places an item up for bid with no intention of delivering it.
- *Misrepresentation.* The seller deceives the buyer as to the true value of an item.
- *Black-market goods.* Illegal goods sold on online auction sites.
- *Fee stacking.* The seller adds hidden charges to the item after the auction is over.
- *Triangulation.* Stolen credit is used to buy from an online merchant and the item is resold at auction.
- *Shill bidding.* Intentional fake bidding by sellers to drive up the price of their items.

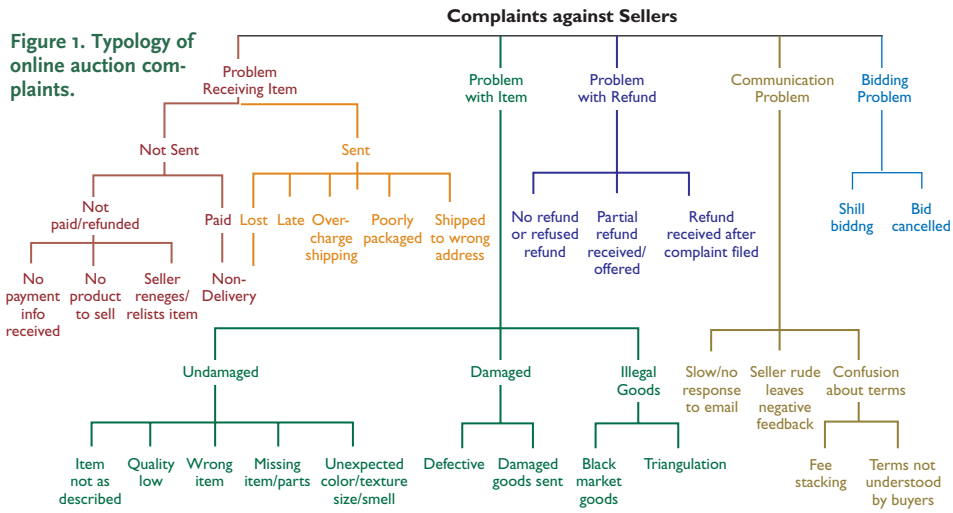


Figure 1. Typology of online auction complaints.

In addition to fraud, online auction buyers can experience prob-

lems that are undesirable but legal (such as difficulty contacting the seller). To analyze the characteristics of negative comments placed at online auction sites, we developed a complaint categorization scheme that describes the problems buyers can have when purchasing from an online auction. It includes problems related to the payment and shipping of items, problems with the item received, along with refunds or exchanges, communication problems, and bidding. The typology of complaints is shown in Figure 1. It should be noted that the complaint classification system is designed to classify allegations of misconduct that have not been proven. It is possible that some allegations are unfounded; nevertheless, the allegations are useful for understanding overall patterns of misconduct and estimating whether those patterns change over time.

Complaint	Example	# Instances	% of Complaints 2003	% of Complaints 2005
Item is not as described	"Disappointed. DVD is not US. Look at PICTURE carefully. Seller did not state on ad"	1132	14.94%	17.30%
Quality is low	"This leather peels in a weeks time, and is not of high quality at all"	279	3.74%	3.81%
Wrong item sent	"Sent wrong item, 1 month later still not rectified"	212	2.95%	2.08%
Missing an item or parts missing	"Pieces were missing promised but never sent , waiting since February"	208	2.91%	1.96%
Item has unexpected color/texture/ size/smell	"Jacket was a size small, and smelled!"	123	1.61%	1.96%
Defective—will not work	"RECEIVED IN GOOD PHYSICAL CONDITION, BUT DOES NOT WORK. WHY WAS THIS NOT SAID?"	385	5.40%	3.46%
Damaged item shipped	"WARNING! damaged goods—undamaged packing—denial WARNING"	192	2.65%	2.08%
Black market item	"Listing was for a DVD when in fact it was a VCD burn! Don't buy, Stay away!"	178	2.22%	3.69%
Total for Complaints About Items		**2709**	**36.43%**	**36.33%**

Table 2. General complaints about items.

Data for this study was gathered from eBay's reputation system. eBay allows users to post positive, neutral, or negative comments about their transactions. This study classified negative feedback posted about sellers and estimated the frequency of the different complaint types. Initial samples of 6,571 negative comments from May 2003 were used to validate the complaint typology, and to provide estimates of the complaint rates for each of the complaint categories. An additional 867 negative comments from July 2005 were used to determine if the frequency and distribution of complaints changed significantly over the intervening two years. The complaints examined were extracted from a sample of over one million eBay comments (across both studies), providing an overall complaint rate for this study was 0.73 complaints for every 100 comments made.

The eBay data was analyzed using content analysis—a manual process in which every complaint was read by at least one of the researchers and categorized into one or more of the complaint categories shown in Figure 1. The content analysis found negative feedback records often referred to more than one seller problem (such as both a communication problem and non-delivery). In these cases, the complaint was placed into more than one complaint category. There were 11,371 different negative comments made in the 7,438 complaints examined. The complaints were grouped into five broad categories: about receiving items, about the item received, about returning items, about communication, and complaints about bidding.

Complaints about receiving items. Problems related to receiving the products are summarized in Table 1. The principal complaint was that the item was paid for but never received. This accounted for 36.52% of all complaints made. Although this could have been due either to seller or shipper error, the buyers largely assumed that sellers had never shipped the item. Complaints that the item was paid for but never received usually represent an accusation of non-delivery fraud. In a very small fraction of the complaints, buyers complained of non-delivery without allowing sufficient time for the seller to ship the item, as in this complaint: "It has been over a week. Where is the jacket?" However, in these cases the complaint was coded as slow shipping as opposed to non-delivery. The average amount of time buyers waited before placing a complaint accusing a seller of non-delivery was 36 days and 74.5% of buyers waited at least 21 days before complaining about non-delivery. A comparison of complaint rates for 2003 with those of 2005 showed that a higher proportion of buyers made allegations of non-delivery fraud at the later date. However, the overall rate of complaints about receiving items remained relatively constant.

Complaints that the auction was won but the transaction was not completed because the buyer never heard from the seller, the seller did not follow through with the sale because the price was too low, or the seller no longer had the product to sell were found

in 9.01% of all complaints. These are not fraud because the buyer did not lose any money. However, it does violate eBay's policy on non-selling sellers, which states: "It is not permitted for a seller on eBay to refuse payment or delivery of an item at the end of a successful sale."

There were a variety of problems reported related to the shipment of the item, with 6.7% of buyers complaining that their products were shipped late or to the wrong address. There were also complaints that sellers overcharged for shipping, with buyers charging that the seller used excessive shipping charges to make extra money on the sale. In general, shipping problems do not constitute fraud, nor do they violate any stated eBay policies. If the complaint indicated that the excessive shipping charge was different than the one listed in the auction it was categorized as fee stacking, which is fraudulent, not as shipping overcharge.

Table 3. (a) Complaints about returns or refunds, (b) Communication complaints.

(a)

Complaint	Example	# Instances	% of Complaints 2003	% of Complaints 2005
No refund received or refund is refused	"CAUTION 15 days have passed since 2 day promise for refund, very crooked company"	658	8.89%	8.54%
Partial refund received or offered (e.g. requires buyer to pay for shipping)	"Charged 15 percent restocking fee that was NOT listed in auction returns details"	83	1.14%	0.92%
Refund received after a 3rd party complaint or from insurance claim	"SCAM...I had to file with Paypal, Ebay and Postal inspection service for refund."	55	0.70%	1.04%
Total for Complaints About Returns or Refunds		**796**	**10.73%**	**10.50%**

(b)

Complaint	Example	# Instances	% of Complaints 2003	% of Complaints 2005
Slow/no response to email/phone	"Sent several emails after auction ended. Took several days to respond. Awful"	2,741	37.24%	33.91%
Seller is rude and/or leaves negative feedback, or reports non-paying buyer	"Nasty Seller!!! Beware!!!! Rips off people and threatens through e mails!! Nasty"	550	7.56%	6.11%
Seller changes price after the close of the auction: Fee Stacking	"Watch out for exorbitant shipping charge conveniently left off bidding page."	94	1.16%	2.08%
There is a miscommunication of the terms of sale	"Uncooperative in posting internationally"	75	0.94%	1.50%
Total for Complaints About Returns or Refunds		**3,460**	**46.90%**	**43.60%**

General complaints about items. In the sample of 7,438 complaints were several reported problems related to the products themselves (see Table 2). These include cases where the item received was undamaged but the buyer was dissatisfied, the item received was damaged, and the item received appeared to be counterfeit or stolen. In 26.27% of complaints, a working product was received but the complaint indicated that the item had been misrepresented either in the item title, description, or photo. Most often, the buyer complained that the seller had omitted important product details from the description. Buyers also complained that the item received was not the item they purchased. Usually, the incorrect item received was of lower quality or had fewer features than the item that the buyer actually purchased. There were also complaints that the item was of lower quality than the buyer expected. These complaints included words like "junk" or "trash." Buyers also complained that they did not receive everything they had purchased or that that the item had an unexpected color, texture, size, or smell. Some of these fraud allegations could have been the result of buyer error, but the majority are likely cases of misrepresentation fraud in which the seller intentionally (or unintentionally) misrepresented the product to receive a higher price.

Buyers reported receiving damaged or defective goods in 7.76% of the complaints filed. The cases where buyers reported the damage was present before shipping were recorded as a problem with the item (instead of a problem that occurred during shipping). These would also be cases of misrepresentation fraud. In all, 30.3% of the complaints alleged there had been some type of misrepresentation fraud committed.

This complaint category also included complaints from buyers who believed their products to be forged, copied, or stolen. A total of 146 complaints (2.39% of the total) related to illegal products, or black market fraud. None of the complaints about illegal products indicated that the products had been purchased with stolen credit; this would be a different type of fraud: triangulation.

Complaints about returns or refunds. Table 3a summarizes the complaints related to returning the product or receiving a refund. These complaints were often coupled with some other type of complaint. For example, the following complaint indicates that the seller appears to be making income from fraudulently misrepresenting products and then charging customers to correct his error: "Sent wrong speakers he wants 2 charge me 25% restocking 4 his mistake!

Beware!!" Other complaints related to refunds and exchanges include sellers accepting a product return but never sending the refund, sellers who refuse refunds altogether, and cases where refunds were only obtained after eBay, PayPal or law enforcement were involved. Most of the refund-related complaints began with the fraudulent non-delivery of goods or with goods that were misrepresented (732 of 796 refund complaints).

Complaints about communication. Table 3b summarizes the complaints that included some reference to a communication difficulty. Often the buyer's first sign that he or she would be a victim of non-delivery fraud was a difficulty communicating with the seller. In 1,287 of the 2,716 reported instances of non-delivery, the buyer also reported difficulties in contacting the seller either via email or phone. In 404 cases, communication difficulty (either nonresponse to email or rudeness) was the only problem reported. However, more often communication difficulties co-occurred with other types of reported problems. One type of communication problem indicates a type of fraud, known as fee stacking fraud. This occurs when the seller changes the price of the item, shipping cost, or payment methods accepted after the close of the auction. Fee stacking was reported in 1.26% of online auction complaints.

Complaints about bidding. No problems related to bidding were reported in any of the complaints from 2003. However, two complaints about shill bidding were found in the 867 complaints from 2005. There were also five complaints about bid cancellation. In these cases the sellers cancelled the winning bidders bid because the price was either too low or because they made a side deal to sell to a different seller.

Conclusion

Results of this study indicate that more than 97% of complaints allege serious problems with the seller. Comments often indicate that sellers lack business training and clear commerce standards, like proper communication skills (44.2%) and appropriate return policies (10.5%). This suggests that legitimate online auction sellers interested in establishing a "good reputation" should maintain good communication throughout the auction process and be willing to accept returns—especially in the case of seller or shipper error.

However, a greater proportion of the complaints contain allegations of fraud. This study shows that 69.7% of negative comments posted in eBay's feedback forum indicate the seller may have defrauded the buyer by failing to deliver the item, misrepresenting the item in the product description, selling illegal goods, adding charges after the close of the auction, or by shill bidding. The proportion of complaints that allege fraud increased slightly between 2003 and 2005 (from 69.4% to 71.8%); however, the increase was not statistically significant (p=0.158). The fraud allegation rates (as a percentage of complaints made) for each online auction fraud type are summarized in Figure 2. This data indicates that both non-delivery fraud (found in 36.5% of complaints) and misrepresentation fraud (found in 30.3% of complaints) comprise the vast majority of frauds reported. Black-market goods (stolen, counterfeit, or pirated goods) were only reported in 2.4% of the negative comments analyzed. This may mean that buyers were unaware that the goods were illegal or that they did not care that the goods were illegal as long as they got a good price. Fee stacking was only reported in 1.2% of complaints. This type of fraud may be less prevalent because it only generates a small return (the extra fee sellers tack on after the auction close). Shill bidding was only reported in 0.03% of the auction complaints. Shill bidding is difficult for the average buyer to detect, and thus, actual instances of shill bidding may be much higher than those reported as negative feedback. Finally, triangulation was not reported in any of the complaints examined. In general, buyers would only know they were a victim of triangulation if contacted by the merchant victim or law enforcement; something that would happen long after feedback was provided to the seller. As with black market goods and shill bidding, it is likely that triangulation fraud is underreported in the eBay reputation system.

Figure 2. Online auction fraud reported as percentage of eBay complaints.

The primary contribution of this research is that it demonstrates that reputation systems contain infor-

mation about online auction fraud that is not found anywhere else. eBay has consistently maintained that less than 0.01% of its auctions are fraudulent [1, 7]. However, this study suggests that the problem of online auction fraud may be more severe than the number of officially reported cases would indicate. Prior research shows that between 41.8% and 52.1% of all successful auctions receive feedback [4, 8]. The rate of negative feedback (as a percentage of all feedback left) found during this study was 0.73%, and 69.7% of negative comments alleged fraud. Thus, the rate of fraud accusations (as a percentage of completed auctions) made in the eBay reputation system was closer to 0.2%, 20 times higher than the rate reported through official channels.

This research highlights the prevalence of various types of fraud at online auction sites and suggests more could be done to reduce current fraud rates. For example, since many of the fraud complaints relate to non-delivery of goods, online auction sites could more actively promote the use of escrow services, which reduce the ability of sellers to accept payment without delivering goods. This research also shows that reputation systems contain important information related to fraudulent activities, and thus improvements to these systems could make it easier for buyers to detect and avoid fraudulent sellers. For example, mixing negative comments with the large number of positive comments may make it more difficult for buyers to find comments about illegal behavior. Redesigning reputation systems so that recent negative feedback is highlighted could potentially improve a buyer's ability to assess fraud likelihood.

One benefit of this study is that it presents a framework for classifying complaints and information about the rate of fraud occurring on the eBay online auction site during 2003 and 2005. This provides a baseline for future research on online auction fraud and will allow researchers to assess the effectiveness of fraud reduction measures.

One limitation of this study is that it focused exclusively on eBay, which was selected for this study because it owns nearly 75% of the global online auction market share. For this reason fraud rates for eBay dominate any determination of auction fraud rates in general and it is common research practice to use eBay data exclusively when studying online auction markets. However, each online auction site has different security precautions, which could change fraud rates for these sites. Doing an in-depth comparison of complaint rates across multiple online auction sites was beyond the scope of this study, but should be included in future research on online auction fraud.

This research shows that reputation systems serve an important function in today's online world. They can allow buyers to assess the trustworthiness of unknown online auction sellers and can be used by sellers to improve their customer service. However, these systems play another important role. They contain information about potentially illegal activities. Since the rate of fraud reported in these systems is 20 times higher than the rate quoted by eBay, it is likely that instances of online auction fraud are often reported only in these systems. This makes these systems important to both online auction houses and to law enforcement as they try to combat rising levels of online auction fraud.

References

1. Cox, B. And the online fraud goes on... Internet.com, (Feb. 14, 2003); www.ecommerce-guide.com/news/news/article.php/11825_1584531_2.
2. eBay. eBay Outlines Global Business Strategy at 2005 Analyst Conference. eBay press release (Feb. 10, 2005); investor.ebay.com/ReleaseDetail.cfm?ReleaseID=155513.
3. Gray, T. Online shopping boomed this holiday season. Internetnews.com, (Jan. 3, 2005); www.internetnews.com/ec-news/article.php/ 3453931.
4. Gregg, D.G. and Scott, J. The role of reputation systems in reducing online auction fraud. *International Journal of Electronic Commerce 10*, 3 (2006), 97–122.
5. IC3 2004 Internet Fraud Crime Report, Jan. 1, 2006-Dec. 31, 2006. National White Collar Crime Center and the Federal Bureau of Investigation (2007); www.ic3.gov/media/annualreport/2006_IC3Report.pdf.
6. IFCC, Internet Auction Fraud. National White Collar Crime Center and the Federal Bureau of Investigation (2001); www1.ifccfbi.gov/strategy/AuctionFraudReport.pdf.
7. Konrad, R. EBay losing allure to some entrepreneurs. *USA Today Online* (June 27, 2005); www.usatoday.com/tech/news/2005-06-27-ebayallure_x.htm.
8. Resnick, P. and Zeckhauser, R. Trust among strangers in internet transactions: empirical analysis of eBay's reputation system. The Economics of the Internet and E-Commerce, M.R. Baye, Ed. *Advances in Applied Microeconomics, Vol. 11*. JAI Press, Amsterdam, 2002.
9. Resnick, P., Zeckhauser, R., Friedman, E., and Kuwabara, K. Reputation systems. *Commun. ACM 43*, 12 (Dec. 2000), 45–48.
10. U.S. Census Bureau. Quarterly Retail E-Commerce Sales 4th Quarter 2006; www.census.gov/mrts/www/data/html/06Q4.html.

Dawn G. Gregg (dawn.gregg@cudenver.edu) is an assistant professor of information systems management at the Business School at the University of Colorado Denver, CO.

Judy E. Scott (judy.scott@cudenver.edu) is an assistant professor in the Business School at the University of Colorado Denver, CO.

DOI: 10.1145/1330311.1330326

introducing...

ACM's Newly Expanded Online Books & Courses Programs!

Helping Members Meet Today's Career Challenges

2,500 Online Courses from SkillSoft

The ACM Online Course Collection features **unlimited access to 2,500 online courses** from SkillSoft, a leading provider of e-learning solutions. This new collection of courses offers a host of valuable resources that will help to maximize your learning experience. Available on a wide range of information technology and business subjects, these courses are open to ACM Professional and Student Members.

SkillSoft courses offer a number of valuable features, including:

- ***Job Aids***, tools and forms that complement and support course content
- ***Skillbriefs***, condensed summaries of the instructional content of a course topic
- ***Mentoring*** via email, online chats, threaded discussions - 24/7
- ***Exercises***, offering a thorough interactive practice session appropriate to the learning points covered previously in the course
- ***Downloadable content*** for easy and convenient access
- ***Downloadable Certificate of Completion***

"The course Certificate of Completion is great to attach to job applications!"

ACM Professional Member

600 Online Books from Safari

The ACM Online Books Collection includes **unlimited access to 600 online books** from Safari® Books Online, featuring leading publishers including O'Reilly. Safari puts a complete IT and business e-reference library right on your desktop. Available to ACM Professional Members, Safari will help you zero in on exactly the information you need, right when you need it.

500 Online Books from Books24x7

All Professional and Student Members also have **unlimited access to 500 online books** from Books24x7®, in ACM's rotating collection of complete unabridged books on the hottest computing topics. This virtual library puts information at your fingertips. Search, bookmark, or read cover-to-cover. Your bookshelf allows for quick retrieval and bookmarks let you easily return to specific places in a book.

Association for Computing Machinery

Advancing Computing as a Science & Profession

pd.acm.org

www.acm.org/join

Missing Links: BUILDING CRITICAL SOCIAL TIES *for* GLOBAL COLLABORATIVE TEAMWORK

Face-to-face meetings may be invaluable, but they are not a panacea for the challenges facing teams spread around the globe—managers must also prioritize activities before and after these meetings to help team members stay connected.

By Ilan Oshri, Julia Kotlarsky, and Leslie Willcocks

ILLUSTRATION BY ROBERT NEUBECKER


JAPAN
CHINA
TAIWAN
ALASKA
CANADA
USA
MEXICO
CUBA
PACIFIC OCEAN
AUSTRALIA
ANTARCTICA
FINLAND
SWEDEN
NORWAY
BALTIC
BENELUX
GERMANY
UK
ICELAND
FRANCE
ITALY
SPAIN
MEDITERRANEAN
ATLANTIC OCEAN
LIBYA
ALGERIA
MALI
BRAZIL
BOLIVIA
PERU
ARGENTINA
NEUBECKER

Globally distributed teams have become increasingly common in many sectors. Yet managing dispersed groups is far more challenging than managing co-located teams. Some advances in supporting globally distributed collaborative work have been introduced in recent years mainly in the form of information and communication technologies (ICT). In this regard, the focus of research and practice has traditionally been on the appropriate application of technical and operational mechanisms, such as tools, methodologies and coordination mechanisms that support coordination activities between dispersed project teams. As a supplementary mechanism, which improves collaborative work through the development of interpersonal ties between remote counterparts, firms also advocate face-to-face (F2F) meetings [9, 11]. In this article, we focus on the use of F2F meetings in promoting collaboration between remote counterparts.

F2F Meetings: The challenges in developing social ties in globally distributed projects
F2F meetings are short and tend to offer only limited social space that accommodates cultural differences.
Most time spent in F2F meetings is dedicated to project procedures and technical issues (that is, they are formal to a great extent).
F2F meetings are selective in the sense that not all counterparts are invited to F2F meetings.
Short and infrequent F2F meetings offer sporadic interpersonal interactions between remote counterparts, which restrict the build-up of interpersonal relationships.
ICT offers limited opportunities for personal contact and social space, as compared to F2F meetings.

Table 1. The challenges of social ties and F2F meetings.

The entire project team usually attends these formal meetings, which are designed to address project management and technical issues, as well as to create interpersonal ties and improve collaborative work between remote counterparts [1]. We argue that F2F meetings, though very much needed, still pose challenges to globally distributed teams in creating and sustaining social ties between remote counterparts. Consequently, we propose a set of activities that improves and renews social ties between remote counterparts, before and after F2F meetings. These activities are organized into three stages for developing social ties that we label as: Introduction, Build-up, and Renewal. We briefly summarize evidence from several projects at the software company SAP and oscilloscope manufacturer LeCroy, and we offer practical implications to managers.

The Challenge of Social Ties

Globally distributed projects consist of two or more teams working together to accomplish project goals from different geographical locations. In addition to geographical dispersion, globally distributed teams face time zone and cultural differences that may include, but are not limited to, different languages, national traditions, values, and norms of behavior [1]. To cope with such differences and to ensure a smooth collaborative mode of operation between remote counterparts, numerous technical and operational mechanisms have been offered to managers, including collaborative technologies (such as groupware technologies that include email and instant messaging [2, 10, 12]) and coordination mechanisms (such as more explicit, documented, and formalized project processes through standardizing and documenting the development methodology, and through the division of work aimed at reducing the need for inter-site coordination and communications [4, 6]).

Thus far, the solutions proposed to support collaborative work of globally distributed teams have been technical in nature, paying little attention to the human and social aspects involved in such settings [3]. The few studies that have focused on social aspects in globally distributed projects have suggested that firms should promote and hold F2F meetings to tighten interpersonal ties between remote counterparts in an attempt to improve collaborative work [7, 8, 11]. Indeed, creating and renewing social ties between remote counterparts may even open additional channels, supplementary to technical solutions, through which collaborative work can be improved. Using F2F meetings to advance social ties in globally distributed teams may also improve the formation of a globally distributed team as members get to know each other during these meetings, learn about cultural differences between team members, discuss and agree on ways to resolve tensions, set up procedures for coordinating work activities, and start working together toward a successful completion of a project [5].

In line with past research [1, 5], we have observed that supporting interpersonal contacts between remote counterparts throughout the project life cycle is rather challenging—creating and renewing such contacts throughout the project life cycle poses a strong challenge for managers. So far, the emphasis from practice and research has been on F2F meetings that set the stage for bonding and socializing between remote counterparts, and as a vehicle for creating social ties between remote counterparts. Nonetheless, we argue that F2F meetings alone may not create the

conditions through which interpersonal ties between remote counterparts can be created and renewed. F2F meetings tend to last only a few days, and the agendas for these meetings often revolve around project and technical issues that must be resolved, leaving little space for socialization and one-on-one meetings. In Table 1 we have summarized the emerging challenges in creating social ties between members of globally distributed teams.

While F2F meetings assist in acquainting counterparts of globally distributed teams with each other and addressing project and technical issues, these meetings, being sporadic, short, selective, and formal to a great extent, hardly support the long-term build-up and renewal of interpersonal ties between dispersed counterparts. In the following paragraphs we present evidence from SAP and LeCroy, two companies in which software development teams collaborate globally to develop products. In particular, we focus on before and after F2F meeting activities that contributed to collaborative work through the development of social ties.

While F2F meetings assist in acquainting counterparts of globally distributed teams with each other and addressing project and technical issues, *these meetings, being sporadic, short, selective, and formal to a great extent, hardly support the long-term build-up and renewal of interpersonal ties* between dispersed counterparts.

The Collaborative Tools project at SAP was located at three sites: Germany, India, and the U.S. When the project was launched in September 2001, the key players (managers and architects) and team members from remote locations did not know each other. Before F2F meetings, activities revolved mainly around creating awareness of the composition of remote teams and their members. Videoconferencing sessions were scheduled between the three locations to introduce the remote counterparts to each other. Furthermore, global mini-teams were formed, consisting of technical staff from different remote locations who jointly worked on one design module. These mini-teams also needed to communicate with other mini-teams to ensure a smooth integration of the different modules. For each mini-team a contact person was appointed. The contact people were senior technical staff located in Germany. These contact people were responsible for providing and communicating information about the design and integration processes to their mini-teams. Since the remote counterparts did not know each other and the process of becoming acquainted took, in some cases, several weeks, this structure of mini-teams and contact persons was critical in ensuring a smooth flow of information between remote teams.

F2F meetings were organized to make time for one-to-one interactions between remote counterparts so that they could get to know each other and become familiar with communication styles. These activities included team-building exercises, and discussions about communication styles and about rules for communications between individuals and teams. These activities assisted in creating interpersonal ties, relaxing tensions, and improving understanding between remote counterparts.

After F2F meetings, activities included regular and frequent communications, such as teleconferences and videoconferences between software managers and developers, and short visits to remote locations. In particular, when newcomers joined, managers organized videoconferences to introduce new team members. However, to ensure that remote counterparts would stay in touch, speak the same "lingo," and feel comfortable working remotely, managers traveled to remote sites at least once every three months, and developers visited remote sites a few times a year. These activities reportedly improved the bonding between remote counterparts and enhanced the collaborative atmosphere across the team.

The project studied at LeCroy, called Maui, was distributed across two sites: Switzerland and the U.S. These software team members had a long history of working together; thus, when this study was carried out, the team had already developed strategies for working together across distance. However, the Maui project, which involved switching to Microsoft COM technology, introduced new challenges, since the LeCroy software engineers were using new technologies to develop embedded software. Therefore, one of the dilemmas LeCroy faced while developing the Maui platform was how to jointly train embedded programmers located at different sites, while ensuring the transition would not trigger disruptive communication problems and breakdowns.

Pre-F2F meeting activities included transatlantic videoconferences in which newcomers were introduced to the team. To reduce language barriers, soft-

ware engineers in Geneva, whose native language is French, were offered English language lessons. Overcoming language barriers, in addition to the introduction of remote counterparts through videoconferences, was a key factor in creating direct and effective communication channels between remote counterparts. The videoconferences furthermore helped increase team member awareness of communication styles rooted in cultural differences, and reminded them to be attentive to the style and content of communications.

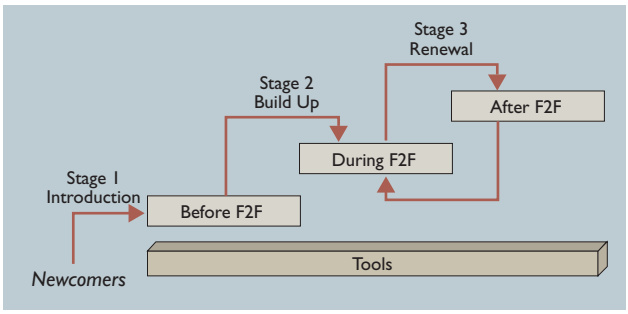


Figure 1. The life cycle of social ties.

Several F2F meetings were held by this distributed team. A key F2F meeting in a remote Alps location combined training sessions in Microsoft COM technology with social events allowing participants to get to know each other better.

Post-F2F meeting activities included frequent communications between the remote sites in the form of teleconferences, videoconferences, and visits by managers from Geneva and N.Y. several times a year. Short visits and the temporary co-location of software engineers also took place, so remote counterparts could work and solve design problems together, as well as improve interpersonal contacts. Lastly, a wide range of collaborative technologies employed in daily communications allowed remote counterparts to combine audio and visual cues, by undertaking design reviews using application sharing tools and the telephone simultaneously, for example. While these activities reduced miscommunications and breakdowns and improved collaboration during the design process, several team members reported that the sense of bonding, which was strong right after a F2F meeting, faded away, often leading to miscommunications and tension between remote counterparts. To overcome this situation, managers organized videoconferences with the entire software development team, followed by a F2F meeting between the engineers involved in the particular assignment. These activities were carried out in addition to regular short visits and relocations in an attempt to renew interpersonal ties between remote counterparts.

Implications: The Life Cycle of Social Ties

The before, during, and after F2F meeting activities described here provide insights into the way SAP and LeCroy supplemented collaborative tools and methodologies with human-related activities to ensure the build-up and renewal of social ties between remote counterparts. The experiences we have described suggest that firms benefit from shifting the traditional focus on F2F meetings as the main vehicle through which interpersonal ties are created, to include before and after F2F meeting activities.

	Introduction	Build-Up	Renewal
Individual	• Increase awareness of communication styles • Offer language courses • Offer short visits of individuals to remote locations	• Create space for one-on-one interactions • Provide sense of importance to each member • Adjust communication styles	• Ensure real-time communication channels • Ensure mixed audio and visual cues • Offer short visits to remote locations • Offer temporary co-location
Team	• Introduction of new team members • Increase awareness of team composition • Increase awareness of communication protocol • Appoint contact person per remote team • Set up mini-teams • Offer virtual F2F meetings	• Conduct kick-off meeting • Discuss differences between national and organizational cultures • Offer space for multiple interactions between counterparts • Offer team-building exercises • Organize social events • Discuss organizational structure	• Facilitate reflection sessions • Facilitate round-the-table discussions • Facilitate progress meetings • Conduct virtual F2F meetings • Offer F2F meetings
Organizational	• Distribute newsletters • Create and offer shared cyberspaces	• Support sharing of information from F2F meetings (for example, photos)	• Encourage direct communication channels
Tools	Phone, email, groupware tools, knowledge repositories, shared databases, teleconference, videoconference, online chat, intranet		

Table 2. Individual, team, and organizational activities supporting social ties.

Managers should consider the full lifecycle of social ties when they plan and execute collaborative work between remote sites. The life cycle of social ties consists of three stages: Introduction, Build-up and Renewal (as shown in the figure here). Each stage represents an array of activities that a globally distributed team can participate in to move from the Introduction stage to the Build-up of social ties, and finally to the Renewal phase, in which social ties are renewed after F2F meetings.

LeCroy, for example, invested in activities associated with the Renewal stage. SAP, on the other hand, mainly invested in activities associated with the Introduction and Build-Up stages. Most companies will tend to engage in activities associated with the Introduction stage to introduce newcomers when a new project is assembled.

What implications does this study have for team development? In line with past research we have observed that development of globally distributed teams faces unique challenges induced by geographical and cultural differences, thus requiring management's intervention in supporting the timely development of a team from "forming, through storming and norming to performing" [5]. Furthermore, from a social ties perspective, we observed that our globally distributed teams had to "re-norm" from time to time, mainly because newcomers joined and changed the dynamics of interpersonal ties within dispersed teams. In addition, disagreements and miscommunications arose even in late stages of the project due to fading interpersonal ties. For this reason, we recommend that managers consider "re-norming" dispersed teams and renewing social ties through bonding activities, such as short visits or F2F meetings—both in the early stages of the team development and the later stages, when social ties may fade and affect collaborative work.

To act upon the model noted here, managers could consider various activities at the individual, team, and organizational levels (see Table 2). Activities within each level contribute to the development of social interactions across the entire organization. For example, language lessons offered at the introductory stage are likely to contribute to one-on-one interactions when the build-up of social ties is taking place, and these lessons will also support direct communications when ties are renewed.

Prior to introducing specific activities, managers should ascertain the dispersed team's current stage. Teams in the Introduction stage, for example, require different types of activity to support the build-up of social ties than teams in the Renewal stage. Furthermore, as the project progresses and remote counterparts get to know each other and establish a collaborative mode, renewing these social ties may require only a subset of the activities offered in Table 2. In this regard, the activities offered in Table 2 are not a recipe for building and renewing social ties but rather represent a set of possibilities from which managers can choose when attempting to strengthen social ties between team members. Comprised of a unique assortment of unique individuals, each team differs in how it bonds with others, thus requiring a different set of activities that support the renewal of these social ties. It is the manager's responsibility to sense, analyze, and apply the most appropriate and timely activity, to ensure that social ties are renewed, and collaborative work is improved [5].

Lastly, the renewal and the strengthening of interpersonal relationships may benefit from staffing project teams based on their shared past experience in addition to their set of skills and expertise. Through such considerations, firms may reduce the costs associated with the initial development of social ties and focus more on activities that aim at renewing interpersonal relationships. C

References

1. Carmel, E. *Global Software Teams: Collaborating Across Borders and Time Zones.* Prentice-Hall PTR, Upper Saddle River, NJ, 1999.
2. Carmel, E. and Agarwal, R. Tactical approaches for alleviating distance in global software development. *IEEE Software 18*, 2 (2001), 22–29.
3. Doherty, N.F. and King, M. From technical to socio-technical change: tackling the human and organizational aspects of systems development projects. *European Journal of Information Systems 14*, 1 (2005), 1–5.
4. Ebert, C. and De Neve, P. Surviving global software development. *IEEE Software 18*, 2 (2001), 62–69.
5. Furst, S.A., Reeves, M., Rosen, B. and Blackburn, R.S. Managing the life cycle of virtual teams. *The Academy of Management Executive 18*, 2 (2004), 6–20.
6. Herbsleb, J.D. and Mockus, A. An empirical study of speed and communication in globally-distributed software development. *IEEE Transactions on Software Engineering 29*, 6 (2003), 1–14.
7. Jarvenpaa, S.L. and Leidner, D.E. Communication and trust in global virtual teams. *Journal of Computer-Mediated Communication; 3,* 4 (1998); www.ascusc.org/jcmc.
8. Majchrzak, A., Rice, R.E., King, N., Malhotra, A. and Ba, S. Computer-mediated inter-organizational knowledge-sharing: Insights from a virtual team innovating using a collaborative tool. *Information Resources Management Journal 13*, 1 (2000), 44–54.
9. Maznevski, M.L. and Chudoba, K.M. Bridging space over time: Global virtual team dynamics and effectiveness. *Organization Science 11*, 5 (2000), 473–492.
10. Qureshi, S. and Zigurs, I. Paradoxes and prerogatives in global virtual collaboration. *Commun. ACM 44*, 12 (Dec. 2001), 85–88.
11. Robey, D., Khoo, H. and Powers, C. Situated learning in cross-functional virtual teams. *IEEE Transactions on Professional Communications 43*, 1 (2000), 51–66.
12. Smith, P.G. and Blanck, E.L. From experience: Leading dispersed teams. *J. Product Innovation Management 19* (2002), 294–304.

Ilan Oshri (ioshri@rsm.nl) is an associate professor of strategy and technology management at the Rotterdam School of Management in Erasmus, the Netherlands.

Julia Kotlarsky (jkotlarsky@wbs.ac.uk) is an assistant professor of information systems at the Warwick Business School in Coventry, U.K.

Leslie Willcocks (l.p.willcocks@lse.ac.uk) is a professor of work, technology, and globalization at the London School of Economics and Political Science, U.K.

DOI: 10.1145/1330311.1330327

Group Term Life Insurance**

10- or 20-Year Group Term Life Insurance*

Group Disability Income Insurance*

Group Accidental Death & Dismemberment Insurance*

Group Catastrophic Major Medical Insurance*

Group Dental Plan*

Long-Term Care Plan

Major Medical Insurance

Short-Term Medical Plan***

Who has time to think about insurance?

Today, it's likely you're busier than ever. So, the last thing you probably have on your mind is whether or not you are properly insured.

But in about the same time it takes to enjoy a cup of coffee, you can learn more about your ACM-sponsored group insurance program — a special member benefit that can help provide you financial security at economical group rates.

Take just a few minutes today to make sure you're properly insured.

Call Marsh Affinity Group Services at **1-800-503-9230** or visit **www.personal-plans.com/acm.**

MARSH
Affinity Group Services
a service of Seabury & Smith

KNOWLEDGE MANAGEMENT IN SMALL AND MEDIUM-SIZED ENTERPRISES

A balanced combination of management support, technology, and organizational structural factors is necessary for successful knowledge management program implementation.

Knowledge has long been recognized as a crucial competitive tool for organizational survival and competition. In practice, many organizations that are adept in leveraging and capitalizing their knowledge resources experience business success and performance improvement [4]. Despite dedicated attempts to follow the prescribed knowledge management (KM) guides and success path, small and medium-sized enterprises (SMEs) often encounter uncertainties and face the threat of possible failure or unmet KM results, which are little known and attended [11]. This study on KM capability was motivated with a view to filling this knowledge gap and in consideration of the important economic role played by SMEs in many countries. In Hong Kong, SMEs represent 98% of business establishments and 50% of total employment according to Hong Kong Government statistics circa 2007. In comparison with the large enterprises, SMEs could be even more nimble and flexible in adapting their systems and structures for KM purposes, with fewer problems

By Ivy Chan *and* Chee-Kwong Chao

of communication, implementation, and replacement costs [11].

As suggested by Gold et al. [3], effective KM is primarily influenced by two types of KM capability—infrastructure and process that have to be deployed and harnessed to sustain organizational competitiveness. This article reports the findings of survey research that adapts the measurement items from Gold et al. [3] (see Table 1). Our sample is drawn from 68 SMEs with KM initiatives launched in the past few years. In this study, we consider any organizations that employ fewer than 200 employees as SMEs [9]. Key informants in the surveyed organizations completed the questionnaires, and the profiles and background information of the organizations (such as organization size) and respondents (job position) are aggregated in Table 2. The results show the mere presence of KM awareness or KM operation plans are no guarantee the KM programs will automate and be successful as expected. Organizations must harness a balanced deployment of culture, technology, and structure infrastructure, together with adequate capability to acquire, combine, apply, and create knowledge. Some specific recommendations based on the study with particular reference to individual capability dimensions are provided later in this article.

INFRASTRUCTURE CAPABILITY	
Technology	My organization uses technology that allows employees to collaborate with other persons inside the organization (for example, cross-department colleagues)
Structure	My organization's structure encourages interaction and sharing of knowledge
Culture	My organization's structure encourages interaction and sharing of knowledge
PROCESS CAPABILITY	
Acquisition	My organization has processes for acquiring knowledge from our suppliers
Conversion	My organization has processes for converting competitive intelligence into plans of action
Application	My organization has processes for applying knowledge learned from mistakes
Protection	My organization has processes to protect knowledge from inappropriate use inside the organization

Table 1. Survey items extracted from the questionnaire.

Knowledge Management Goals

With regard to the keen competition and dramatic changes in the business environment, most SMEs claim they are attracted to the KM promises, with its proven impacts on productivity and profits in many other organizations [11]. Nearly half (49.2%) of the respondents stated that the primary goal in pursuing KM in their organizations is to manage knowledge resources and the sources, then, to increase profit (44.4%), to reduce duplication of work (44.4%), and lastly, to gain competitive advantages (41.3%). In contrast, controlling information overload, improving business processes, and inspiring innovation received the least attention or may be considered out of their business agenda.

Particularly due to the limited human capital and relatively small organizational size, most respondents described that the KM goals in their organizations remain elementary or least inspiring. For example, some respondents described that their organizational members, particularly those at junior or operational levels, usually show minimum interest in KM such as in sharing ideas. They seem to be passive and prefer management or seniors to provide instructions on the kind of knowledge that has to be explored, the resources or contact persons needed, and new product or service ideas to be discussed. In essence, they claimed that KM is relatively new and abstract; therefore, a "wait and see" attitude can minimize the chance of committing mistakes.

Other respondents claimed their top management takes an "assembly" approach to set the goal, and then shifts the KM responsibility to the information technology department/colleagues to follow up. The respondents further commented that their management is too preoccupied in developing business opportunities, and assume the IT department is able to convert the explicit KM vision into corresponding KM activities and programs. On the other hand, the IT departments often emphasize their technical specialization, and claim they have no time to consider management issues (such as what knowledge can be considered the core to business survival). Without a common discourse of KM goals, the IT departments cannot grasp an appropriate working definition of knowledge, while treating KM as another type of IT project, falsely expecting that the systems can automate the KM processes, (such as storing all of what the employees know into a giant database that can promote knowledge sharing). As such, among those respondents with KM systems used in their organizations, more than 50% of the respondents assert that the KM systems they used (such as knowledge sharing and repository platform) are not useful to the end users because of undue system functions (difficult to search useful information from volumes of documents) and poor interfaces (difficult to locate the functional key buttons).

Infrastructure Capability

From the perspective of social capital, it is believed that new knowledge can be effectively developed through the connection and interaction of people, networks, and norms [3]. Three specific dimensions of the infra-

structure capabilities have been investigated in the current study: technology, structure, and culture. The SMEs are found with financial capital constraints, which directly affect their KM systems in place.

Forty-eight respondents (70.6%) stated their organizations neither possess nor intend to install any KM-related technical support such as corporate yellow pages and groupware. A plausible explanation is that their senior management is technocratic but fails to appreciate the positive impacts of technology that can improve the business processes. Of the 20 respondents, 50% stated that document management system and yellow pages are widely adopted as KM systems to facilitate knowledge capture and storage. Despite the presence of awareness toward the indispensability of information technology to organizational success, the respondents revealed they do not often utilize the existing KM systems in their organizations. Some expressed their fear with regard to job security, saying if they adopt more technology in their work process, management may consider substituting manpower with technology.

	Frequency	Percent
Organization by business sector		
Import/export trade	29	42.6
Services	17	25.0
Manufacturing	16	23.5
Others	6	8.8
Organization by size		
51–200	42	61.8
21–50	18	26.5
20 or below	8	11.7
Respondents by job position		
Business manager/general manager	44	64.7
Management officer/project leader	24	35.3
Respondents by years in the business sector of the organization		
More than 15 years	28	41.2
10 years–15 years	30	44.1
6 years to less than 10 years	10	14.7
Respondents by age		
45–54	26	38.2
35–44	34	50.0
Below 35	8	11.8
Respondents by gender		

Table 2. Profile of the respondents in SMEs.

The relatively flat owner-manager role and informal structure of SMEs are generally regarded as conducive to prompt intimate communication across organizations. More than half (61.8%) of the respondents stated their organizations have a favorable and simple structure that promotes collective rather than individual behavior, thus encouraging interpersonal interaction and sharing of knowledge among employees. However, the results showed that a contentious reward system was often employed to achieve the goals of the company. In line with this, 54% of the respondents were found unwilling to share knowledge as they do not feel or sense the benefits of doing so. They stated that knowledge is scarce and can be considered as personal capital; therefore, it should not be shared or traded unless adequate rewards are provided. In addition, a number of respondents (44.4%) have been working in their present organizations and present positions for a long period of time. They have developed a good understanding of their roles and job responsibilities and have been content with them. Yet, they have little interest in knowing what others are doing as they perceive the more they know, the more duties will be designated to them. Therefore, it discourages the creation of new knowledge as they minimize their efforts to engage in cross-functional learning or sharing.

Interestingly, it was found that the SMEs demonstrate a paradoxical culture capability on individual knowledge development. Culture capability as defined by Gold et al. [3] refers to the "shared and widely accepted values and visions that permeate in mind to direct work practice or facilitate necessary changes." The findings revealed the majority of the respondents (80.5%) held a positive perception and feeling toward the importance of KM in leveraging organizational performance and competitiveness, in particular if knowledge can be used within their working groups, teams, or departments. However, it was also found that such KM vision is not communicated effectively throughout the entire organization. In practice, some managers are influenced by their personal values in assessment of performance based on an individual's expertise and experience, instead of group contribution and team effectiveness. Therefore, more than 80% of the 68 respondents claimed their employees are willing to participate or have been engaged in various on-the-job training sessions as these sessions can directly improve their skills, efficiency, and organizational performance.

It is also interesting to note that while the KM culture is promoted extensively, more than half (51.5%) the respondents stated it is a flamboyant deed, as senior management support and dedication to KM could be inadequate and sporadic. For example, the KM vision is infrequently reviewed once it was established; the essential knowledge of business success may not be incorporated. Some other respondents (38.2%) stated their KM philosophy is presumed to allow making mistakes as the pathway of learning. However, a lot of their employees found that cases of failure are often associated with or perceived as incompetence (or incompetent staff), wasting organizational resources and having an adverse effect on their performance evaluation.

Thus, it reaffirms our prior finding (in the discussion of KM goals) that employees are neither highly proactive nor motivated to KM endeavors.

Process Capability

Taking into account the synergy and integration of organizational resources, it is believed that knowledge can be created through a dedication of acquisition, conversion, application, and protection of knowledge assets [3]. Most of the respondents stated that various kinds of knowledge are present and do exist in different repositories. However, they encounter problems in capturing knowledge in terms of quantity, place, time and people. In fact, a majority of the respondents (75%) complained against information overload or the excessive influx of information that is not systematically sorted or filtered. More than two-thirds of the respondents (69%) claimed there is no unanimous or systematic mechanism to store knowledge captured from various employees. Given the relatively informal organizational structure, the majority (88%) stated that they are required to spend a lot of time doing additional work that is not specified in their job description. As such, they can hardly find time to engage in knowledge sharing or discovery.

In the comparison of different possible knowledge sources, nearly half of the respondents (48%) stated that employees in their organizations (particularly those who are novices) rely mostly on an internal network (that is, with peers and colleagues) for learning or acquisition of expertise where trust and reliability are rooted. Those employees with long tenures of work are usually perceived as experienced and experts. In contrast, they stated that there are few mechanisms or processes formulated to acquire or obtain knowledge from suppliers or business partners, not withstanding that they have intimate relationships with them. Some SMEs are designated the original equipment manufacturers for renowned brand products of international firms yet they seldom engage in joint collaboration with external parties for acquiring or sharing production and design knowledge.

Many successful KM practices reveal that once useful knowledge is identified and acquired, organizations should devote efforts and motivate employees to make it accessible and explicit to others who need it or have not learned yet. More than 70% of the respondents mentioned that they can usually communicate and discuss the explicit knowledge such as procedures in manipulating machines However, while dealing with tacit knowledge such as sales experience, judgment of competitors' moves or actions, more than half of the respondents (58%) stated that it is difficult to express their minds in a comprehensible format (analogy or framework). In addition, most respondents expressed that their organizations have been in their respective industries for more than 15 years. They claimed their management is sensitive toward business changes and does not risk taking on changes. Therefore, the employees in the organizations agree to "generally accepted knowledge," and prefer to seek "predictability and visibility," maintaining status quo or ensuring stability of their work. Moreover, more than 50% put emphasis on the value of "face" and status, therefore, are unwilling to share ideas and learning experiences from past failure or disappointment. They also do not have clear processes for replacing outdated knowledge or incorporating knowledge from business partners. In addition, they are cautious and skeptical to new knowledge before they integrate it into daily work.

An exceptional finding identified is that despite the uncompromising scenario as described previously, approximately 19% of the respondents reported there are "informal" working teams (with small group sizes) that actively discuss among team members, sharing the latest information or effective workflow procedures. Other than knowledge conversion, it is important for organizational members to apply knowledge to new problems or link prior knowledge to stimulate new ideas on products or services. Approximately 71% of the respondents said their management has put more attention on initiating KM programs, while there are inadequately formulated plans to direct employees on what or how to apply knowledge to improve efficiency or regulate strategic direction. As discussed previously, the management style of the SMEs somewhat affects the inclination of employees toward KM. More than 50% of the respondents stated the employees in their organizations are inclined to maximize their efficiency within their scope of expertise or skills. They are tasked to exploit their existing knowledge and apply it to similar problems and challenges.

Another human factor that impedes the extensive usage of knowledge is caused by experts within organizations. More than half the respondents expressed that those experienced or highly regarded as experts in organizations usually have strong beliefs in their experience and become less open to new perspectives or knowledge. They prefer others, particularly the new employees or their apprentices to take on their ideas and instructions in a rigid manner. However, the respondents also revealed there is possibility for a slight change in knowledge application in the event of keen competition, frequent changes in business environments, or succession of younger management. Some (22%) of the respondents stated their organizations have initiated a substantial change in business processes (such as streamlining the coordination among departments) in

the past year. Moreover, 16% of the respondents declared their organizations have encouraged innovation by adopting a breakthrough in applying knowledge (such as competitors' design as an external knowledge source and stimuli) to the existing product designs and functionality.

To capitalize on the value of knowledge, management should not overlook the importance of knowledge protection from inappropriate use, possession, and distribution. In relation to this, our respondents reported their management does not have a comprehensive mind-set on protecting intellectual capital or properties. In general, most of the respondents (80%) stated their organizations have some form of control to limit the designated parties to access explicit organizational knowledge such as product design and manufacturing procedures. However, there are various complaints of knowledge loss due to staff retirement or leaving. Approximately 66% of the respondents said their organizations do not have formal and effective plans concerning knowledge succession and they do not hold exit exercises with departing key or important knowledge personnel. Therefore, the situation of transferring knowledge from a company to the competitor becomes very common, resulting in a certain threat to the prior organizations. In addition, most respondents revealed that their management does not have a strong intention to undertake close supervision and monitoring of how knowledge is being used or stored within the organizations. More than 60% of the respondents stated that the information, documents, or resources in computers are not well protected or secured as the management usually has unwarranted faith and trust toward employees. For example, there are certain occasions when employees share their passwords with others when asking someone to help in accessing or transferring some files.

The Way Ahead

Knowledge is generally regarded as a strategic asset, which is valuable and inimitable by competitors, and hence crucial to maintain competitive edge. Developing adequate capability to manage knowledge is therefore important. The examination of KM capability in the current study reveals that SMEs would need to devote more effort and attention in order to harness the values of knowledge effectively. It is considered that effective KM requires unified and coherent KM preconditions. In other words, it is our view that the two categories of KM capabilities, namely infrastructure and process capabilities as external and internal thrusts should be more balanced and deployed systematically (see the figure here). Management of SMEs should understand that effective KM practices require considerable time and efforts to take effect, given the distinct business characteristics and competence of their organization. Here, we describe specific recommendations for actions SMEs should consider when pursuing further improvements of the various capability dimensions.

Infrastructure Capability

Technology. In general, the technology capability needs to be further strengthened. It has been found that most SMEs are underinvested in KM-related technology due to financial constraint. Therefore, the SMEs should consider seeking assistance from government funding schemes for preliminary IT deployment. A simple set of a KM system with access to the Internet, email, and database management may serve as a cost-effective start. For those SMEs with unwelcome or underutilized IT applications, management has to reconsider the role of people vis-à-vis the KM systems [4, 8]. More end-user computing and collaborative design, communications, and continuous evaluation can facilitate mutual understandings, and increase the sense of acceptance of the new technology.

Structure. It is necessary to supplement the KM-prone organization structure of SMEs (by virtue of their small size and simple structure) with suitable incentive schemes and reward systems to encourage more knowledge sharing among the employees [6, 12]. In addition, management can set up a steering committee or invite experienced key speakers to promote KM programs within the organization. It is recommended that clear responsibilities be assigned to various KM roles or specializations to enable effective evaluation. Furthermore, management should provide a transparent report on the KM progress, and publicize the progress and development of KM activities tailored to all employees to increase interest in getting involved in the designated KM tasks.

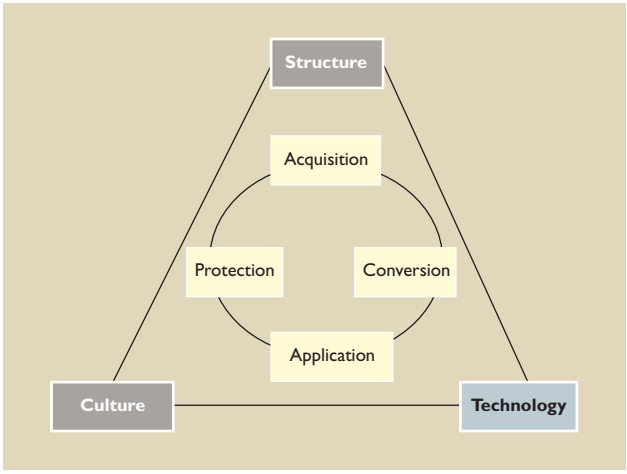
Culture. The SMEs are found to possess an awareness of KM for business competitiveness. However, it is necessary to further strengthen management support and monitoring of KM visions and goals. Management can infuse knowledge vision to everyone visibly, regularly, and extensively. Being a role model in KM programs, management can demonstrate to employees that KM is not just management jargon, but is a course of action to identify and share everyone's skills and experience in order to foster organizational competence. Moreover, management should be open to various ideas, opinions, and innovations.

Process Capability

Acquisition. For most SMEs, designated plans are needed to be in place to ensure systematic capture, screening, categorization, and storage of useful knowl-

edge or relevant information from internal networks as well as from suppliers and business partners. Employees need to be provided with extra time to engage in knowledge sharing and discovery [2]. Management and employees may jointly identify the working definitions of knowledge, skills, and competence that are critical to differentiate their own business from that of the competitors. It is believed that a common discourse and unanimous understanding of knowledge can easily diffuse KM to everyone within organizations.

Conversion. Management can play a facilitating role to involve everyone to convert what they know into what others can learn or what others may have to know into comprehensible formats [6, 7]. More encouragement has to be communicated to employees that knowledge is not confined to a certain group of people or to experienced staff. Frequent free-ranging discussions can be conducted in order to promote creative ideas and generate innovative thinking from different employees. Management may make use of intranets to enable employees to share experiences, disseminate new findings from other competitors' practices, or collaborate to work out novel views on product design or business development.



Unity of knowledge management capability.

Application. Employees may be provided with more opportunities to utilize and experiment with their knowledge on various occasions. Explicit rewards such as promotion and implicit incentives such as recognition in organization publications and events can be used to encourage employees to apply what they know or learn, or combine various sources in solving new problems and design new products or reconfigure business processes [5, 7]. Management may likewise try to adopt new ideas to be implemented in existing workflows or business processes in order to support more knowledge experimentation from conceptual ideas to practical actions. It should be noted that committing mistakes is part of the learning process, thus management should avoid penalizing employees if some new ideas do not work as expected. Otherwise, employees will have less motivation to devise innovative endeavors and will retain the old practices in order to maintain their performance and job security.

Protection. Management has to attend to knowledge protection at various organizational levels. There should be well-formulated plans for knowledge succession and prevention of knowledge loss due to staff departure. Exit exercises can be adopted to take note of the important knowledge from the employees, and then store it in appropriate systems [1, 10]. In addition, management must formulate regulatory control or monitoring systems (such as identifying extraordinary email correspondence between employees and external parties) to protect information or business secrets from being inappropriately used by the employees. Moreover, some effective reward systems can be provided in order to increase employees' loyalty toward organizations, thus helping to retain knowledge within organizations, and enabling knowledge to be exploited to a greater extent. C

References

1. Burrows, G.R., Drummon, D.L., and Martinsons, M.G. Knowledge management in China. *Commun. ACM 48*, 4 (Apr. 2005), 73–76.
2. Edvardsson, I.R. Knowledge management in SMEs: The case of Icelandic firms. *Knowledge Management Research and Practice 4*, 4 (Apr. 2006), 275–282.
3. Gold, A.H., Malhotra, A., and Segars, A.H. Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems 18*, 1 (Jan. 2001), 185–214.
4. Griffith T.L., Sawyer, J.E., and Neale, M.A. Virtualness and knowledge in teams: Managing the love triangle of organizations, individuals, and information technology. *MIS Quarterly 27*, 2 (Feb. 2003), 265–287.
5. King, W.R., Marks, Jr., P.V., and McCoy, S. The most important issues in knowledge management. *Commun. ACM 45*, 9 (Sept. 2002), 93–97.
6. Mason D. and Pauleen D.J. Perceptions of knowledge management: A qualitative analysis. *Journal of Knowledge Management 7*, 4 (Apr. 2003), 38–48.
7. Nonaka, I. A dynamic theory of organizational knowledge creation. *Organization Science 5*, 1 (Jan. 1994), 14–37.
8. Quan, J., Hu, Q., and Wang, X.A. IT is not for everyone in China. *Commun. ACM 48*, 4 (Apr. 2005), 69–72.
9. U.S. Small Business Administration; www.sba.gov.
10. Wasko, M.M. and Faraj, S. Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly 29*, 1 (Jan. 2005), 35–57.
11. Wong, K.Y. and Aspinwall, E. An empirical study of the important factors for knowledge-management adoption in the SME sector. *Journal of Knowledge Management 9*, 3 (Mar. 2005), 64–83.
12. Zhu, Z.C. Knowledge management: Toward a universal concept or cross-cultural contexts? *Knowledge Management Research and Practice 2*, 2 (Feb. 2004), 67–79.

Ivy Chan (ccivy@polyu.edu.hk) is a lecturer at the Hong Kong Community College, the Hong Kong Polytechnic University.
Chee-Kwong Chao (kchao@ouhk.edu.hk) is an assistant professor in School of Business and Administration, Open University of Hong Kong.

DOI: 10.1145/1330311.1330328

DEMOGRAPHIC CHANGES IN IS RESEARCH PRODUCTIVITY AND IMPACT

Compared to research in other business disciplines, information systems (IS) research is relatively in its infancy. In the last decade, an increasing number of academic institutions have recognized IS as a discipline and have created IS departments/groups. These developments introduced important changes to the demographics of IS researchers. The regional differences and top performers have changed considerably.

In this research, we analyze the development of IS research in the last decade with an emphasis on demographic changes. More specifically, we examine IS research productivity and impact, investigating changes in regional and institutional contributions and highlighting the top performers for both academic and non-academic institutions. This research

By Mohamed Khalifa *and* Kathy Ning

Always considered an area dominated by North American institutions, there are signs afoot that the globalization of IS research productivity is making moves, particularly in Asia and Europe.

THIS RESEARCH SHOULD BE OF INTEREST TO ACADEMICS AND PROFESSIONALS ALIKE. THE REPORTED RESULTS WILL ALLOW FIRMS AND ACADEMIC INSTITUTIONS TO BENCHMARK THEIR RESEARCH PERFORMANCE AND TO IDENTIFY TOP PERFORMERS FOR POTENTIAL COLLABORATION.

should be of interest to academics and professionals alike. The reported results will allow firms and academic institutions to benchmark their research performance and to identify top performers for potential collaboration.

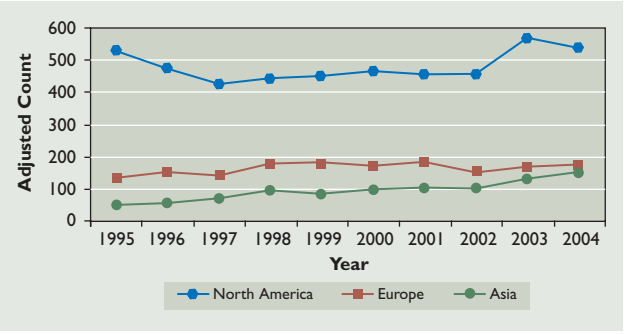


Figure 1. Annual productivity by region.

This study will also provide researchers with important indicators of IS research, for example, overall productivity and impact, evolution over the last 10 years, internationalization, concentration, and the level of industry involvement.

Productivity refers to the total IS research publications output. Consistent with prior studies we measure it with the adjusted count (fraction based on the number of co-authors) of research articles published by IS researchers in top journals in IS and referent disciplines. In addition, we also account for the impact of the research output, that is, the level of dissemination, which is measured with the adjusted impact scores (yearly impact ratios of the journal where a research article gets published). The impact ratios are reported by the Science Citation Index and the Social Sciences Citation Index.

Although more "objective" than perceptions, adjusted counts and impact ratios do not fully account for the rigor and prestige of the journals. Additional objective measures (for example, acceptance ratios), however, are not readily available and subjective measures (for example, journal rankings based on perceptions) are usually controversial. A quick Web search reveals that except for very few top journals, institutional rankings of IS journals differ significantly. We therefore opted not to mix objective and subjective measures, while acknowledging the limitations of our approach.

The journal selection is based on the most recent citation-based ranking [1], with minor differences. We chose a cut-off of 0.1 for the impact ratio, removing *Journal of Computer Information Systems* (only 0.034 when listed). We also removed *IEEE Computer,* as it was not clear which journal/magazine the authors meant. We could identify several journals/magazines with such a name, but all having impact ratios different from the one reported in [1]. Furthermore, most previous rankings did not include such a journal, but listed instead the IEEE Transactions [3, 4]. We therefore consistently included *IEEE Transactions on Engineering Management, IEEE Transactions on Systems, Man, and Cybernetics,* and *IEEE Transactions on Software Engineering* [3, 4]. We also added the *Journal of the Association of Information System* (JAIS). Although this journal has no impact ratio due to its relatively short history, it is generally regarded as a rising top-ranked journal. Indeed, several recent studies have included JAIS as one of the important IS journals, for example, [2-4]. Without an impact ratio, this journal counts for productivity calculation only. We ended up with 25 IS journals. For referent disciplines, we included the top 11 journals from the original ranking.

The collection of information about all articles published in the selected 36 journals during the last decade (1995–2004) took 40 person-months. To prevent errors, we incorporated several validity checks within the data entry system. We also assigned three individuals to check all entries and reconcile discrepancies. The resulting database consists of 18,711 research articles written by 24,517 authors from 4,111 institutions. The identification of research articles is based on the ISI classification. An article is included in the analysis if it has at least one IS co-author.

Given the multi-disciplinary nature of IS research, we adopted a rather broad view of IS affiliation, defining IS authors as those that satisfy one of the following criteria: published in an IS journal; listed in the AIS directory; or published in a non-IS journal but are clearly affiliated with an IS department. We could identify 8,362 articles published by 6,760 IS authors from 1,901 institutions.

To examine changes in productivity and research impact in the last decade, we compared the first half period (1995–1999) to the second one (2000–2004). The overall productivity of IS research had a moderate increase of 14%, from 3,639.07 adjusted article counts in the first period to 4,132.46 in the second period. The impact of IS research, however, experienced a dramatic boost with the adjusted impact scores increasing from 2,260.18 to 4,573.51. This important growth rate of 102% provides a strong indication for the enhanced recognition and influence of IS research. While the overall productivity of IS research has increased slightly, its impact has doubled.

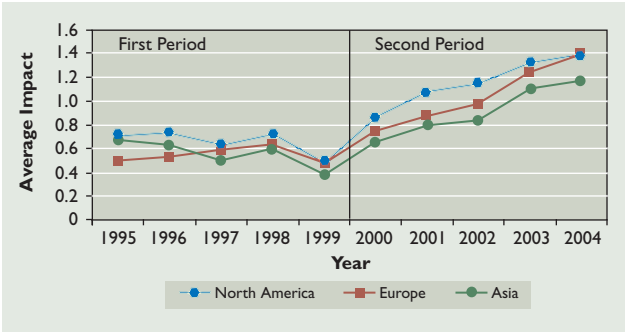


Figure 2. Average annual impact by region.

Regional Analysis

We limited our regional analysis to North America, Europe, and Asia, as they account for over 95% of the publications. As depicted in Figure 1, North America institutions continuously dominated IS research in the last decade with an annual productivity level ranging from 423.25 to 572.89 and accounting for 58.2% to 69.4% of the global productivity. It is worth noting that such results are somehow expected given that the selected journals are predominantly U.S.-based. Although North American productivity dropped during 1995–1997 by 19.4%, it picked up again gradually in 1998–2002 and in 2003 it experienced a sharp increase from 460.38 to 572.89. The annual productivity level of Europe remained relatively stable, ranging from 136.83 to 184.95 and accounting for 18% to 24% of the IS research publications. The biggest change occured in Asia with its annual productivity increasing from 50.71 (6% share) in 1995 to 149.67 (16.5% share) in 2004. Asia is bridging its productivity gap with Europe with a growth rate of 65% over the last decade compared to 8% for both North America and Europe.

As for the overall impact, North America experienced a decrease in the first period (from 374.54 in 1995 to 218.76 in 1999) and a boost in the second (from 402.32 in 2000 to 742.97 in 2004). The impacts of Asia and Europe, on the other hand, increased steadily. Consequently, the gap between North America and the other two regions decreased in the first period and sharply widened in the second. The overall impact of Europe increased from 68.5 in 1995 to 242.42 in 2004, while that of Asia increased from 34.16 to 176.11. Interestingly, while Asia was able to bridge its productivity gap with Europe, it could not reduce the impact gap, which actually increased from 34.34 in 1995 to 66.31 in 2004. The changes in overall impact are largely due to changes in productivity.

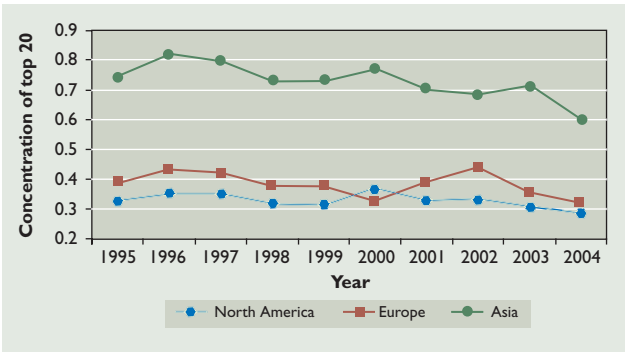


Figure 3. Annual productivity concentration rate by region.

To control for the productivity effects, we also examined the annual average impact ratios (average adjusted impact score for a single publication). Figure 2 shows a small decrease in the first period (1995–1999) but a clear upward trend in the second (2000–2004). The average impact of Europe improved the most (from 0.50 in 1995 to 1.39 in 2004) with an average annual growth rate of 13.9%, followed by North America with 11% (from 0.71 in 1995 to 1.38 in 2004), and Asia with 10% (from 0.67 in 1995 to 1.18 in 2004). In 2004 Europe's impact (1.39) exceeded that of North America (1.38). Europe bridged its impact gap with North America.

To examine the extent to which IS research productivity is evenly spread among academic institutions in different regions, we examined the regional concentration ratios (percentage of the output of top 20 productive institutions). As indicated in Figure 3, North America and Europe have more or less similar concentration ranging from 29% to 44%, sharply

Table 1. Research productivity and impact of top 20 academic institutions.

Institutions	Adjusted Count [Rank]		Adjusted Impact [Rank]	
	2000-2004	1995-1999	2000-2004	1995-1999
Massachusetts Institute of Technology	99.05[1]	74.06[1]	126.28[1]	49.62[1]
Georgia State University	60.44[2]	48.73[5]	68.74[2]	36.65[4]
National University of Singapore	57.75[3]	54.22[3]	52.2[6]	29.32[6]
University of Maryland, College Park	49.45[4]	30.9[14]	61.24[4]	22.37[13]
Indiana University	47.23[5]	-	44.3[11]	-
City University of Hong Kong	45.63[6]	-	47.09[10]	-
Carnegie Mellon University	43.83[7]	50.74[4]	63.9[3]	48.62[2]
University of Texas at Austin	40.29[8]	44.19[6]	54.2[5]	27.99[7]
University of Michigan	34.97[9]	30.17[16]	51.92[7]	27.6[8]
University of Minnesota	34.8[10]	-	49.2[9]	27.44[9]
Korea Advanced Institute of Science & Technology	32.83[11]	29.73[17]	-	-
Pennsylvania State University	32.61[12]	-	39.66[13]	-
University of California, Irvine	31.67[13]	31.73[10]	42.9[12]	26.7[10]
University of Southern California	31.41[14]	40.68[7]	50.47[8]	30.47[5]
The Chinese University of Hong Kong	31.3[15]	-	-	-
University of Arizona	31.11[16]	57.48[2]	35.14[18]	42.81[3]
Arizona State University	29.77[17]	-	33.51[19]	-
Hong Kong University of Science & Technology	29.25[18]	31.12[13]	-	-
Michigan State University	28.08[19]	-	35.45[17]	-
University of Pennsylvania	27.81[20]	27.25[18]	38.96[14]	-
University of Pittsburgh	-	36.76[8]	-	17.73[19]
University of South Carolina	-	31.92[9]	-	19.54[17]
University of Illinois at Urbana-Champaign	-	31.55[11]	-	25.9[11]
Stanford University	-	31.48[12]	31.41[20]	23.64[12]
University of Georgia, Athens	-	30.48[15]	-	-
Georgia Institute of Technology	-	27.23[19]	-	-
Texas A&M University	-	25.45[20]	-	19.84[16]
University of California, Berkeley	-	-	36.31[15]	22.37[14]
University of Connecticut	-	-	35.83[16]	-
New York University	-	-	-	21.99[15]
California State University, Carson	-	-	-	18.11[18]
Rutgers, The State University of New Jersey	-	-	-	17.67[20]

"-" Not listed among the top 20 of that period

contrasting with that of Asia. Although the concentration ratios are slightly declining from 75% in 1995 to 60% in 2004, research in Asia remains highly concentrated with 20 institutions contributing over 70% of the publications in the last decade.

Institutional Analysis

Table 1 presents the changes in the top 20 academic institutions from the first period (1995–1999) to the second (2000–2004) based on total productivity and impact. It is important to keep in mind the size factor in interpreting these results, as institutions with large IS faculty are more likely to have better scores. It is interesting to notice that the productivity rankings are different from the impact rankings and that three institutions in the top 20 productivity list are not in the impact list in both periods. These results emphasize that productivity does not necessarily lead to impact and that both indicators must be considered in evaluating an institution's research performance.

The dominance of Massachusetts Institute of Technology is obvious. It is consistently ranked first, widening its lead in the second period for both productivity (over 50% higher than the second in line) and impact (almost 100% higher than number 2). Another interesting observation is the absence of European institutions in the top performers. Asian institutions, however, are becoming more competitive. The number of Asian universities listed in the top 20 increased from three in the first period to five in the second for productivity and from one to two for impact. These results are consistent with the high concentration ratios of Asia. Although the overall productivity of Asia is similar to that of Europe, fewer institutions are driving it. Asian institutions such as National University of Singapore and City University of Hong Kong are now among the top 10 in both productivity and impact.

The emergence of Asian leaders is contributing

While still dominated by North American institutions, there are signs of internationalization with Asia increasing its productivity and Europe enhancing its overall impact.

Institutions	Adjusted Count [Rank]		Adjusted Impact [Rank]	
	2000-2004	1995-1999	2000-2004	1995-1999
IBM	30.51[1]	16.43[1]	45.48[1]	13.68[1]
Accenture	10.53[2]	3.20[5]	20.99[2]	-
Microsoft	9.29[3]	-	14.87[3]	-
AT&T	3.00[4]	12.6[2]	5.32[5]	11.93[2]
HP (Compaq Computer Corp.)	2.96[5]	-	3.54[8]	-
Price Waterhouse	2.67[6]	-	-	-
Lucent	2.27[7]	4.57[4]	3.36[9]	4.42[5]
Accurate Automation Corporation	2.25[8]	-	-	-
FedEx Corporation	2.17[9]	-	-	-
Nielsen Norman Group	2.00[10]	-	7.02[4]	-
Advanced Telecommunications Research (Asia) Institute (Japan)	-	-	3.58[7]	-
Xerox	-	7.65[3]	-	7.23[3]
NEC (Asia)	-	3[6]	-	3.7[6]
Ernst & Young	-	2.92[7]	-	-
Klein Associates Inc.	-	2.92[8]	-	2.3[7]
Mathworks Inc.	-	2.83[9]	-	-
Apple Computer	-	2.62[10]	-	4.47[4]
Nokia (Europe)	-	-	3.87[6]	-
Bell Canada Enterprises	-	-	3.35[10]	-
GM	-	-	-	1.99[8]
Innovative Skills Training and Education Program, Inc.	-	-	-	1.86[9]
GTE Communication Systems Division, Needham Heights	-	-	-	1.86[10]
"-" Not listed among the top 10 of that period				

Table 2. Research productivity and impact of top 10 firms.

further to the performance dynamism. A comparison of the two periods reveals important changes in rankings and in the composition of the top performers with seven new entrants for both productivity and impact. Although the composition of the top 20 academic performers has considerably changed from the first period to the second one, it is still characterized by the absence of European institutions and the dominance of MIT.

Several firms are actively conducting IS research. However, their relative contribution in the last decade was minimal, ranging from 4.1% to 5.8% of the total productivity and from 4.6% to 6.5% of the total impact. Table 2 presents the changes for both productivity and impact in the top 10 industry performers from the first period to the second one. An analysis of the industry performers reveals similar patterns to the ones reported for academic institutions in terms of dominance, dynamism, and regional representation. One firm, IBM, is consistently dominating IS research. During the period of 2000–2004, its productivity is almost three times that of the second productivity performer (Accenture) and its impact is more than double that of the second impact performer (Microsoft). A comparison of the two periods also reveals a very high level of dynamism with six new entrants in the top 10 for productivity and seven for impact.

As for regional representation, only one Asian firm and one European firm enter the current top 10 firms. An interesting observation about research done by the industry is that although the productivity of the top 10 firms is much smaller than that of the top 10 academic institutions, their average impact is higher (1.64 vs. 1.25). Industry top performers publish fewer but higher-impact articles than their academic counterparts.

Conclusion

In conclusion, we would like to highlight the modest growth of IS research productivity and the impressive improvement of its impact. While still dominated by North American institutions, there are signs of internationalization with Asia increasing its productivity and Europe enhancing its overall impact. The composition of the top performers is dynamic, but with consistent academic and industry leaders. The dynamism and internationalization trends should contribute further to the enhancement of the IS research diversification and recognition. C

References

1. Barnes, S.J. Assessing the value of IS journals. *Commun. ACM 48*, 1 (Jan. 2005), 110–112.
2. Bhattacharjee, S. Author experiences with the IS journal review process. *Commun. AIS 13*, (2004), 629–653.
3. Huang, H.-H. and Hsu, J.S.-C. An evaluation of publication productivity in information systems: 1999 to 2003. *Commun. AIS 15*, (2005), 555–564.
4. Lowry, P.B., Romans, D. and Curtis, A. Global journal prestige and supporting disciplines: A scientometric study of information systems journals. *J. AIS 5*, 2 (2004), 29–77.

Mohamed Khalifa (iskhal@cityu.edu.hk) is a professor in the Information Systems Department and Director of the Asia Center of Electronic Business at City University of Hong Kong.
Kathy Ning Shen (kathy.ningshen@student.cityu.edu.hk) is a Ph.D. student in the Information Systems Department at City University of Hong Kong.

DOI: 10.1145/1330311.1330329

ACM Digital Library

www.acm.org/dl

The Ultimate Online INFORMATION TECHNOLOGY Resource!

Powerful and vast in scope, the **ACM Digital Library** is the ultimate online resource offering unlimited access and value!

The **ACM Digital Library** interface includes:

- **The ACM Digital Library** offers over 40 publications including all ACM journals, magazines, and conference proceedings, plus vast archives, representing nearly 2 million pages of text. The ACM DL includes full-text articles from all ACM publications dating back to the 1950s, as well as third-party content with selected archives. **www.acm.org/dl**

- **The Guide to Computing Literature** offers an enormous bank of over one million bibliographic citations extending far beyond ACM's proprietary literature, covering all types of works in computing such as journals, proceedings, books, technical reports, and theses! **www.acm.org/guide**

- **The Online Computing Reviews Service** includes reviews by computing experts, providing timely commentary and critiques of the most essential books and articles.

Available only to ACM Members.
Join ACM online at **www.acm.org/joinacm**

To join ACM and/or subscribe to the Digital Library, contact ACM:

Phone: 1.800.342.6626 (U.S. and Canada)
+1.212.626.0500 (Global)
Fax: +1.212.944.1318
Hours: 8:30 a.m.-4:30 p.m., Eastern Time

Email: acmhelp@acm.org
Join URL: www.acm.org/joinacm
Mail: ACM Member Services
General Post Office
PO Box 30777
New York, NY 10087-0777 USA

*Guide access is included with Professional, Student and SIG membership. ACM Professional Members can add the full ACM Digital Library for only $99 (USD). Student Portal Package membership includes the Digital Library. Institutional, Corporate, and Consortia Packages are also available.

Association for Computing Machinery

Advancing Computing as a Science & Profession

AD28

By Pamela Whitten, Deirdre Mylod, Goran Gavran, *and* Howard Sypher

"MOST WIRED HOSPITALS" RATE PATIENT SATISFACTION

Considering the role of IT as a variable in health care institution quality assessment.

Information technology is one of the most significant tools currently available to improve health care quality and productivity. When it comes to IT, however, health care lags behind almost every other industry [9]. Although the health care industry does not lack for technology, major expenditures are limited to profit-making sectors such as surgery and treatment [6]. Other data-driven industries such as insurance or financial services budget more than 10 percent of their finances for IT, whereas health care puts only two to three percent of its budget into IT. Along the same lines, private industry spends an average of about $7,000 per worker on IT hardware, software, and services, with banking approaching $15,000 a worker; health care averages about $3,000 annually per worker for IT [6].

This contrast in IT investment is important to note as it comes at a time when we are realizing that patients see real benefits from increased investment in technology. In fact, examinations into how users feel about technological applications in health care indicate generally high levels of satisfaction as both patients and providers appreciate the convenience and efficiency that comes with new technologies. Videoconferencing consultations between specialists and patients improves

patient satisfaction by reducing burdens associated with travel and scheduling while promoting a feeling of involvement in the physical examination itself [11]. Store-and-forward consultations in record-driven fields such as dermatology lead to positive reviews from all parties involved (patients, referring physicians, and specialists) [12]. Even basic Internet searching for health information makes patients more likely to pose more informed questions to their doctors and to follow prescribed treatment regimens [4].

The possibility of increased patient satisfaction is an immense consideration for many institutions, especially for larger health care facilities that tend to have lower satisfaction ratings. The importance of measuring, improving, (and achieving) patient satisfaction has not always been a top priority for health care institutions. Whereas in the past, patient satisfaction was not necessarily seen as related to institutional success, today it is recognized that quality of care, customer satisfaction, and financial outcomes are all interrelated. Higher patient satisfaction can help retain a customer base, increase physician loyalty, bring more patients, raise employee satisfaction and retention, cut costs, and reduce length of stay [3].

On the other hand, patient dissatisfaction is associated with a significant decrease in revenue for the health care organization [5]. In light of this situation, Press Ganey, the largest health care satisfaction measurement firm in the U.S., aims to provide one of the largest pools of comparative data in the nation [7]. This allows hospitals to not only measure and compare patient satisfaction scores, but also to identify areas that are lacking and improve upon them.

Given the ever-growing standards and recognition of satisfaction research, the current environment is ripe for new and more detailed investigations into the antecedents of patient satisfaction. More specifically, a pressing question remains to be explored in the realm of health care satisfaction research: Are hospitals that invest more heavily in health IT more likely to achieve higher

patient satisfaction? A growing number of examples seem to point strongly in this direction.

Overall, evidence is continually mounting that there is something special about health care organizations that invest in IT (hospitals that are "wired"). This project seeks to further investigate the relationship between investment in health IT and patient satisfaction in the hospital context through analysis of patient satisfaction data for hospitals with validated Press Ganey satisfaction survey [7] data that was included in the 2005 *Hospitals & Health Networks* annual list of the "100 most wired hospitals and health systems." Specifically, we sought to test the following hypotheses:

H1: Patients from the Most Wired Hospitals would report higher satisfaction scores regarding the overall experience in the hospital.

H2: Patients from the Most Wired Hospitals would report higher satisfaction regarding specific aspects of their hospital experience, including: H2a: Their admission process and experience; H2b: Their experiences with hospital-based nurses; H2c: Items related to tests and treatments within the hospital; H2d: Their experience with physicians during their hospitalization; H2e: Their discharge experience; H2f: Personal issues such as sensitivity and pain control.

H3: Status as a most wired hospital would more accurately predict higher patient satisfaction than specific demographic characteristics of the hospitals such as number of patient beds, case mix, number of critical days, payer mix, community size, total number of full-time equivalents, and services provided.

This work is based in part on the revisitation of a theoretical proposition developed almost 30 years ago. Ben-Sira offered a revised model of social interaction regarding relationships in the health context whereby the mode of an interaction may equal or supercede the actual content [1]. Specifically, Ben-Sira suggested that a client's satisfaction may indeed be a consequence of the mode of a professional's response. He argues that an emotional involvement in treatment, a lack of detailed medical knowledge, and an ability to connect treatments to healing will lead patients to judge medical providers on the basis of the physician's behavior toward the patient [2]. Thus, high levels of socio-emotional behavior on the part of the provider can promote patient satisfaction, self-disclosure, and trust [10]. We seek to update this theory to allow mode to encompass the use of information technologies to facilitate communication-related activities in the health setting. With this in mind, we sought to test whether most wired hospital patients report higher levels of satisfaction related to the inpatient experience.

Business Processes
• Automate the supply chain • Automate patient eligibility and financial transactions with insurance companies and other payers • Automate the business office and financial operations
Customer Service
• Improve the efficiency of administrative services to patients such as pre-registration • Assist patients in researching and tracking their own conditions • Provide the general public with health information and resources to improve their health
Safety and Quality
• Reduce errors in prescribing and ordering medications • Reduce errors in the administration of medications • Improve clinical decision making by providing physicians and clinicians with access to electronic health record for their patients • Improve clinical decision making by providing real-time clinical alerts to assist physicians and other clinicians at the point of care • Reduce adverse events by electronically monitoring patients and using surveillance systems to alert physicians and other clinicians about changes in a patient's condition
Work Force
• Assist in the recruitment, selection, and training of qualified personnel • Provide extensive training and support to physicians and other clinicians on information systems • Use work force management tools to ensure adequate staffing and measure staff performance
Public Health and Safety
• Deploy a wide range of security technologies to safeguard confidential patient information • Conduct pilot programs or offer patients some form of a Web-based personal health record • Participate in local, regional, and national cooperatives to share health information • Use evidence-based standards to monitor and improve the hospital's performance on specific clinical practices

Source: *Hospitals & Health Networks*' Most Wired Survey and Benchmarking Study (see www.usnews.com/usnews/health/articles/050722/wired.criteria.htm).

Table 1. Evaluation criteria for most wired evaluation.

METHODOLOGY

During the time of data collection for this study (inpatient surveys received between Jan. 1, 2004 and Sept. 1, 2005), Press Ganey collected patient satisfaction surveys for 1,382 hospitals in the U.S. Specifically, standardized questionnaires were mailed shortly after discharge to patients hospitalized in an acute care hospital. This procedure yielded over three million survey responses from patients discharged from 1,382 hospitals nationwide.

In 2005, *Hospitals & Health Networks* magazine published its list of the 100 most wired hospitals in the U.S.[1] The annual *Hospitals & Health Networks' Most Wired Survey and Benchmarking Study* asks hospitals via an eight-page survey to self-report on their use of IT in five key areas: business processes, customer service, safety and quality, work force, and public health and safety. (See Table 1 for evaluation criteria.) *Hospitals & Health Networks* then reviews the results of the proprietary sur-

[1] See www.hhnmag.com/hhnmag/jsp/articledisplay.jsp?dcrpath=HHNMAG/PubsNewsArticle/data/backup/0507HHN_CoverStory_WinnersList&domain=HHMAG.

vey and evaluates the hospitals to determine which hospitals have the highest performance. Top-scoring hospitals are published in the Top 100 list (actual scores and scoring criteria are not included with the published list); 42 of these Top 100 most wired hospitals are Press Ganey clients. Therefore, patient satisfaction scores were compared between the two groups, the 42 hospitals included on the most wired list and the 1,340 not included on the list, referred to as "other" in this article.

The Press Ganey Inpatient Survey was first developed in 1987 and has undergone rigorous validation testing. The conceptual model behind the ratings is real-world-based in that it derives from typical experiences a patient may actually encounter during a hospital stay. Events that occur, (admission, meals, tests or treatments, discharge); personnel encounters (nurses, physicians, and technical staff); the physical surroundings (room and hospital) and the interpersonal aspects of the stay are seen as important contributors to the patient's total experience. They are also believed to be reflections of the quality of the medical care delivered and received.

The survey includes 49 standard questions asked by all organizations that are organized into 10 sections or sub-scales including: Admission, Room, Diet and Meals, Nursing, Tests and Treatment, Visitors and Family, Physician, Discharge, Personal Issues, and Overall Assessment. Within each section, respondents are asked to evaluate a set of attributes that relate to that conceptual area. Responses are coded on a Likert-type scale from 1–5 (1=Very Poor, 2=Poor, 3=Fair, 4=Good, and 5=Very Good). Scores are linearly transformed to a 0–100 scale for ease of interpretation. Chronbach alphas indicating the reliability of the subscales range between 0.78 and 0.95. Reliability for the entire instrument is 0.95. Factor analysis supports the construct areas measured by each of the subscales. More information about the psychometric properties of the Press Ganey Inpatient Survey can be obtained from the authors.

Independent samples t-tests were performed to compare the satisfaction scores between the most wired hospitals and the rest. Patient-level satisfaction survey responses were first aggregated at the facility level to create the two distributions for comparison. The 42 hospital-level mean scores (comprising those hospitals from the Most Wired list) were used to create the mean for 'Most Wired Hospitals'. Similarly, the 1,340 hospital-level mean scores for facilities not on the most wired list were use to create the mean for the 'Other Hospitals' Group.

The standard parametric t-test requires the assumption that variances are homogeneous between the two groups being compared. When this assumption is met, a pooled variance estimate is used to calculate *t*. When variances are not equal, the *t* statistic is calculated using separate variance estimates. Additionally, the Welch correction for degrees of freedom is applied when using the *t* designed for unequal variances. In each comparison reported, Levene's test for the equality of variance was performed first to determine if the pooled variance or separate variance results should be reported. See Tables 2 and 3 for notation as to which results assumed equal variances per the results of the Levene's test.

	-1	0	1	2	t-test	df	Sig. (2-tail)
Overall Mean Score		0.76			2.116	45.72	0.040
►Overall Assessment Section *		1.24			2.242	1380	0.025
►►Overall cheerfulness of the hospital *		0.93			1.680	1379	0.093
►►How well staff worked together to care for you		0.81			2.183	46.08	0.034
►►Likelihood of your recommending this hospital to others *		1.66			3.049	1380	0.002
►►Overall rating of care given at hospital *		1.24			2.340	1380	0.019

* Asterisks denote comparisons in which equal variances were assumed following the use of Levene's test for equality of variances. All other comparisons report results where equal variances were not assumed and the Welch correction for degrees of freedom was applied.
Note: Darker bars (shaded in blue) denote significant differences. Lighter bars (shaded in yellow) reflect non-significant findings.

Table 2. Global satisfaction results.

Results

Data from the surveys revealed there were significant differences in satisfaction-related issues for clients at the most wired hospitals. These differences were demonstrated for overall satisfaction, as well as for specific aspects of the hospital experience.

First, the data demonstrated consistent support for the first hypothesis that patients receiving care at the most wired hospitals would report higher global satisfaction scores. The measure contains several indicators of global satisfaction including a composite overall performance score, a subscale addressing the patients overall assessment of the care experience, as well as four individual questions geared to global outcome measures. In each case, the most wired hospitals fared better (see Table 2). Notably, wired hospitals scored 0.76 points higher on the composite overall performance score (t=2.116, df=45.72, p=0.040).

A similar pattern of more positive performance was found when looking at the overall assessment subscale of the measurement tool which was 1.24 points higher for the most wired group (t=2.242, df=1380, p=0.025). The overall assessment subscale that appears at the conclusion of the questionnaire asks the respondent to consider their experience from a broad view and evaluate the overall cheerfulness of the hospital, how well staff

worked together to care for the patient, likelihood of recommending the hospital to others and the overall rating of care given at the hospital. Three of the four individual items that address global evaluations of the hospital were also significantly higher for the most wired group. The most wired hospital group was higher in patient evaluations of overall rating of care (+1.24 (t=2.340, df=1380, p=0.019)); likelihood of recommending (+ 1.96 (t=3.049, df=1380, p=0.002); and coordination of care (+0.81 (t=2.183, df=46.06, p=0.034)). There was no significant difference between the two groups in respect to overall cheerfulness of the hospital.

Statistical comparisons regarding specific aspects of patients' hospital experiences were also conducted (see Table 3). The hypothesis that patients from the most wired hospitals would rate their satisfaction as higher with the admission process and experience was supported. At the subscale level, wired hospitals scored 1.52 points higher (t=3.524, df=45, p=0.001), which was a statistically significant difference. At the individual item level, all three individual items were significantly different. Specifically, wired hospital patients reported higher scores for the speed of admission (+1.98 (t=3.969, df=44.89, p=0.001)), courtesy of admission staff (+1.05 (t=3.244, df=45.3, p=0.002)), and the pre-admission process (+1.43 (t=2.509, df=1375, p=0.012)). However, the hypothesis that patients at the wired hospitals would view the experience of hospital discharge in a manner that was statistically more favorable was not supported at the subscale level or for any of the four individual items within this subscale.

	-1 0 1 2	t-test	df	Sig. (2-tail)
Admission Section	1.52	3.524	45.00	0.001
►Speed of admission	1.98	3.696	44.89	0.001
►Courtesy of person admitting	1.05	3.244	45.30	0.002
►Pre-admission process *	1.43	2.509	1375	0.012
Nurses Section	0.48	1.622	48.55	0.111
►Friendliness/courtesy of the nurses	0.41	1.632	48.23	0.109
►Promptness response to call	0.33	0.831	47.98	0.410
►Nurses' attitude toward requests	0.65	2.178	48.94	0.034
►Attention to special/personal needs	0.42	1.322	49.24	0.192
►Nurses kept you informed	0.55	1.513	46.95	0.137
►Skill of the nurses	0.57	2.128	47.80	0.039
Tests and Treatments Section	0.39	1.215	44.73	0.231
►Wait time for tests or treatments *	0.10	0.193	1379	0.847
►Concern comfort during T&T *	0.57	1.298	1378	0.208
►Explanations:happen during T&T	0.83	2.596	45.28	0.013
►Skill of person took blood	-0.06	-0.171	45.15	0.865
►Courtesy of person took blood	0.24	0.804	45.07	0.426
►Skill of person started IV	0.52	1.541	44.00	0.131
►Courtesy of person started IV	0.67	2.392	45.47	0.021
Physician Section	0.80	2.420	45.86	0.020
►Time physician spent with you *	0.58	1.097	1379	0.273
►Physician concern questions/worries	0.75	2.158	45.89	0.036
►Physician kept you informed	0.63	1.701	45.79	0.096
►Friendliness/courtesy of physician	0.74	2.663	46.29	0.011
►Skill of physician *	1.27	3.484	1379	0.001
Discharge Section *	0.41	0.890	1379	0.374
►Extent felt ready discharge *	0.79	1.926	1378	0.054
►Speed of discharge process *	-0.36	-0.645	1378	0.519
►Instructions care at home *	0.52	1.089	1378	0.276
►Help arranging home care services *	1.09	1.837	1379	0.066
Personal Issues Section	0.89	2.431	46.37	0.019
►Staff concern for your privacy *	0.94	1.958	1380	0.050
►Staff sensitivity to inconvenience	1.00	2.469	45.91	0.017
►How well your pain was controlled	0.83	2.981	46.32	0.005
►Staff addressed emotional needs	0.71	1.842	46.70	0.072
►Response concerns/complaints	0.69	1.675	46.84	0.101
►Staff include decisions re:trtmnt *	0.94	1.722	1380	0.085

* Asterisks denote comparisons in which equal variances were assumed following the use of Levene's test for equality of variances. All other comparisons report results where equal variances were not assumed and the Welch correction for degrees of freedom was applied.
Note: Darker bars (shaded in blue) denote significant differences. Lighter bars (shaded in yellow) reflect non-significant findings.

Table 3. Satisfaction results for specific aspects of care.

In regard to satisfaction with health providers, patients in the most wired hospitals did report statistically reliably higher satisfaction levels with physicians in general. At the subscale level, the most wired hospitals scored 0.80 points higher (t=2.420, df=45.86, p=0.02) than the other group. At the individual item level, three out of five items had significant differences between the two groups. Specifically, wired hospitals' patients were more satisfied with physician's concern with their questions/worries (+0.75 (t=2.158, df=45.89, p=0.036)); friendliness/courtesy (+0.74 (t=2.663, df=46.29, p=0.011)); and skill of physician (+1.27 (t=3.484, df=1379, p=0.001)). Yet, patients

from the most wired hospitals did not report statistically higher satisfaction scores regarding their experiences with hospital-based nurses in general at the subscale level. However, at the item level, patients at the most wired hospitals did report higher satisfaction related to nurses for two of the six items. Most wired hospital patients reported significantly higher satisfaction with nurses' attitude to patient requests (+0.65 (t=2.178, df=48.94, p=0.034)) and skill of nurses (+0.57 (t=2.128, df=47.8, p=0.039)).

The hypothesis that patients from the most wired hospitals would view care more favorably related to the personal issues such as sensitivity and pain control did prove to be supported. At the subscale level, wired hospitals scored 0.89 points higher than the other group (t=2.431, df=46.37, p=0.019). At the individual item level, two out of six items were significantly different, with wired hospitals scoring higher in both cases: staff sensitivity to patient's inconvenience (+1.00 (t=2.469, df=45.91, p=0.017)), and pain control (+0.83 (t=2.981, df=46.32, p=0.005)).

Most wired hospital patients did not report higher satisfaction with tests and treatments at the subscale level. At the item level regarding tests and treatments, only one of the seven items was significantly different in favor of the wired hospitals. Specifically, most wired hospitals' patients were more satisfied with the explanations received regarding medical tests and treatments (+0.83 (t=2.596, df=45.28, p=0.013)).

Finally, status as a most wired hospital proved to be an important variable in more accurately predicting higher patient satisfaction than specific demographic characteristics of hospitals. In general, smaller hospitals tend to have higher patient satisfaction scores than the larger hospitals in the Press Ganey Inpatient Database. The Pearson Correlation between hospital bed size and the overall patient satisfaction score is -0.321 ($p<0.000$). Average bed size of the most wired hospital group in our analysis is 543, and the average bed size for the other group is 260. However, patients treated at the most wired hospital group were significantly more satisfied than those treated at other hospitals (t=2.116, df=45.72, p=0.04).

Hospitals with higher Case Mix Indices (that is, having sicker patients) tend to score lower in patient satisfaction than do hospitals with lower Case Mix Indices. Overall, the Case Mix Index for the most wired hospital group was 359 versus 144 for the other group (with a higher case mix index indicating a sicker population of patients). Yet, patients from the most wired hospitals reported significantly higher levels of satisfaction.

Teaching hospitals (Council of Teaching Hospitals (COTH) members) have lower overall patient satisfaction than the non-members (82.3 vs. 84.3) in the Press Ganey Inpatient Database. In this study, most wired hospitals were more likely to be COTH members (44.8% vs. 13.5%), but nevertheless demonstrated higher patient satisfaction results. A similar relationship holds for non-COTH member teaching hospitals: non-members score significantly higher in patient satisfaction (84.5 vs. 82.9). In this study, most wired hospitals were more likely to be teaching hospitals (52% vs. 27.5%), yet these most wired hospitals demonstrated higher levels of patient satisfaction.

Finally, when examining a number of miscellaneous hospital demographics (the hospitals' community type and size, UHC membership, presence of medical residents in the hospital, types of services provided) we again found that most wired hospital status is a better predictor of higher patient satisfaction than any other hospital demographic variable.

In summary, analysis from this study found that patients from the most wired hospital group report higher levels of overall satisfaction than do patients from the other group of hospitals. Patients from the most wired hospitals also reported higher satisfaction related to the admission process, their experiences with physicians, and personal issues such as sensitivity and pain. However, there was no difference in general satisfaction scores between the two groups for experiences with nurses, the discharge process and tests and treatments (though there were a handful of individual items for these three areas where most wired patients reported higher satisfaction with no items where the other group reported statistically higher satisfaction). Finally, higher satisfaction scores were associated with most wired hospital status more so than for any specific demographic variable tested.

Discussion

The results from this study are important and thought provoking for a variety of reasons. Health care organizations, often non-profit, are faced with challenging resource allocation. Administrators must make difficult decisions regarding investment in IT in lieu of other critical resources such as personnel or capital equipment. Often, administrators are pressured to allocate resources in ways that demonstrate immediate, short-term benefits. Yet, the results of this study suggest that among the longer-term benefits of IT investment in hospitals may actually be issues related to patient satisfaction. This data suggests IT enhancements don't just affect the way health care professionals work, they also affect the way patients receive and perceive their care. As we move toward a new paradigm of health delivery necessitated by public and private desires to contain health costs, we are moving to a world where many patients will be more knowledgeable about managing

health care, better informed about the benefits, risks, costs and alternatives for treatments, more technologically savvy, and more engaged in decision making with providers. As a result, hospitals will need strong IT infrastructure and tools to meet the increasing expectations of these more sophisticated consumers.

Patient satisfaction is a phenomenon determined by expectations and values. These values are important antecedents for patient satisfaction as we ask them to evaluate their care based on what they want and expect from health care providers. In general, patient satisfaction is an evaluative summary of whether a patient likes or dislikes health care services. Raftopoulos explained that patients evaluate care as functions of cognitive (beliefs, expectations and perceptions), affect (feelings) and behavioral intentions (aspirations and expected responses to care provided) [8]. This means that patient satisfaction is a dynamic process determined by the way a patient thinks, observes, and acts. Therefore, patient satisfaction is an attitude based on the way a patient conceives the phenomenon of a health care experience while in the hospital. Patients live in a world where IT and its associated services and benefits abound in almost every sector ranging from banking, entertainment, and communicating with friends and colleagues. It should not be surprising that many of these patients express greater satisfaction in hospitals that also employ IT in significant ways.

This study represents a simple first step to determine if there is merit in further assessing IT as an antecedent for patient satisfaction. The study is not without its limitations. For example, we do not know the level of IT investment in the hospitals included within the other category. There may well be additional explanatory variables that better explain these differences in patient satisfaction. For example, perhaps most wired hospitals inherently possess an innovative and radical culture that permeates all levels of care. Yet, the data in this study repeatedly pointed to instances where patients from the most wired hospitals were more satisfied even in those cases where demographic variables such as hospital size always seem to outweigh other impacts. Also worth noting is that even though there were variables with non-significant results in satisfaction ratings, there was not one single statistical test where the non-wired hospital patients expressed higher satisfaction than those in the most wired hospitals.

We were fortunate to have a large amount of standardized satisfaction data to explore for this study. The existence of a centralized data bank of validated satisfaction results through Press Ganey permits unique and innovative comparisons across hospitals. This study suggests IT may be an important antecedent for patient satisfaction. It is a first step that validates the need for significant future study to better explain this potential. Future work needs to differentiate between the myriad of IT solutions to clarify if some play a more important role in leading to enhanced satisfaction.

Patient satisfaction has emerged as a vital indicator of the quality of medical care, as well as a significant determinant in decisions regarding future health providers. IT investment may well emerge as a strategy to better meet the needs of an evolving hospital patient demographic, ultimately resulting in a hospital's ability to ensure its competitive position. C

References

1. Ben-Sira, Z. The function of the professional's affective behavior in client satisfaction: A revised approach to social interaction theory. *Journal of Health and Social Behavior 17* (Mar. 1976), 3–11.
2. Ben-Sira, Z. Affective and instrumental components in the physician-patient relationship: An additional dimension of interaction theory. *Journal of Health and Social Behavior 21* (June 1980), 170–180.
3. Clark, P.A., Drain, M., and Malone, M.P. Return on investment in satisfaction measurement and improvement: Working paper from Press Ganey Associates. Press Ganey Associates, South Bend, IN, 2005.
4. Harris Interactive. The increasing impact of eHealth on consumer behavior. *Health Care News 1*, 21 (June 26, 2001), 1–9; www.harrisinteractive.com/news/newsletters/healthnews/HI_HealthCareNews2001Vol1_iss21.pdf.
5. Health Care Advisory Board. Return on investment from service excellence initiatives. Washington, DC, 1999.
6. Lohr, S. Health industry under pressure to computerize. *New York Times* (Feb. 19, 2005); www.nytimes.com/2005/02/19/business/19health.html.
7. Press Ganey. Press Ganey 2005 health care satisfaction report. Press Ganey Associates, South Bend, IN, 2005.
8. Raftopuulos, V. A grounded theory for patients' satisfaction with quality of hospital care. *ICUS Nursing Web Journal 22* (Apr.–June 2005).
9. Reese, B. Statement of the National Alliance for Health Information Technology. National Committee on Vital and Health Statistics Subcommittee on Standards and Security. Sentara Healthcare of Norfolk, VA, 2002.
10. Roberts C. and Aruguete M. Task and socioemotional behaviors of physicians: A test of reciprocity and social interaction theories in analogue physician-patient encounters. *Social Science in Medicine 50*, 3 (Feb. 2000), 309–315.
11. Savard, L. Benefits gained by rehabilitation professionals participating in specialty teleconsultations. *Telemedicine Journal and e-Health* (May 9, 2003), (Suppl 1): S56.
12. Whited, J.D. et al. Patient and clinician satisfaction with a store-and-forward teledermatology consult system. *Telemedicine Journal and e-Health 10*, 4 (2004), 422–431.

Pamela Whitten (pwhitten@msu.edu) is a professor and associate dean in the Department of Telecommunication at Michigan State University in East Lansing, MI.
Deirdre Mylod (dmylod@pressganey.com) is the vice president for public policy at Press Ganey Associates in South Bend, IN.
Goran Gavran (Ggavran@nmh.org) is a patient satisfaction data analyst at Northwestern Memorial Hospital in Chicago, IL.
Howard Sypher (hsypher@purdue.edu) is a professor and head of the communication department at Purdue University in West Lafayette, IN.

DOI: 10.1145/1330311.1330330

Dongseo University
Full time faculty of
digital content division

The Division of Digital Content invites applications for a contract base faculty positions beginning Mar 2008. Rank and salary commensurate with experience. Applicants with significant computer graphics experience are particularly encouraged to apply. We are especially interested in candidates who can contribute to our software engineering expertise in one or more of the following areas: character animation, motion capture, software project management. Working on a small team, you will participate in all aspect of the development process within the division and work in close conjunction with the project team head.

Dongseo University is a highly selective, coeducational, primarily university of digital visual content such as animation, movie, game with a vision to be the best institution of its kind in the world

Ongoing professional development is expected of all faculty so that their teaching continues to be outstanding. A Ph.D. in computer graphics or a closely related field is required. Detailed information is available from: Eeljin Chae, Professor and the head of IT foreign faculty program, division of digital content, Dongseo University, Churye 2 dong, Sasanggu, Busan, Korea. Phone: 82-10-5596-1975. Web: http://www.dongseo.ac.kr. Applicants should submit a cover letter, a resume, a career certification, copies of graduate school transcripts, an original copy of diploma and three letters of recommendation or any inquiries to email: dksns@gdsu.dongseo.ac.kr.

Heuristic System
LAMP/ Perl Programmer

Heuristic System is looking for an experienced LAMP/ Perl programmer to play a key role in the design, development, and coding of our unique software. Must have experience with Red Hat, Postfix and sourcing tools such as GIT, SVN, or CVS. We offer a Competitive Salary, Benefits Package, and Bonus Program. Please send your resumes to jobs@heuristicsystem.net

Jackson State University
Department of Computer Science
Faculty Position

The Department of Computer Science invites applications for a tenured or tenure-track appointment at a rank commensurate with qualifications and experience to begin in August 2008. Candidates at all ranks will be considered. Applicants must have a Ph.D. (by the time of appointment) in Computer Science or a closely related discipline, and a strong commitment to excellence in teaching, research, and service. The successful candidate will be expected to demonstrate excellent teaching performance, establish a strong externally-funded research program, establish collaborations, demonstrate strong communication skills, and contribute to professional and public service. Candidates for the senior ranks must have an excellent record of professional accomplishments.

Responsibilities include: teaching and developing undergraduate and graduate courses; supervising graduate and undergraduate student research; developing and directing a funded research program; publishing research results in journals and conferences; and in university, professional, and public service. Applicants in all research areas are encouraged to apply.

Jackson State University is an urban university located in Jackson, Mississippi, the capital city and a metropolitan area with a population of approximately 500,000. The department has 15 faculty members and offers both the BS and MS degrees in Computer Science, with approximately 150 undergraduate and 75 graduate students. Current faculty research interests include high performance computing, graphics and visualization, reconfigurable computing, computer networks, computer security, and information and intelligent systems. Research activities and experimental laboratory facilities in the department have received high levels of support from various federal research and infrastructure grants and contracts.

Applicants should send a letter of application, a curriculum vita, official transcripts, a brief statement of research and teaching interests and arrange for three letters of reference to be sent to: Faculty Search Committee, Department of Computer Science, Jackson State University, P. O. Box 18839, Jackson, MS 39217-1039, cscsearch@jsums.edu.

Application review begins immediately and will continue until the positions are filled. Jackson State University is an Equal Opportunity/Affirmative Action Employer. Minorities, women, and persons with disabilities are encouraged to apply.

PAUL WATSON

Jamestown Community College
Instructor

Jamestown Community College is a comprehensive community college with degree granting campuses in Jamestown and Olean in southwestern New York State. A full-time, tenure-line faculty position in computer science on the Cattaraugus County Campus in Olean, NY. Required: Bachelor's degree in computer science or related field, object oriented programming experience, and ability to teach a wide range of computer science courses. Please send cover letter, resume, college transcripts, and references to humanresources@mail.sunyjcc.edu. For more information about JCC visit our website at http://www.sunyjcc.edu/.

Milwaukee School of Engineering
Software Engineering
Milwaukee School of Engineering (MSOE) Software Engineering

The Milwaukee School of Engineering invites applications for a full-time open rank faculty position in its software engineering program. Applicants must have an earned doctorate degree in software engineering, computer engineering, computer science or closely related field, as well as relevant experience in engineering practice.

The successful candidate must be able to contribute in several areas of software engineering process and practice while providing leadership in one of the following: human-computer interaction, computer security, computer gaming, software architecture and design, and software process.

MSOE expects and rewards a strong primary commitment to excellence in teaching at the undergraduate level. Continued professional development is also expected.

Our ABET accredited undergraduate software engineering program had its first graduates in spring 2002. Founded in 1903, MSOE is a private, application-oriented university with programs in engineering, business, and nursing. MSOE's 15 acre campus is located in downtown Milwaukee, in close proximity to the Theatre District and Lake Michigan. Please visit our website at http://www.msoe.edu/.

Submit all application material via email in pdf format to se.search@msoe.edu. Applicants should include a letter of application, curriculum vitae, statement of teaching interests, and names (with email and physical addresses) of at least three references.

MSOE is an EEO/AA Employer

Murex North America
Technical Consultant – Integration

Integration analysts & consultants work with our clients throughout the whole life cycle: Pre-sale, implementation, updates and assistance. Must have a good background in CS, Engg. or related. Proficiency in Java. C++ or other OOP required.

National University of Singapore
Tenure-track Faculty Positions

The Computer Science Department of the National University of Singapore is looking to add to its tenure-track faculty at all ranks. While we encourage strong candidates from all areas to apply, we are particularly interested in the following areas:

- Human-Computer Interfaces (HCI)/ Interactive Media Design
- Computer Security
- Computational Biology

NUS is a research university, with low teaching loads, excellent facilities, ample research funding and support for conference travel. The Computer Science Department consists of active and talented faculty members working in a variety of areas. Its student body includes some of the best in the region. It offers undergraduate programs in computer science and computer engineering and a graduate program awarding Masters and PhD degrees. Salary and benefits are competitive with the top universities around the world.We seek people with excellent potential/achievements in both research and teaching. Interested candidates are requested to send the following materials to csrec@comp.nus.edu.sg:

- Curriculum Vitae
- Research Statement
- Teaching Statement

Names of at least three refereesThe interview visits for selected candidates will take place during September-October and February-March.We also seek committed teachers for our teaching track positions. We are particularly interested in people with expertise in teaching HCI and Computer Security courses.

Penn State University
Assistant Professor

Penn State Hazleton invites applications for a faculty position in Information Sciences and Technology (tenure track Assistant Professor preferred; willing to consider multi-year appointment; 36 weeks). Begin August 2008. Teach in areas such as networking, systems analysis, and systems integration using traditional and blended delivery modes; publish in refereed journals; engage in service activities. Ph.D. in Information Science is required. To learn more about the campus, visit http://www.psu.edu/ur/cmpcoll.html. To learn about the position and how to apply, visit http://www.psu.jobs/Opportunities/Opportunities.html and follow the "Faculty" link.

AA/EOE

Saint Anselm College – Computer Science
Assistant Professor

Saint Anselm College invites applications for an assistant professorship in computer science. This is a one-year position (renewable up to 3 years) to start in August 2008. Ph.D. required (will consider ABD). Duties include teaching a variety of undergraduate computer science courses and advising students. A commitment to excellence in teaching is paramount. Candidates must be supportive of the mission of this Catholic College. Saint Anselm College is committed by its mission to actively building a diverse academic community that fosters an inclusive environment. It therefore encourages a broad spectrum of candidates to apply. Applications will be accepted until the position is filled.

Applicants should send a letter of application, a curriculum vita, and contact information for three references to:

Professor Carol Traynor
Chair, Department of Computer Science
Saint Anselm College
Box 1658
100 Saint Anselm Drive
Manchester, NH 03102-1310
[Phone: (603) 656-6021]
[E-mail: ctraynor@anselm.edu]

The Catholic University of America Washington D.C. 20064
Tenure-Track Position
Assistant/Associate Professor in Computer Engineering/Science

The Department of Electrical Engineering and Computer Science of The Catholic University of America (CUA), invites applications for a tenure-track assistant/associate professor position in Computer Engineering/ Science beginning September 2008, or as soon as possible thereafter. All areas of research related to Computer Engineering/ Science will be considered. Applicants should hold a doctoral degree in computer engineering/science. We are seeking applicants with a strong commitment to undergraduate education and scholarly research. For appointment at the rank of associate professor, the candidate must show evidence of established research program capable of attracting external research funding. CUA is a selective undergraduate and graduate institution having programs leading to bachelors, masters and doctoral level degrees. Candidates should send curriculum vitae, statement of career objectives, and names of at least three references to:

Professor Philip Regalia, Chair, Search Committee,
Department of Electrical Engineering and Computer Science
The Catholic University of America
Washington D.C. 20064
Phone (202) 319-5879

Fax: (202) 319-5195
CUA-EECSposition@cua.edu

Review of applications will begin on March 15, 2008, and continue until the position is filled. For more information about our department, please visit our web site at http://EECS.cua.edu . The Catholic University of America was founded in the name of the Catholic Church as a national university and center of research and scholarship. Regardless of their religious affiliation, all faculties are expected to respect and support the University's mission. The Catholic University of America is an Equal Opportunity/ affirmative action Employer.

The University of Toledo

Lecturer

Computer Science & Engineering (CSE)Lorain County Community College (LCCC)University of Toledo

The Electrical Engineering and Computer Science (EECS) Department at The University of Toledo invites applications for candidates for a full-time instructional position in our CSE program located at LCCC in Elyria, OH (approximately 30 miles Southwest of Cleveland, OH) beginning immediately. The position will be a continuing non-tenure track appointment, contingent upon satisfactory performance and instructional need. Candidates must possess an earned doctorate in computer science or computer engineering, a strong commitment to teaching, and an interest in pursuing multidisciplinary applied research. Applicants for the position should submit curriculum vitae, reprints of selected publications, a narrative describing their research and teaching interests and professional goals along with the names and contact information of at least three references. The position will remain open until the appointment is made. Application materials should be submitted to Dr. Krishna Shenai, Professor and Chair, EECS Department - NI2008, MS 308, University of Toledo, 2801 W. Bancroft St., Toledo, Ohio 43606-3390. Inquiries may be addressed to krishna.shenai@utoledo.edu (Ph: 419-530-8196). The University of Toledo is an Affirmative Action Employer. Women and minorities are strongly encouraged to apply.

University of Maryland University College

Associate Provost, SSL (002383)

UMUC is seeking an Associate Provost to oversee the operations of the Securities Studies Laboratory. Requires a PhD, DSc, DM, or other terminal degree with administrative experience in information technology and information assurance or homeland security. Please visit http://www.umuc.edu/employ.shtml for a complete description and to apply.

University of Michigan – Flint

Assistant Professor of Computer Science

Duties to begin fall 2008

Visit www.umflint.edu/csesp for more information

University of Nebraska at Omaha

Associate/Full Professor of Information Assurance (IA)

The University of Nebraska at Omaha's (UNO) College of Information Science & Technology invites applications from faculty candidates for a tenure track position in Information Assurance at the Associate/Full Professor level starting fall 2008. Candidates should have a well-established, active and vigorous research program in IA or affiliated disciplines and a demonstrated ability to generate external research and development grants. Candidates must have a doctorate in CS (Computer Science) or IS (Information Systems) or a related field and have a demonstrated commitment to undergraduate and graduate education in IA. Teaching experience and publication record must be commensurate with the rank sought. Contributions to service in the form of interactions with university, business, government agencies and professional organizations are expected and important requirements for this position. The successful candidate should have the ability to obtain US government clearance. To apply and for more information please visit our web site at http://careers.unomaha.edu. All applicants are required to submit a cover letter, curriculum vita and a list of references via the web site.

Review of applications will begin immediately and will continue until the position is filled.

UNO has a strong commitment to achieving diversity. We encourage applications from under-represented groups, women and persons of color.

Virginia Tech-Advanced Research Institute

Associate Professor

The ECE Department at Virginia Tech invites applications for a tenured faculty position in information security, critical infrastructure interdependencies, and use of Information Technology in designing resilient infrastructures. The position will be at The Advanced Research Institute in Arlington Virginia. Preference will be given to candidates who currently have tenure and/or a proven record of obtaining funding in the area. Please visit http://www.jobs.vt.edu/ (Posting # 071312) for further information and the application process.

Chuck Litecky, Bipin Prabhakar, and Kirk Arnett

The Size of the IT Job Market

Comparing the U.S. IT job markets of the 1990s and 2000s.

Jobs are disappearing" and "steady erosion of IT jobs to global outsourcing" are recent themes in the media, presenting a grim outlook for IT jobs in the U.S. This underscores the importance of systematic study of the IT job market in an environment of global outsourcing [3]. Many observers feel the effect of outsourcing has been to reduce the number of IT jobs in the U.S. One approach to assess the relative effects of factors, such as outsourcing, is to study the relative size of the job market for IT personnel before the advent of global outsourcing and then compare it with the current conditions of plentiful global outsourcing.

Starting in the early 1990s, researchers have systematically sampled job advertisements. Objectives of this research stream were to determine what skills were most in demand for IT professionals, and any data presented on the size of the job markets was merely a by-product. Similarly, newspaper advertising was assessed in a longitudinal format during much of the 1990s. With the growing popularity of Internet job sites, sampling of job advertisements switched to the Internet in order to offer a longitudinal base for appraising the relative size and direction of the current job market. Current objectives are to appraise the strength and direction of today's IT job market as compared to that of the last decade and to the tumultuous early part of this decade. Continuity is achieved through consistency of the geographic locations sampled. The cities or metro areas included in the current study are those sampled in the 1990s. Early findings from this study were presented at the ACM SIGMIS/CPR conference with 2005 data [2]. This column updates the data and poses the questions: How does the IT job market of this decade compare to that of the previous decade, and Are there trends in the job market of the previous decade that may hold lessons for the near future?

Data Collection

Data collection in the 1990s was based on newspaper job ads. The major newspaper in each of the selected cities was analyzed once a year. This was a laborious, manual classification task that was aided by the development of a job skill classification taxonomy. This taxonomy was revised several times as popular job skills changed. Another major change was a switch to Internet-based job sites. After some time was spent studying the relative accuracy and effectiveness of competing job sites, the Monster.com site was selected as the research site, as it is one of the most popular job sites for IT jobs and lends itself well to sys-

tematic analysis of position advertisement trends.

The nationwide sampling of geographic locations for selection of job ads is an important aspect of the scope and continuity of this research. From the beginning, it was obvious to researchers that a systematic selection of cities to cover the geography of the U.S. would add substantially to the ability to extrapolate research results to the entire U.S. IT job market. Accordingly, this research has been based on a geographic cross section of the U.S. IT job market. This concept continued as the research migrated to the Monster.com site and extended in 2001 from the original 10 cities to the 35 metropolitan areas offered by Monster.com. For example, the job-location retrieval criterion of "Chicago" was extended to: "Chicago, North" or "Chicago, Northwest" or "Chicago, South" or "Indiana, Gary/Merrillville." The logic of this extension was that commutes from surrounding areas into a metropolitan site were becoming common.

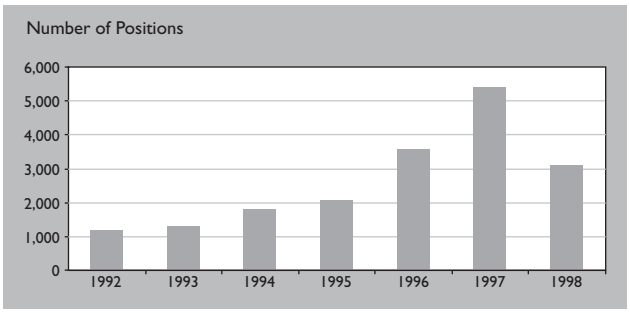


Figure 1. IT jobs in selected cities, 1992–1998.

Monster.com allows the separation of IT jobs from other jobs by general job descriptors, which are used by advertisers for each of their jobs. The job descriptor set selected was: Computer, hardware; Computer, software; Information Technology; Internet/E-commerce; and Telecommunications. Other job descriptors, such as Marketing, Accounting, and the like were not selected. Again, the IT job descriptors were also restricted to the 35 geographic locations for sampling continuity.

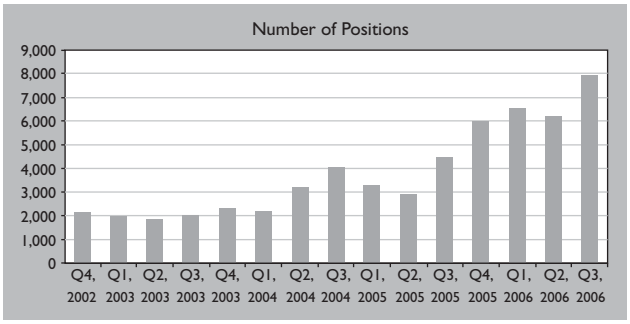


Figure 2. IT jobs in 35 selected metropolitan areas, 2002–2006.

Historical and Current Job Data

Figure 1 shows a summary of the (historical) data for the number of positions collected in the 1990s. Figure 1 summarizes the total number of open IT/IS positions in the selected cities as advertised in the newspapers of those cities on a given Sunday in that year (data collection methodology given in [4]). After 1994 there was a tremendous boom in the economy and a matching increase thereafter in the demand for and supply of IT graduates. At the end of that decade and into the start of the next, there was the dot-com downturn followed by the terrorist attacks of Sept. 11, 2001. Data collection resumed in early 2002 with a change to Internet data collection and use of the Monster.com job Web site for the same cities studied in the 1990s (details of the revised data collection methodology are given in [4]). Figure 2 summarizes total jobs by year and quarter in this decade.

The data in Figure 2, (collected for each quarter of those years), in contrast to the job market for the same cities in the 1990s shows a much restricted size for the total IT jobs advertised for the early part of this period and a much improved size more recently. Assuming the data is comparable, an interesting question is: How bad has the job market been? From the data in early 2002, immediately after the dot-com decline and the terrorist attacks of Sept. 11, 2001, it appears the number of jobs was reduced to about one-third of its peak for the same cities in the 1990s. Similar results for the depth of the market have been shown [1].

It may be that for a global economy where outsourcing is common, critical and complex development work continues to be conducted on site rather than outsourced.

What is the current condition of the job market? It seems that as of late, the job market has roughly tripled and may quadruple from its low point in early 2002. Combined with anecdotal evidence, this supports the position that the IT job market has recovered.

Conclusion

The IT job market is on an upward trend and seems to be improving in quite a dramatic fashion. It may be that for a global economy where outsourcing is common, critical and complex development work continues to be conducted on site rather than outsourced. The recent declines and low enrollments in CS and MIS programs means the number of graduates will be low enough so that, as the market improves, job demand might be even greater than in the boom times of the 1990s. The past shortages of IT personnel may well return before the end of the decade. C

References

1. Gallivan, M.J., Truex III, D.P., and Kvasny, L. Changing patterns in IT skill sets 1998–2003: A content analysis of classified advertising. *The Database for Advances in Information Systems 35*, 3 (Summer 2004), 64–90.
2. Litecky, C., Prabhakar, B., and Arnett, K. The IT/IS job market: A longitudinal perspective. *SIGMIS CPR, Proceedings of the 2006 ACM SIGMIS CPR Conference* (Pomona, CA, Apr. 2006).
3. McKinsey and Company. *The Emerging Global Labor Market.* McKinsey Global Institute; www.mckinsey.com/mgi/publications/emerginggloballabormarket/index.asp.
4. Prabhakar, B., Litecky, C., and Arnett, K. IT skills in a tough job market. *Commun. ACM 48*, 10 (Oct. 2005), 91–94.

Chuck Litecky (clitecky@cba.siu.edu) is a professor in the Department of Management at Southern Illinois University-Carbondale.

Bipin Prabhakar (Bipin.Prabhakar@uc.edu) is an assistant professor in the Department of Information Systems at the University of Cincinnati.

Kirk Arnett (kpa1@msstate.edu) is a professor in the Department of Management and Information Systems at Mississippi State University.

DOI: 10.1145/1330311.1330331

ACM's calendar policy is to list open computer science meetings that are Sponsor by ACM, sister societies, or other scientific, technical or educational tax-exempt organizations. Educational seminars, institutes, and courses are not included due to space limitations. Listings for conferences NOT Sponsor by ACM should include the title of the conference, Sponsor organization, a contact name and full address. Phone number, email address, URL and/or fax numbers are optional. Please address to: Calendar Items, CACM, 2 Penn Plaza, New York, NY 10121-0701; fax: (212) 869-0481; email: calendar@acm.org. For Conferences and Workshops Sponsor or cosponsored by ACM, the calendar listing should be included with the initial documents submitted for approval to ACM. All requests for ACM sponsorship or cooperation should be addressed to: Conference Coordinator, ACM Headquarters, 2 Penn Plaza, New York, NY 10121-0701; (212) 626-0602; email: SIGS@acm.org. The Technical Meeting Request Form (TMRF) for this purpose can be obtained from the Conference Coordinator. The TMRF should be submitted at least nine months in advance of the event to ensure time for processing the approval and to accommodate lead time for CACM listings.

The ACM calendar and calls can also be accessed on-line via the URL http: //www.acm.org/events/coe.html. For further details please contact webmaster@acm.org

Conferences receiving ACM sponsorship/co-sponsorship or cooperation are noted in boldface.

2008

April 13-16

International Symposium on Physical Design Portland, OR, Contact: David Pan, Phone: 512-471-1436, Email: dpan@ece.utexas.edu

April 13-16

Spring Simulation Multiconference Ottawa, ON, Contact: Hassan Rajaei, Phone: 419-372-2002, Email: rajaei@cs.bgsu.edu

April 14-15

Eurographics 2008 Symposium on Parallel Graphics and Visualization Crete, Greece, Contact: Daniel Weiskopf, Phone: 49-711-7816-368, Email: weiskopf@vis.uni-stuttgart.de

April 14-16

FLOPS08: 9th International Symposium on Functional and Logic Programming Ise, Japan, Contact: Manuel V Hermenegildo, Phone: 34 91 336 7435, Email: herme@fi.upm.es

April 18-19

Consortium for Computing Sciences in Colleges (CCSC) South Central Corpus Christi, TX, Contact: James R Aman, Phone: 773-298-3454, Email aman@sxu.edu

April 21-25

WWW08: The 17th International World Wide Web Conference Beijing, China, Contact: Yih-Farn Robin Chen, Phone: 973-360-8653, Email: chen@research.att.com

May 1-3

MICA08: Milestones in Computer Algebra 2008, Contact: Stephen M. Watt, Phone: 519-661-4244, Email: Stephen.watt@uwo.ca

May 4-6

Great Lakes Symposium on VLSI 2008 Orlando, FL, Sponsored: SIGDA, Contact: Vijay Narayanan, Email: vijay@cse.psu.edu

May 5-7

CF '08: Computing Frontiers Conference Ischia, Italy, Contact: Alex Ramirez, Email: alex.ramirez@bsc.es

May 5-8

FMX08: 13th International Conference on Animation, Effects, Realtime and Content Stuttgart, Germany, Contact: Thomas Haegele, Phone: 490-714-1969-800, Email: Thomas.haegele@filmakademie.de

May 10-18

International Conference on Software Engineering Leipzig, Germany, Contact: Wilhelm Schaifer, Email: wilhlem@upb.de

May 12-16

7th International Conference on Autonomous Agents and Multi Agent Systems Estoril, Portugal, Contact: David C. Parkes, Phone: 617-384-8130, Email: parkes@eecs.harvard.edu

May 17-20

Symposium on Theory of Com-

PUTING CONFERENCE 2008 Victoria, Canada, Contact: Venkatesh Srinivasan, Phone: 250-472-5731, Email: venkat@cs.uvic.ca

May 27-29

THE INTERNATIONAL CONFERENCE ON ADVANCED VISUAL INTERFACES Naples, Italy, Contact: Stefano Ledialdi, Phone: 39-6-88-41962, Email: levialdi@di.uniroma1.it

May 28-30

THE 18TH INTERNATIONAL WORKSHOP ON NETWORK AND OPERATING SYSTEMS SUPPORT FOR DIGITAL AUDIO AND VIDEO Braunschweig, Germany, Contact: Lars C Wolf, Phone: 49-531-3913288, Email: wolf@ibr.cs.tu-bs.de

June 7-13

ACM SIGPLAN CONFERENCE ON PROGRAMMING LANGUAGE DESIGN AND IMPLEMENTATION Tuscon, AZ, Contact: Rajiv Gupta, Phone: 951-827-2558, Email: gupta@cs.ucr.edu

June 9-12

INTERNATIONAL CONFERENCE ON MANAGEMENT OF DATA Vancouver, Canada, Sponsored: SIGMOD, Contact: Laks V.S. Lakshmanan, Phone: 604-822-3153, Email: laks@cs.ubc.ca

June 11-13

IDC08: 7TH INTERNATIONAL CONFERENCE ON INTERACTIVE DESIGN AND CHILDREN Chicago, IL, Contact: Justine Cassell, Phone: 847-491-3534, Email: justine@media.mit.edu

June 15-20

JCDL '08: JOINT CONFERENCE ON DIGITAL LIBRARIES Pittsburgh, PA, Contact: Ronald Larsen, Phone: 412-624-5139, Email: rlarsen@pitt.edu

June 18-20

IEA/AIE-2008: 21ST INTERNATIONAL CONFERENCE ON INDUSTRIAL, ENGINEERING, & OTHER APPLICATIONS OF APPLIED INTELLIGENT SYSTEMS Wroclaw, Poland, Contact: Moonis Ali, Email: ma04@txstate.edu

June 19-21

19TH ACM CONFERENCE ON HYPERTEXT AND HYPERMEDIA Pittsburgh, PA, Sponsored: SIGWEB, Contact: Dr. Peter Brusilovsky, Phone: 412-6249404, Email: peterb@pitt.edu

June 21-25

THE 35TH ANNUAL INTERNATIONAL SYMPOSIUM ON COMPUTER ARCHITECTURE Beijing, China, Contact: Kai Li, Phone: 609-258-4639, Email: li@cs.princeton.edu

June 23-26

WOSP '08: WORKSHOP ON SOFTWARE AND PERFORMANCE Princeton, NJ, Phone: 908-615-4524, Email: beto5599@yahoo.com

June 23-27

HPDC '08: INTERNATIONAL SYMPOSIUM ON HIGH PERFORMANCE DISTRIBUTED COMPUTING Boston, MA, Contact: Manish Parashar, Phone: 732-445-5388, Email: parashar@caip.rutgers.edu

June 30- July 2

ITICSE '08: 13TH ANNUAL CONFERENCE ON INNOVATION AND TECHNOLOGY IN COMPUTER SCIENCE EDUCATION Madrid, Spain, Contact: June Amillo, Phone: 349-133-67427, Email: amillo@fi.upm.es

July 2-4

DISTRIBUTED EVENT-BASED SYSTEMS CONFERENCE Rome, Italy, Contact: Baldoni Roberto, Email: baldoni@dis.uniroma1.it

July 3-4

EUROPEAN CONFERENCE ON INTERACTIVE TELEVISION 2008 Salzburg, Austria, Contact: Manfred Tscheligi , Email: Manfred.tscheligi@sbg.ac.at

July 7-11

EUROPEAN CONFERENCE ON OBJECT ORIENTED PROGRAMMING Paphos, Cyprus, Contact: Jan Vitek, Email: jv@cs.purdue.edu

July 12-16

GECCO '08: GENETIC AND EVOLUTIONARY COMPUTATION CONFERENCE Atlanta, GA, Contact: Hod Lipson, Email: hod.lipson@cornell.edu

July 20-23

INTERNATIONAL SYMPOSIUM ON SYMBOLIC AND ALGEBRAIC COMPUTATION Linz/Hagenberg, Australia, Contact: Juan R. Sendra, Phone: 341-885-4902, Email: rafael.sendra@uah.es

July 20-24

INTERNATIONAL SYMPOSIUM ON SOFTWARE TESTING AND ANALYSIS Seattle, WA, Contact: Barbara G. Ryder, Phone: 732-445-6430 x3699, Email: ryder@cs.rutgers.edu

July 21-25

MOBIQUITOS08: 5TH ANNUAL INTERNATIONAL CONFERENCE ON MOBILE AND UBIQUITOUS SYSTEMS: COMPUTING, NETWORKING AND SERVICES Dublin, Ireland, Contact: Liviu Iftode, Phone: 732-445-2001, Email: iftode@cs.rutgers.edu

July 22-30

OREGON PROGRAMMING LANGUAGES SUMMER SCHOOL Eugene, OR, Contact: Yannis Smaragdakis, Phone: 541-346-3491, Email: yannis@cs.uoregan.edu

September 1-3

8TH INTERNATIONAL CONFERENCE ON INTELLIGENT VIRTUAL AGENTS Tokyo, Japan, Contact: Helmut Prendinger, Email: helmut@nii.ac.jp

September 2-5

10TH INTERNATIONAL CONFERENCE ON HUMAN COMPUTER INTERACTION WITH MOBILE DEVICES AND SERVICES, Henri Hofte, Phone: 31-575-516319, Email: henri.terhoft@telin.nl

September 8-11

PRINCIPLES AND PRACTICE OF PROGRAMMING IN JAVA 2008 Modena, Italy, Contact: Giacomo Cabri, Phone: 39-059-2056190, Email: giacomo.cabri@unimore.it

September 8-12

12TH INTERNATIONAL SOFTWARE PRODUCT LINE CONFERENCE 2008 Limerick, Ireland, Contact: Lero Klaus Pohl, Email: klaus.polhl@sse.uni-due.de

September 16-19

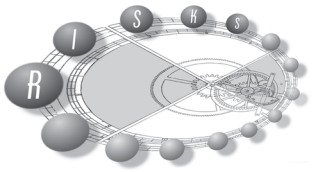
ECCE08: EUROPEAN CONFERENCE ON COGNITIVE ERGONOMICS Madeira, Portugal, Contact: Joaquim A. Jorge, Phone: 351-21-3100363, Email: jaj@inesc.pt

September 20-23

THE 10TH INTERNATIONAL CONFERENCE ON UBIQUITOUS COMPUTING Seoul, South Korea, Contact: Joseph McCarthy, Phone: 650-804-6987, Email: joe@interrelativity.com

September 22-23

MULTIMEDIA AND SECURITY WORKSHOP Oxford, United Kingdom, Sponsored: SIGMM, Contact: Andrew David Ker, Phone: +44 1865 276602, Email: adk@comblab.ox.ac.uk



A Current Affair

It's not a revelation that as a society we're often amiss when it comes to properly prioritizing technological issues. So it should be no surprise that one of the most significant upcoming changes in our physical infrastructure is getting little play not only in the mass media, but in technology-centric circles as well.

There are increasing concerns that many persons in the U.S. are still unaware that virtually all over-the-air analog television signals are slated to cease in February 2009 as part of the conversion to digital TV (although betting against a Congressionally mandated extension at this time might be problematic). Yet it seems that almost nobody is talking about a vastly more far-reaching transition that is looming in our future just 12 years from now.

Hopefully, you realize that I'm talking about the Congressionally ordered Development Initiative for Return to Edison Current Technology (DIRECT) and its core requirement for all public and private power grids in this country to be converted from AC to DC systems by 2020, with all new consumer and business devices using electricity to be capable of operating directly from these new DC power grids without transitional power conversion adapters by no later than 2030.

OK, 2020 may still seem a long way off—2030 even more so. But for changes on such a scale, this is really very little time, and we'd better get cracking now or else we're likely to be seriously unprepared when the deadlines hit. It's really too late at this stage to reargue whether or not switching from AC to DC makes sense technologically. Personally, I find the arguments for the conversion to be generally unconvincing and politically motivated.

As you may recall from those purposely late-night hearings on C-SPAN, significant aspects of the conversion have been predicated on anti-immigrant rhetoric. Many of those emotionally loaded discussions focused on the supposed "national shame" of our not using the "rock-solid stable" direct current power system championed by American hero Thomas Edison, and instead standardizing many years ago on an "inherently unstable" alternating current system, developed by an eccentric Croatian immigrant who enthusiastically proposed ideas characterized as grossly un-American—such as free broadcast power.

PAUL WATSON

Similarly, it's easy to view the associated legislative language as largely a giveaway to the cryogenics industry, which of course stands to profit from the vast numbers of superconducting systems that will be necessary to create large, practical DC grids. Conversion proponents pointed at existing long-distance DC transmission facilities, such as the Pacific DC Intertie, and the success of the conventional telephone system largely operating on DC current. But the Intertie is a highly specialized case, and even the phone system has relied on AC current for telephone ringing purposes.

But this is all water over the spillway. There is a lot of money to be made from this power transition. Stopping it now looks impossible. And admittedly, it's difficult to argue very convincingly against the ability to do away with device power supplies that are needed now to convert wall current AC into DC, or against the simplicity of DC current when powering future generations of LED bulbs that will presumably replace both incandescents and mercury-laden fluorescents.

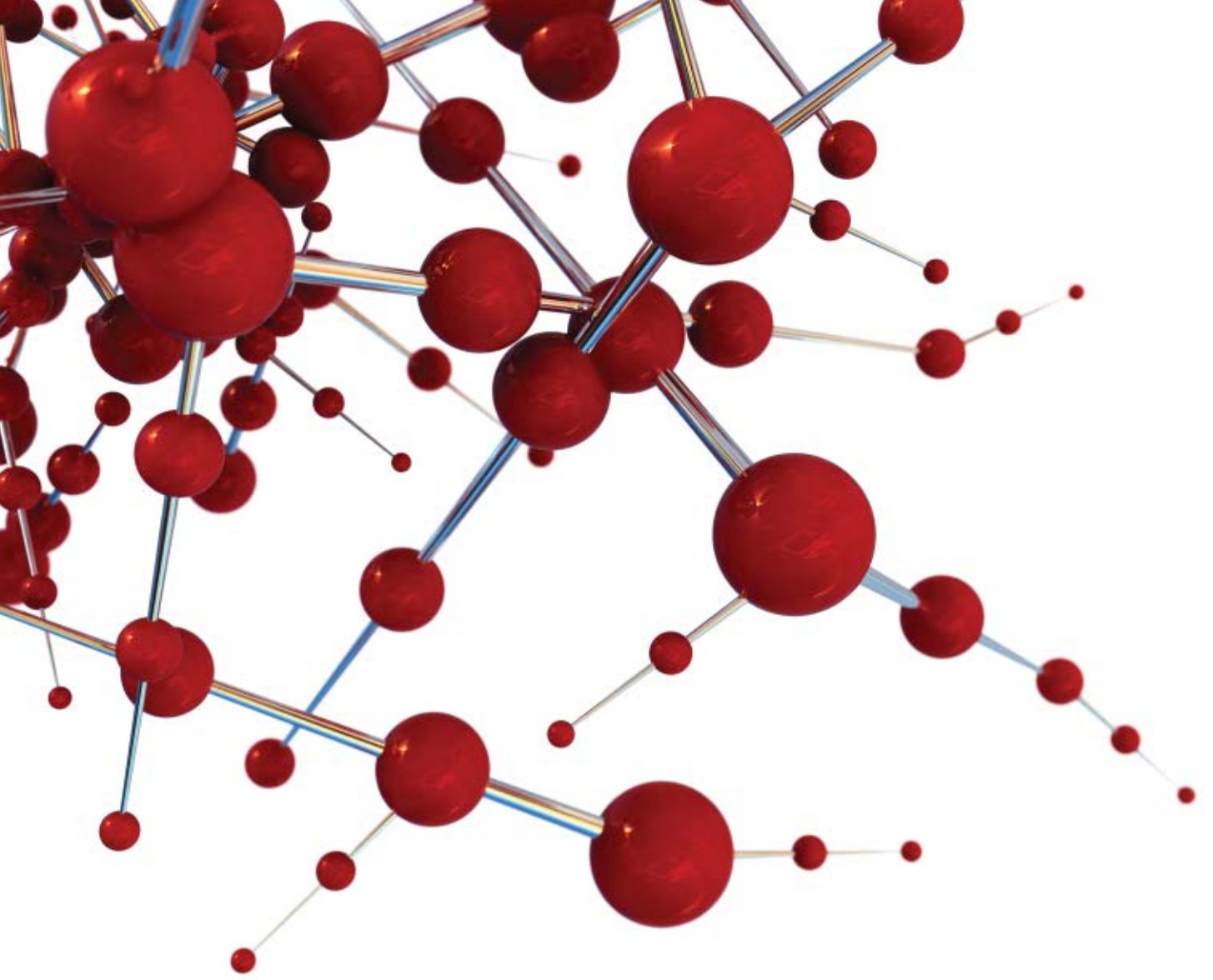
It's also true that much additional employment will be created, at least in the short term. Workers will be needed to install the new DC generating plants, distribution components, and power meters. Also, the many AC transformers hanging on poles and buried in vaults all over the U.S. will need to be bypassed.

Still, from a public-policy standpoint, I'd be lying if I didn't state outright that, in my opinion, this entire affair is a risky fiasco, from political, economic, and even safety standpoints. For example, because Congress required that the same style wall sockets and plugs be retained for new DC devices as have long been used by existing AC products, we're sure to see RISKS horror stories galore about damaged equipment, and injured—even killed—consumers, when they run afoul of nasty power confusion accidents.

Freewheeling AC/DC may be great for a rock band, but it's no way to manage technology. While we can't unplug this coming mess, we should at least internalize it as an object lesson in how special interests and jingoistic propaganda can distort technology in ways that are counterproductive, dangerous, and even...shocking. C

Lauren Weinstein (lauren@pfir.org) is co-founder of People for Internet Responsibility (www.pfir.org). He moderates the Privacy Forum (www.vortex.com/privacy).

DOI: 10.1145/1330311.1348684



essays, {craft, art, science} of software, python, eclipse, agile development, onward!, {generative, functional} programming, .net, open source, concurrency, smalltalk, aspects, second life, ruby, service-orientation, objects, embedded, ultra large scale {model, test}-driven passion, fun!, agents, domain-specific use cases, movies, lightning talks, systems, objective-c, development, c#, design patterns, languages, wiki, product-lines, java, refactoring, plop

OOPSLA

2008 NASHVILLE

DEFINE THE FUTURE OF SOFTWARE

www.oopsla.org/submit

CONFERENCE CHAIR
GAIL E. HARRIS
Instantiated Software Inc.
chair@oopsla.org

PROGRAM CHAIR
GREGOR KICZALES
University of British Columbia
papers@oopsla.org

ONWARD! CHAIR
DIRK RIEHLE
SAP Research
onward@oopsla.org

CALL FOR PAPERS
March 19, 2008
Due date for Research Program, Onward!, Development Program, Educators' Symposium, Essays and proposals for Tutorials, Panels, Workshops and DesignFest

July 2, 2008
Due date for Development Program Briefs, Doctoral Symposium and Student Volunteers

Association for Computing Machinery

NASHVILLE CONVENTION CENTER, NASHVILLE, TN
October 19 - 23, 2008