**2015 IEEE Services Congress**
**IEEE BigData Congress**

**June 27 - July 2, 2015, New York, USA**

1. IEEE 12th International Conference on Services Computing (SCC 2015)
2. IEEE 8th International Conference on Cloud Computing (CLOUD 2015)
3. IEEE 4th International Congress on Big Data (BigData Congress 2015)
4. IEEE 22nd International Conference on Web Services (ICWS 2015)
5. IEEE 4th International Conference on Mobile Services (MS 2015)
6. IEEE 11th World Congress on Services (SERVICES 2015)

**Submission Deadlines**
- 1/15/2015 ICWS 2015 (http://icws.org)
- 1/15/2015 CLOUD 2015 (http://theCloudComputing.org)
- 1/31/2015 SCC 2015 (http://conferences.computer.org/scc)
- 1/31/2015 MS 2015 (http://theMobileServices.org)
- 2/10/2015 BigData Congress 2015 (http://ieeeBigData.org)
- 2/10/2015 SERVICES 2015 (http://ServicesCongress.org)

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Enabling the Internet of Things
ROY WANT, BILL N. SCHILIT, AND SCOTT JENSON

Second-Generation Big Data Systems
FADI H. GEBARA, H. PETER HOFSTEE, AND KEVIN J. NOWKA

Cybersecurity: From Months to Milliseconds
PETER FONASH AND PHYLLIS SCHNECK
JANUARY 2015
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For more information on computing topics, visit the Computer Society Digital Library at www.computer.org/csdli.
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A Time of Change

Tom Conte, IEEE Computer Society 2015 President

As aspects of computing undergo massive transformation, the Computer Society and the profession itself are at a special inflection point. The Society is adapting to these changes to remain valuable and useful to you, its members.

Since the days of John von Neumann and Alan Turing, the computing field has followed a set of design choices that led to exponential performance scaling, in which single-processor performance doubled every 18 months. Many people mistakenly refer to this as Moore’s law—after Intel founder and Silicon Valley pioneer Gordon Moore. But Moore instead predicted a doubling in the number of transistors per unit area every two years (now 18 months). In 2004, however, Moore’s law and exponential computer-performance scaling parted ways due to thermal constraints. Although we continued to produce more transistors during the past decade, 11 nanometers is only marginally better than 14 nm, which is only marginally better than 22 nm.

In response, the computing field shifted to thread-level parallelism, and the multicore era began. But parallelism and multicore computing likewise failed to return us to exponential computer-performance scaling. The reason was simple: not everything can be parallelized. Now, 10 years into the multicore era, even Moore’s law is reaching its limits: the doubling of transistors per unit area is slowing down as well and is projected to end at 7 nm circa 2020.

Meanwhile, the need for faster computers hasn’t slowed. If fact, with advances in machine learning, the demand is greater than ever. We need to rethink the fundamental decisions we made along the way to consider whether—had we gone down a different path, taken a right turn instead of a left—we would still be experiencing exponential performance scaling.

In 2013, IEEE started the Rebooting Computing initiative (http://rebootingcomputing.ieee.org), which I co-chaired with Elie Track, 2014 president of the IEEE Council on Superconductivity. We gathered a team of experts, held three summits, and explored interesting possibilities for an effective way forward toward renewed exponential scaling. None of these will be easy; each of these possibilities requires a fundamental shift in the computer industry and thus necessitates a significant investment from government and industrial channels. But we have no choice: we must explore these alternatives. Returning computing to its historic exponential performance scaling trends is critical to ensure the continuation of computing’s benefits to society.

THE COMPUTER SOCIETY MUST ALSO CHANGE

As computing is itself at an inflection point, so too is the CS. Many of our activities are either in the process of or about to begin rapidly changing. The way we communicate, publish, educate our members, and so on are all in flux. The CS must update its structure to position itself for this change, or it will cease to be a society that serves its members.
My immediate predecessor, Past-President Dejan Milojčić, undertook an aggressive agenda to revitalize the Society, and I will continue his initiatives. Specifically, I will focus on advancing the strategic directions identified in the CS’s three-year plan, including taking the lead in next-generation conferences and publications, supporting and delivering high-quality professional education to our members, listening to all of our constituent communities, and in general providing value to you, our members.

NEXT-GENERATION CONFERENCES AND PUBLICATIONS

We still think of articles in terms of 8½” × 11” pages, even though all of our content—including Computer—is read on electronic devices by the vast majority of our members. But the digital publishing revolution has come to the CS, and we must think in terms of free-flow content (like Kindle e-books). The transformation doesn’t stop at format though; the content itself can no longer be static.

When I discuss this shift with undergraduate students, their reactions reveal more than a little disbelief. “How could you not see this coming?” they ask. These future members no longer turn pages. They think printed books are as quaint as my Walkman—obsessed generation regarded the transistor radio. Today they disseminate ideas online, and even reputations are based on social media principles. Take, for example, stackoverflow.com: good, technically sound answers can contribute to one’s professional standing in much the same way as patents and peer-reviewed publications.

Change is never easy, and this is quite a shift in thinking for many of us. What will it mean for your peers to review your “paper”? Will people need to physically be at a conference, or will virtual attendance be a welcome middle ground between traveling and just reading the proceedings? What will it mean to disagree with an aspect of a published article? Could the author have a chance to address errors directly? Will each paper become a living document, with versions and revision histories (think: an IEEE Transactions on Computers Github)?

I’m proud of the huge step the CS has taken in embracing next-generation magazines and journals, and I’m excited about how it means for us as a Society. I was the vice president of publications when our volunteer leaders decided to move our magazines to a primarily digital format. We weighed such factors as the changing behavior of our readership, the potential for enriching our content, and the ability to reach new communities. As the CS blazes a trail, we find ourselves one of the leaders in STEM publishing. But this is only the first step. We have much more to do!

So that the infrastructure for the new ways of conferencing and publishing is in place for our members, we need to anticipate the future and set things in motion now. We are our members. If you have an idea, tell the CS leadership—let’s go try it out!

SUPPORT AND DELIVER HIGH-QUALITY PROFESSIONAL EDUCATION

The CS engages in educational activities to prepare members for their pre-professional and professional careers as practitioners engaged in disciplines such as computer engineering, computer science, information technology, information systems, systems engineering, and software engineering. Our educational offerings should be of high value to our members.

The need for high-quality, just-in-time, practitioner-focused education is great. Much like the revolution in publishing, this revolution will require experimentation. For example, at Georgia Tech we’re offering an online master’s in computer science degree program. This program isn’t for everyone, so traditional in-person and workshop-based delivery will continue. However, tomorrow’s workforce will expect the option to get their continuing education online. Many of you are leaders in the online higher education revolution. As with publishing, if you have new ideas, let the CS leadership know and we’ll try them out!

REACHING OUT TO SERVE AND LISTEN TO EVERYONE

The CS leadership determined a number of years ago that the Society was becoming very research/academic focused. We made a concerted effort to better address our practitioner members’ needs, beginning certification programs and establishing an Industrial Advisory Board. It worked: our professional practitioner members now look to the CS as a source for information, lifelong learning, and career guidance.

Some in the research community wonder, I think rightly, if the pendulum might have swung too far in the
PRESIDENT’S MESSAGE

Let’s get started! This is a special time in the history of both computing and the CS. The CS leadership needs your help to “get it right.” You are the CS. If you want to be involved in plotting the future of this Society, please—I want to hear from you. Let’s be the revolutionaries. Let’s reboot!

I had the privilege of being the President-Elect during the term of 2014 President Dejan Milošijić. Dejan has done many things to strengthen the CS and position us for success in the future. At the same time, I’ll have the pleasure of serving with 2015 President-Elect Roger Fujii, who is an accomplished engineer and industry executive. Your Society is in good hands.

Another population that we’ve taken for granted is our computer engineering members. These are performance-oriented computer professionals, often with computer engineering degrees from accredited programs around the world. As electrical engineers who specialize in computing, there’s no more natural home for them than the CS. I will seek to engage this community, starting with the student population, and welcome them to contribute actively to the Society.

One of my goals is to strengthen and empower the community of research engineers and scientists. To that end, I have asked Harold Javid of Microsoft Research to establish a Research Advisory Board to serve as a counterweight and give voice to this community. Similarly, I have asked vice president of Technical & Conference Activities Phillip Laplante to consider ways to restructure the Society so that our technical communities have a larger leadership role.

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Sustaining Computer’s Impact and Adapting to Change

Sumi Helal, University of Florida

Computer’s 2015–2016 Editor in Chief, Sumi Helal, describes plans to sustain Computer’s momentum, audience engagement, and ability to adapt to changes.

Computer’s mission is to be the primary source for timely technical information and an indispensable resource for learning and understanding the advances and emerging trends in computing theory, practice, applications, and technology. As the flagship publication of the IEEE Computer Society, Computer also serves as a communication platform between the Computer Society and its members by publishing and highlighting Society news, awards, and benefits—including the many products and services it offers.

I am honored to serve as Computer’s 2015–2016 editor in chief (EIC) after a six-year stint as an associate EIC (AEIC) under past EICs Ron Vetter (2011–2014) and Carl Chang (2007–2010). Ron dramatically reenergized Computer with an effective content development model and bolstered the magazine’s multimedia foothold. Carl successfully launched many initiatives; a particular success was the establishment of Computer’s Industrial Advisory Board (IAB), which went on to become the IAB for the whole of the Computer Society.

SUSTAINING THE MOMENTUM

My plans for Computer are to sustain its current momentum and successes, to make necessary adaptations to cope with changes and advances in the field, to venture a little by trying a few new things, and to make sure Computer editorial board, I will appoint three to four new members annually. New appointments will bring additional energy and perspectives to help us keep up with fast-paced changes in research, technology, and practice. Computer’s increased emphasis on multimedia content is an important component of its future success, and I will continue to support this, along with the editorial board and staff, by appointing Charles (Chuck) Severance as the Associate Editor in Chief of Multimedia. Through Chuck’s diligent efforts, his Computing Conversations column has been a great hit—featuring interviews with luminaries in the field from both the past and present. I plan to sustain this successful yet demanding multimedia endeavor by allocating more resources and appointing an additional editor to assist Chuck as he initiates even more conversations. In addition, with help from Computer’s multimedia staff editor Brian Brannon, members of the editorial board will increasingly participate in interviewing article and column authors.

Computer’s healthy number of diverse and interesting columns and departments is another feature that I wish to enhance. I will add three to five new columns to the current list of 14 that currently run monthly or bimonthly. The quantity, diversity, and quality of Computer’s columns add great value and appeal for our readers.
EIC’S MESSAGE

CONTENT-DEVELOPMENT PROCESS
Timely special issues on emerging topics and applications are the mainstay of Computer’s content. Special issues typically include four to five articles. You are invited to submit proposals to Bill Schilit, Computer’s special issues AEIC, provide a key differentiator between accessing digital Computer as a member and accessing its articles from the IEEE Xplore digital library or Qmags editions as a nonmember. I will examine this possibility further with the editorial board and the Computer Society leadership.

Computer will continue its efforts to be more inclusive of and relevant to a younger audience.

for consideration. The editorial board also cultivates its own timely special issue proposals from prominent academicians and practitioners. The board meets annually to create the editorial calendar based on general submissions and proposed special issues.

To round out our peer-reviewed Research Features (technical articles that describe significant computing advances in a language our broad readership can understand), Perspectives (articles providing stimulating commentary on a topic of interest to computing professionals), and Computing Practices (reports on practical experience and solutions), Computer will continue to publish timely columns and departments. Column editors are highly encouraged to periodically invite guest authors who are considered to be pioneers in their field to contribute a column.

ENGAGING OUR AUDIENCE
Our readers should feel empowered to truly become part of the magazine. This is the expectation today in many online-only publications, and should be the case for Computer as it moves to a predominantly digital format. Many topics covered in each issue invite useful and stimulating discussions. If we are able to overlay Computer articles, columns, and departments with a discussion layer, we will create a valuable engagement channel that boosts the value of our content. Additionally, this discussion layer could

Computer will continue its efforts to be more inclusive of and relevant to a younger audience of college students and the emerging, fast-growing maker community. The December 2014 issue, guest edited by Intel’s Brian David Johnson, provided a glimpse of what this young audience has to offer to the rest of our readership. A new Student Design Showcase column, exclusively dedicated to this component of our audience and edited by Greg Byrd, will begin appearing regularly with the February issue.

Awards will also be an important part of our new engagement model. By awarding the most influential authors, the most useful reviewers, and even the most active readers (discussants), Computer increases its value and further stimulates member engagement.

EDITORIAL BOARD UPDATES
We are grateful to Ron Vetter for his diligent work in executing the improvements that helped Computer achieve its current level of success and prominence. Ron will continue with us in a new role as a member of the advisory board. Also joining the advisory board is Savitha Srinivasan, who is stepping down as Multimedia Area Editor (AE).

After 17 years of dedication and hard work, Jennifer Stout, the Computer Society’s manager of editorial services and Computer’s long-time clutch player, decided to step down to pursue other ventures. We are grateful to Jenny for her great service and tremendous professionalism, and we wish her all the best in her future plans. Carrie Clark, Computer’s managing editor, will continue to fill in until recruitment is completed for Jenny’s replacement.

After 10 years of service as AEIC for Research Features, Kathleen Swigger is also stepping down, passing the torch to Ying-Dar Lin. We welcome Ying-Dar to his new role as AEIC and appreciate the commitment Kathleen has shown over the years.

Also stepping down are Graphics and Multimedia Area Editor Oliver Bimber, Invisible Computing Column Editor Albrecht Schmidt, and Entertainment Computing Column Editor Kevin Sung. We thank them for their dedication and wish them all the best.

Starting with the January 2015 issue, we welcome five new editorial board members whose appointments have been confirmed by the IEEE Computer Society Publications Board. These new members’ roles along with changes to areas are described below.

NEW AREAS AND COLUMNS
Computer’s area coverage will adapt in response to significant recent advances in the field. Six new areas have been established (Internet of Things; Big Data and Data Analytics; Vision, Visualization, and Augmentation; Cloud Computing; Identity Sciences and Biometrics; and Green and Sustainable Computing), three of which were previously covered as columns (Green IT, Discovery Analytics, and Identity Sciences); the Cloud Computing column will continue to be edited by San Murugesan. Computer will also add two new columns.

Google’s Roy Want will serve as the new Internet of Things AE. Roy, along with other colleagues from Google, contributes one of the Outlook articles in this issue (“Enabling the Internet of Things”), which eloquently articulates the R&D roadmap for the IoT area.

Naren Ramakrishnan from Virginia Tech, who served as Information
and Data Management AE, will now be joined by Google’s Ravi Kumar; the two will jointly serve as the new Big Data and Data Analytics AEs. Another Outlook article in this issue comes from the IBM Research Lab in Austin, Texas (“A Second Generation of Big Data Systems”), and it presents an overview of how emerging technology and new applications are driving big data systems to undergo significant changes.

Mike Daily of HRL Laboratories will serve as the new Vision, Visualization, and Augmentation AE (see “New Computer Area” sidebar). This new area, which caters to the convergence of Computer Vision, Visualization, and Augmented Reality, replaces Graphics and Multimedia.

Schahram Dustar from the Technical University of Vienna will serve as the new Cloud Computing AE. This new area covers cloud performance and elasticity, cloud security, mobile cloud, and numerous issues related to utilizing software, platform, or infrastructure as services.

Karl Ricanek from the University of North Carolina Wilmington, who previously edited the Identity Sciences column, will serve as the Identity Science and Biometrics AE.

Kirk Cameron from Virginia Tech, who previously edited the Green IT column, will serve as the new Green and Sustainable Computing AE.

Antti Oulasvirta from Aalto University in Finland will serve as editor of the new column, Indistinguishable from Magic, which fosters a closer examination of interactive technologies and addresses broader human–computer interaction issues.

Finally, Greg Byrd from North Carolina State University, who has been an AE of Computer Architecture, will edit the Student Projects Showcase column, as described above.

**IN THIS ISSUE**

In addition to the aforementioned Internet of Things and big data systems “Outlook” articles, we also have a perspective from the US Department of Homeland Security’s Peter Fonash and Phyllis Schneck on future cybersecurity challenges. The article, “Cybersecurity: From Months to Milliseconds,” highlights new threats and requirements triggered by the advent of the IoT.

The fourth Outlook article, “Interoperable Privacy-Aware E-Participation within Smart Cities,” is by Constantinos Patsakis, Paul Laird, Michael Clear, Mélanie Bourrochea, and Agusti Solanas, and contributes algorithms that help guarantee citizens’ privacy as they participate in future smart-city applications (such as crowdsensing and crowdsourcing).

**NEW COMPUTER AREA: VISION, VISUALIZATION, AND AUGMENTATION**

**Mike Daily,** HRL Laboratories

Computer vision is the science behind converting high-dimensional data obtained from sensors into computable representations that enable our understanding of the sensor’s environment. Similarly, visualization describes representations of information and knowledge depicted in visual form—giving rise to “aha!” moments for human viewers who can visualize previously hidden aspects of their data. Human capability and performance can be made “better, stronger, faster” through computer augmentation, which is perhaps the central unifying aspect of modern technology.

This new area focuses on the challenges facing these technologies, which are thought to form a powerful triangle—taking sensor data and converting it into representations (computer vision), taking representations in the context of their surroundings and forming images (visualization), and using the information from visualizations for improved modes of interaction and functioning (augmentation).

Computer solicits articles from this area, particularly new perspectives on the underlying theory, models, data, technologies, and applications that address this triangle as a whole or its parts, as well as related areas.

**SUMI HELAL** is a professor in the Department of Computer and Information Science and Engineering at the University of Florida. He also directs the Mobile and Pervasive Computing Laboratory and the Gator Tech Smart House (an experimental facility for human-centric and Internet of Things research in support of smart health and managing disabilities and aging). He received a BS and an MS in computer engineering from Alexandria University, Egypt, as well as an MS and a PhD in computer science from Purdue University. Helal is a founder of two start-up companies and a Fellow of IEEE. Contact him at sumi.helal@gmail.com.

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Selected CS articles and columns are also available for free at [http://ComputingNow.computer.org](http://ComputingNow.computer.org)
Computer Highlights Society Magazines

The IEEE Computer Society’s lineup of peer-reviewed technical magazines cover cutting-edge topics in computing, including scientific applications, Internet computing, machine intelligence, pervasive computing, security and privacy, digital graphics, and computer history. Select articles from recent issues of other Computer Society magazines are highlighted below.

Software

Once a network of networks, the Internet has become not just the platform of choice for delivering services to increasingly mobile users but also the connective tissue among people, information, and things. The January/February 2015 issue of IEEE Software presents six cover features focusing on the Internet and beyond, as well as a roundtable, “The Future of Software Engineering for Internet Computing,” in which seven research leaders discuss important issues that will shape this field.

Security & Privacy

In 2013, the US Federal Energy Regulatory Commission approved cybersecurity regulations for the bulk electric system. The Critical Infrastructure Protection standards place the power industry, rather than federal regulators, at the center of design and enforcement. Critics argue that the regulations are flawed—but are they actually a secret success? In “Regulating Cybersecurity: Institutional Learning or a Lesson in Futility?,” from IEEE S&P’s November/December 2014 issue, Ryan Ellis of the Harvard Kennedy School summarizes this debate.

Communications

Communications (WebRTC), a joint World Wide Web Consortium (W3C)/Internet Engineering Task Force (IETF) project. This security architecture is meant to integrate with federated Web identity systems, but it’s incompatible with identity protocols that don’t satisfy WebRTC requirements. In “Who Is Calling Which Page on the Web?,” from IEEE Internet Computing’s November/December 2014 issue, Li Li, Wu Chou, Zhihong Qiu, and Tao Cai from Huawei Shannon IT Lab present alternative architectures to fill this gap.

Privacy

Increasingly important in areas such as healthcare and gaming, automatic emotion recognition focusing on the whole body and not just facial expressions poses significant research challenges. “Automatic Emotion Recognition Based on Body Movement Analysis: A Survey,” by Haris Zacharatos and Yiorogos Chrysanthou of the University of Cyprus and Christos Gatzoulis of Bahrain Polytechnic, from the November/December 2014 issue of IEEE CG&A, considers what’s been learned in this field so far.

Intelligent Systems

As AI research continues, the line between humans and machines begins to blur—even though human-level AI remains impossible to achieve. The November/December 2014 special issue of IEEE Intelligent Systems presents four cover features exploring current cyborg intelligence research, which integrates AI with biological intelligence by tightly connecting machines and biological beings—for example, via brain–machine interfaces.

Professional

As cloud computing evolves, presenting opportunities unimaginable just a few years ago for meeting the information
processing and computational needs of individuals, businesses, governments, and even entire industries, it’s important to recognize that the cloud still poses key risks and challenges. In *IT Pro’s* November/December 2014 special issue devoted to “Advances in Cloud Computing,” guest editors Irena Bojanova of the University of Maryland, Vladimir Dimitrov of the University of Sophia, and Fulvio Corno of Politecnico di Torino offer three articles that go “beyond the buzz.”

In modern scientifi c inquiry, substantial discoveries require computational training or the assistance of a computational scientist. Increasingly, leadership in high-performance computing gives nations an enormous competitive advantage in nearly every sector of the global economy, which is why many are heavily investing in domestic and collective supercomputing capabilities. In the November/December 2014 special issue of *CiSE*, guest editors James Hack of Oak Ridge National Laboratory and Michael Papka of Argonne National Laboratory present four articles focused on “New Frontiers in Leadership Computing.”

As social media location information increases, location can bridge the gap between users’ online and offl ine activities: if all information were geolocated, social media could serve important real-world tracking functions, such as election prediction, epidemic forecasting, and emergency detection. In “Graph-Based Residence Location Inference for Social Media Users,” from *IEEE MultiMedia’s* October–December 2014 issue, a team from Tsinghua University propose using social, visual, and textual information to infer missing information about location.

Although smart watches let users receive many forms of communication, there’s usually no direct way to reply. In “Text Input on a Smart Watch,” from *IEEE Pervasive Computing’s* October–December 2014 issue, Andreas Komninos and Mark Dunlop of the University of Strathclyde introduce an interaction design and an optimized alphabetic layout for smart-watch text entry.

Many critical real-time embedded systems feature complex safety-related, performance-demanding functionality. But the necessary aggressive technologies challenge time predictability and reliability. In “Timing Verification of Fault-Tolerant Chips for Safety-Critical Applications in Harsh Environments,” from *IEEE Micro’s* November/December 2014 issue, a team of authors from the Universitat Politécnica de Catalunya and Barcelona Supercomputing Center propose an approach to obtain trustworthy worst-case time execution estimates.

During the 1960s, artists and engineers began building sophisticated *video synthesizers* that produced abstract or distorted images by electronically manipulating either a video signal or the cathode ray tube on which it was displayed. Peter Sachs Collopy from the University of Pennsylvania explores this technology’s evolution in “Video Synthesizers: From Analog Computing to Digital Art,” from *IEEE Annals*’s October–December 2014 issue.

CS president emeritus Sorel Reisman’s blog on computer science education topics, “Musings from the Ivory Tower,” is online at www.computer.org/web/Musings-from-the-Ivory-Tower. The blog is a feature of the Computing Now Education page (www.computer.org/web/computingnow/education). Also included here is a range of instructional materials on topics drawn from CS conference tutorials, audio-video presentations, and interviews with leading computer science experts and technology innovators.
Carrying out Phylogenetic Analyses through Computational Model Checking

Ying Xu, University of Georgia

This installment of Computer’s series highlighting the work published in IEEE Computer Society journals comes from IEEE/ACM Transactions on Computational Biology and Bioinformatics.

Phylogenetic analysis is the main technique used to study evolutionary relationships among a given collection of organisms or homologous biomolecules, such as DNA and proteins encoded or used in these organisms. Researchers use such analyses to classify specified organisms taxonomically, determine the origins of protein-encoding genes, and infer how proteins function based on their conserved sequence motifs.

Typically, phylogenetic analysis involves two steps: constructing a phylogenetic tree or network based on the given biosequences and deriving biological information from the tree or network. Many computational methods have been developed to construct phylogenetic trees, but in most published studies the biological information from the phylogenetic trees is derived manually.

In “Temporal Logics for Phylogenetic Analysis via Model Checking” (IEEE/ACM Transactions on Computational Biology and Bioinformatics, vol. 10, no. 4, 2013, pp. 1058–1070), Jose Ignacio Requeno and his colleagues present a novel way to derive biological information from a phylogenetic tree using model-checking techniques. Specifically, the authors represent a phylogenetic tree (or a network, as they plan to do in the future) as a mathematical model using temporal logic and the hypothesized biological properties of the tree.

The authors propose a computational scheme using tools established in the fields of temporal logic and model checking to computationally determine whether the represented phylogenetic tree has the predicted properties, saving evolutionary biologists the time and effort required to manually examine the hypothesized properties against large quantities of biological data. While the presentation may be somewhat technical for readers who aren’t specialists, particularly in biology, the paper clearly outlines the overall logic.

The methodology presented in this paper can potentially be applied to other model-checking problems in data-intensive biological fields, including dynamic property analyses such as flux analyses over provided metabolic networks; dynamic property studies of biomolecular structures such as protein, DNA, or RNA structures; and inferring the structural properties of a collection of given genomes.

This work represents a new and exciting development linking fundamental computer science theories with data-intensive and increasingly model-intensive fields of modern biology. Bringing these two fields together should yield healthy advances in both.

Ignacio Requeno and his colleagues present a novel way to derive biological information from a phylogenetic tree using model-checking techniques.

YIN XU is a professor in the Department of Biochemistry and Molecular Biology at the University of Georgia. Contact him at xyn@bmb.uga.edu.
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Khan Academy was founded in 2006 when Salman Khan started recording short lectures on basic mathematics and uploading them to YouTube. Over time, these lectures expanded into new areas including history, medicine, physics, and economics. Software was also added to help track students' progress toward various learning objectives. Khan Academy is a very valuable resource for students of all ages and those needing remedial education. In 2012, computer science was added to the list of topics.

I spoke with software developer John Resig, who created the popular jQuery library, and curriculum builder Pamela Fox about Khan Academy’s addition of computer science. You can see the full interview at www.computer.org/computingconversations.

John initially joined Khan Academy to develop its software platform, but he wanted to help when Salman and others started thinking about adding computer science to the curriculum in 2011. While working on jQuery, John interacted with some of the most talented software designers in the world. But to understand how a learner might approach computer science with no prior knowledge, he revisited his own early experiences with programming.

John: I was a teenager, maybe 14 or 15, and a friend of mine came over to my house with a floppy disk. On it was a copy of QBasic with a program or two. He loaded a program that he had written that just printed something out. Up to that point, I didn’t realize that you could actually tell a computer what to do. I decided I wanted to build an environment that would replicate my early experience of being able to read, learn, and try things and share them.

Even though the Khan Academy program is called “Computer Programming,” it’s not meant to be equivalent to a college degree in the subject.

John: It’s a bit of a misnomer in that it’s not what most people think of as a computer science curriculum. At this point, we aren’t going to replace Computer Science 101 at a university. A lot of what we’re doing is encouraging students to engage in exploration for themselves, to be able to look at code and see programs that other students have written or that we’ve written. I think the most important thing we can do is be able to create that little spark and really get them excited about programming.

John built an environment that enabled experimentation and sharing, and Pamela added a curriculum and educational materials to his environment.
Pamela: I was worried that we might lose some people who weren’t able to figure it out just by exploring and tinkering. Those who needed to be explicitly told, “This is how a loop works; this is what a variable is and now you try it.” So I took the JavaScript 101 curriculum that I’d been using in various settings and produced Khan Academy-style materials. I created “talk-throughs,” which are like videos except you can actually pause at any time and use the editor to make changes, see how it happens, and then continue playing.

Pamela also created auto-graded coding challenges and peer-graded projects that are somewhat open-ended to help students assess their progress and mastery of the materials.

Pamela: For every talk-through there will be a coding challenge, and then every so often there will be a free-form creative project. This gives learners a lot of freedom as to what to do while still practicing what they’ve learned. One example is to make a fish tank after they learn functions. They create a fish function with parameters so that multiple fish can be different colors or sizes. But it’s open-ended so they can add seaweed or bubbles or whatever they want to.

The goal is to focus on the initial experience of learning to program as early as possible in the K–12 curriculum.

Pamela: Sixth grade is a good age to start learning to program syntactically. You learn the basics of some language like JavaScript, and then you start making your own programs, and then you start creating programs for projects in other classes. I have seen some of our students write programs for a science fair or make a timeline for a history assignment. As they keep going and are making programs, we really want them to be working with other people on programs because that’s one of the most important things in software development. To make great software, you have to work with other people. Working in a group requires a certain level of skill, and is also a great experience.

In addition to teaching programming, the Khan Academy computer science program aims to prepare students for a career in the field. It’s a challenge to succeed if students take their very first programming course in college. John recounted his high school experience with programming.

John: Another experience that was very formative for me was taking AP [advanced placement] computer science in high school. I had been in other AP classes like English and history with friends who were the smartest people I knew. When we got to AP computer science, I had no trouble at all, but my friends who had done well in other AP courses struggled. I realized that there are certain concepts in programming that are challenging, but if they had been taught in the right way, my fellow high school students would’ve done well in programming.

As the Khan Academy computer science curriculum is developed, it’s important to get feedback from students and teachers working with the materials.

Pamela: Getting to visit classrooms that use the curriculum is always incredibly valuable.

Anytime I interact with teachers, I always come back with a bunch of feature requests. We’ve come up with new tools for teachers so now they have a much better dashboard that monitors the students’ progress so you can see where they are in the curriculum.

It’s also important to provide technology that supports teachers to make teaching computer science at the K–12 level as simple as possible.

Pamela: At a high school I visit, there’s a teacher who uses our platform and then there’s another teacher using a desktop Java application. When the students using the desktop software hand in an assignment, they have to zip it all up in a file and email it to the teacher, who then has to read them all to grade them. In contrast, the teacher using our platform just reloads her class’s program page so she can see exactly what her students are working on. It has streamlined her efforts.

If Khan Academy is successful in expanding the number of students exposed to programming during their K–12 education, it’ll be interesting to see how computer science education in college will be influenced by a larger pool of incoming students with a strong understanding of programming principles.
IP Issues for Start-ups

Brian M. Gaff, McDermott Will & Emery, LLP

Most start-ups face myriad issues, even before opening their doors. This includes getting financing, hiring the right people, finding office space, and—importantly—getting the company’s intellectual property under control and adequately protected.

If you’re contemplating starting a new company, there are intellectual property (IP) issues that you’ll need to address. Many of these are complex, and most should be evaluated and acted upon only after receiving competent legal advice that’s specific to your situation. However, as a starting point, you should pay attention to two major issues: freedom to operate and the initial IP strategy.

For an expanded discussion on this topic, listen to the podcast that accompanies this column at www.computer.org/computing-and-the-law.

See www.computer.org/computer-multimedia for multimedia content related to this article.
if you intend to market your product in the US, then you need to search for related US patents and trademarks. If you plan to market in Canada, then look for Canadian patents and trademarks.

Once you determine which countries to search, you should then start looking for trademarks that might be similar to the names you’ve chosen for your product or company. For US trademarks, this means going to the US Patent and Trademark Office website (www.uspto.gov) and navigating to the trademark search area. Simply searching for your product or company names should provide initial results on whether the names are already in use or similar to other names that are already in use. Names that are in use are “registered.”

In many instances, interpreting these results isn’t easy. For example, similar names for similar products that are already registered might cause a problem that could lead to a trademark infringement suit. In rare cases, and when it’s clear that you’ve done a correct and comprehensive search, you might get results that show your names are unique and unlikely to conflict with someone else’s trademarks. However, for most people, the better approach is to have a trademark professional handle the search, evaluate the results, and give you a recommendation. Although this research has a cost, it’s well worth it considering what’s at stake. If you don’t get “clearance” on your names, you might lose your entire marketing strategy and corporate identity in a flurry of infringement allegations.

A freedom to operate analysis of patents is typically more complicated than a trademark analysis. It can start the same way—you can search the patent offices of the countries of interest for technologies that are similar to yours. A goal is to find issued patents that have patent claims that might cover your product. This isn’t an easy task, especially if you’re unfamiliar with patent searching and claim interpretation. That’s why most people have others handle this for them.

An efficient search process starts with preparing an accurate and concise description of the product or service that you intend to sell. One alternative is to provide this description to a patent-searching firm that will navigate through a multitude of categories of patented inventions to find similar subject matter. Low-cost searches—those that are under US$1,000—are typically limited to just a few hours to perform the search and don’t involve extensive analysis of the patent claims. However, this might be adequate in some cases.

At the higher end are searches performed by patent attorneys. These searches can start the same way, with a description of the product or service. They might even involve getting initial results from a search firm, but this is just the initial phase. For example, the patent attorney might follow up with the search firm to perform refined searches based on the initial results. More importantly, however, the patent attorney will carefully analyze the claims in the patents, using the proper legal methods to determine what they cover. This analysis is usually complex and time-consuming and, in many cases, the results are presented in a formal, written legal document known as an opinion.

An opinion of this type is usually prepared for the technology that’s most critical for the start-up—the so-called “crown jewels.” A less extensive approach might be appropriate for secondary technologies. You should determine where to draw the line and what type of analysis to perform only after adequate consultation with your lawyer.

**INITIAL IP STRATEGY**

Assuming that you’ve received the clearances needed from your freedom to operate analyses, the next step is to develop an IP strategy to use during the start-up process and for the initial stage of the company. This strategy should evolve over time based on the company’s direction and needs.

One of the first priorities is to protect the identities of the start-up and the product. That means applying for one or more trademarks that cover the start-up’s name, the name of the product or service, any slogans or taglines, and the domain name. It’s appropriate to apply for trademarks in every country where you plan to market. Getting your trademarks registered should be straightforward if you’ve previously cleared them in your freedom to operate analysis.

If you don’t get “clearance” on your names, you might lose your entire marketing strategy and corporate identity in a flurry of infringement allegations.

You should secure copyright protection as well. This can protect your software code, marketing materials, and your website. In the US, it’s easy and relatively inexpensive to apply for a copyright. Although copyright protection can be narrow—it protects against unauthorized copying—it’s cost-effective and worth having. For certain types of copyright infringement, the damages awarded to copyright owners are set by statute and can be significant.
Obtaining initial patent protection involves weighing several factors. For example, the expense of preparing and applying for a patent can be significant and might be beyond what the start-up can afford. After determining your budget and conferring with your lawyer, you should decide whether to proceed with a full-fledged patent application—called a utility application—in the US—or a provisional patent application. The US patent system is attractive one when funds are limited: for a small government fee, an inventor can submit a description of his or her invention to the US Patent Office. The submission is much less formal compared to what’s required for a utility application. The tradeoff, however, is that a provisional application never matures into a patent and can’t be used to stop someone else from using the technology. A provisional application lasts for only one year and then expires.

A provisional application also allows the applicant to use the one-year period to prove the technology and raise funds. However, the applicant must file a utility application on the same technology, referencing the provisional application, before the latter’s expiration. Having the extra time to raise funds might make it feasible to file the utility application.

Whether you decide on a provisional or utility application, it’s important to file it before going public with your product. Inventions have “absolute novelty.” In other words, to qualify for a patent, an invention must never have been publicly disclosed. Selling an invention or otherwise disclosing it can harm your chances of obtaining a non-US patent.

Another type of patent to consider is a design patent. In the US, design patents cover the ornamental appearance of an object: they don’t cover any functional aspects of the object. If your product has a unique or distinguishing appearance that you want to protect, you should file an application for a design patent. Having a design patent can discourage others who might try to copy your product’s appearance.

THE UNEXPECTED ROADBLOCK

Let’s assume that you’ve ordered your freedom to operate searches and reviewed the results, and those results identify a problem. If it’s a trademark issue—maybe a similar name that’s already in use—you’ll need to evaluate whether you can proceed using a different name. This will probably provide a quick resolution, but it could be difficult in practice because you’ll likely need to make comprehensive changes to your marketing plan. If you can’t change the name, another option is to license or purchase the trademark from its current owner. However, that might not be possible in all situations.

Discovering one or more patents that might block your product or service is a more complex problem. Issued US patents are presumed by statute to be valid and enforceable. Therefore, one way to address this problem is to investigate the possibility that the patents are invalid. This is usually done by having a patent lawyer examine the prior art—any materials that predate the patents—and provide a legal opinion on the validity of the patents in view of the prior art. Your lawyer can also prepare an opinion on whether there is infringement. Based on those opinions, you can decide whether to proceed as you originally intended.

Alternatively, and if it’s feasible to do so, you can redesign parts of your product or service to differentiate them from the blocking patents. This is called design around. This process is usually one where the engineers and patent lawyers work together to ensure that any changes made are sufficient. Certain legal doctrines permit some elasticity in the scope of patent claims, so the lawyer’s input is necessary to ensure that the changes have adequately distinguished your product or service from the claims in terms of how a court could interpret those claims.

In the excitement of launching a start-up, certain issues can slip through the cracks. IP issues shouldn’t fall victim to that fate. Work with your lawyer from the start to ensure that you’ve uncovered clearance issues and taken steps to address them. Apply for IP protection early on. Otherwise, you might encounter an eleventh-hour difficulty that derailed your ability to market your product as you intended.

Selected CS articles and columns are also available for free at http://ComputingNow.computer.org

BRIAN M. GAFF is a senior member of IEEE and a partner at the McDermott Will & Emery, LLP law firm. Contact him at bgaff@mwe.com.
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President’s Message (p. 5) “Our relations with our sister societies within AFIPS, in general, and with the ACM, in particular, are extremely good, but there is still room for greater cooperation that will translate, of necessity, into greater benefits for the profession.”

Introduction (p. 10) “This special issue attempts to bring together a body of work by leading researchers in computer architecture, image processing, pattern recognition, and pictorial database management. ... I hope that these articles will stimulate further investigations towards the cost-effective development of intelligent image analysis computers, which in turn will bring us closer to our ultimate goal: promoting better man-machine interactions in the era of real-time knowledge information processing.”

Cellularity (p. 14) “This article reviews the basic techniques of image processing using two-dimensional arrays of processors, or cellular arrays. It also discusses various extensions and generalizations of the cellular array concept and their possible implementations and applications.”

Biomedical Images [p. 22] “One study in particular, on which descriptions in this article are based, involves a joint effort by the University of Michigan’s human genetics and electrical and computer engineering departments and is supported by a grant from the National Cancer Institute. Basically, automated image analysis is being applied via sophisticated biochemical and computer techniques to derive an accurate estimate of the mutation rate for the human species.”

Pattern Recognition (p. 36) “Cellular logic computers, under development since the 1950s, are now in use for image processing in hundreds of laboratories worldwide. This survey of cellular logic computer architectures for pattern processing in image analysis concentrates on recent efforts and examines some newer architectures that combine logical and numerical computations.”

Pictorial Processing (p. 51) “With VLSI technology, we can integrate image processing, pattern recognition, and database management to produce a cost-effective computer system for advanced automation and machine intelligence.”

Parallel Data (p. 62) “The MPP, a single instruction, multiple data parallel computer with 16K processors being built for NASA by Goodyear Aerospace, can perform over six billion eight-bit adds and 1.8 billion eight-bit multiplies per second. Its SIMD architecture and immense computing power promise to make the MPP an extremely useful and exciting new tool for all types of pattern recognition and image processing applications.”

Workshop Report (p. 83) “The IC industry has so reduced silicon costs and IC development time that a silicon foundry can now provide two-week delivery. Yet the printed circuit board or the interconnection substrate may take six months to fully implement, and its reliability is not yet adequately addressed. This incompatibility and the increasing cost of interconnection were principal concerns at the spring workshop of the IEEE Computer Society’s Computer Packaging Committee.”

Classroom Computers (p. 86) “I propose that the [Computer] society become actively involved with computers in education. It would be a union made in heaven. Our educational community would greatly appreciate the society’s help with this new, exciting, and complicated educational tool. It would eliminate much duplication of effort and establish a smooth transition between the technical and non-technical aspects of computers in the classroom.”

Educational Computing (p. 112) “A new nonprofit organization dedicated to the use of computers for learning and other school-related tasks has been established. Called the National Association for Educational Computing, the organization is open to educators on all levels—preschool; elementary, middle, and high school; college and university—and commercial schools as well as to parents, school board members, students, and other interested individuals.”
JANUARY 1999
www.computer.org/csdl/mags/co/1999/01/index.html

Editor-In-Chief’s Message (p. 4) "Welcome to the 32nd edition of Computer, my first as Editor-in-Chief. I am proud to follow the performance of Ed Parrish, who implemented significant changes during his tenure. After years of research that showed members thought Computer was too theoretical and too detached from the needs of our industry members, Ed and others before him initiated evolutionary changes to Computer."

President’s Message (p. 8) "We plan to focus on software engineering as a major theme this year. Last year, we adopted a statement of software engineering ethical principles. This year, we plan to finish work on identifying the body of knowledge that constitutes the basis for professionalism in this exciting field. We will begin work on a program of competency recognition for practitioners."

Letter (p. 10) “I think computer professionals should take into account the social issues of our developments and not limit ourselves to ethical aspects. Let’s not underestimate the value of the humanities. The truth cannot be explained only with physics and math.”

Think Computing (p. 16) “While forms of voice and gesture recognition have been around for years, neural interface technology—which links the computer to the human nervous and muscular systems—is still in its infancy. Many projects are still in the lab, and only a few have matured enough for commercial release. The technology thus does not have much of a track record in the marketplace.”

Y2K and Skills Shortage (p. 19) “Critical issues such as Asian economic instability and corporate consolidation threaten the underpinnings of some IT organizations. However, the need for organizations to hurriedly cope with both the Y2K problem and the European Monetary Union’s currency conversion may offer many workers at least short-term job possibilities.”

Systems Research (p. 39) “Systems developers are facing a major discontinuity in the scale and nature of both applications and execution environments. Applications are changing from transforming data to directly interacting with humans: they will use hardware and data that span wide-area, even global, networks of resources and involve interactions among users as well. Even the architecture of individual processors is uncertain.”

Computing vs. Networking (p. 40) “On the one hand, the Web’s popularity and growth has been fueled largely by desktop applications consuming bandwidth-intensive images and video. On the other hand, thin-client computers ... are becoming more commonly used as edge-of-network devices, often connected by wireless technology.”

Moore’s Law Support (p. 43) “The Semiconductor Research Corp. is one of the few organizations to get fierce competitors like Intel, Motorola, and IBM to the same table, let alone cooperate. And it has also wrangled money—$37 million annually—from these companies and others. With this money, it funds future research to keep the engines of semiconductor production churning.”

Y2K Diary (p. 51) “As the year 2000 nears, we seek one high-profile technology consultant’s unique perspective on the consequences, compliance efforts, legends, and hype that surround the Y2K problem. This year, Computer will offer a Y2K consultant’s diary, highlighting the experiences of Howard Rubin ... a member of our Editorial Board.”

Wearable Devices (p. 57) “Current projects and industry efforts are attempting to define a new generation of wearables. Several conferences have already been held, in which attendees worldwide addressed the state of research and development, explored how wearable information appliances will let us manage information in new ways, and examined some of the obstacles to making wearables more widespread.”

Reading Online (p. 65) “The questions we need to ask, then, are ‘Which, if any, of paper’s qualities must reading appliances imitate to be successful?’ and ‘What are the advantages of reading online and how can computers help people read?’”

Standards (p. 129) “So it seems that although we are certainly developing object-oriented and distributed operating systems, all of their components are (at best) made out of ice cubes, which are always slowly melting and losing their identity. However, it seems that no matter how computer technology changes, computers continue to look a lot like the Posix Open System Reference Model.”

Future e-Commerce (p. 133) “Microsoft’s desire to integrate its Internet Explorer into Windows, for example, spawned a complex set of competitive and regulatory issues, exemplifying the inherent difficulties in defining and pricing a product in computer-mediated markets. In one sense, then, the new tools provided by computer and engineering sciences are now wreaking havoc with conventional economic theories.”
Hackers Hit Sony with Devastating Attack

Hackers have attacked Sony Pictures with sophisticated malware as part of an assault that crashed the company’s computers for a week, wiped data from its hard drives, froze its email system, leaked its upcoming movies, and exposed confidential corporate documents and information including employee salaries and Social Security numbers.

A group calling itself the Guardians of Peace claimed credit for the attack, in which 100 terabytes of data were stolen.

US investigators say the hack was actually launched by the North Korean government, which is suspected of similar types of intrusions in the past.

That government, which has not claimed credit for the attack, has also expressed strong disapproval of a recently released Sony movie, The Interview, about a couple of US TV show hosts being asked by the CIA to kill North Korean leader Kim Jong-un.

In the recent incident, the hackers obtained copies of several major Sony movies and released them to illegal file-sharing websites. These films included the already-released Fury with Brad Pitt and Annie with Jamie Foxx. They have since been downloaded illegally 2.3 million and 278,000 times, respectively. Illegal downloads cost Sony millions of dollars in lost revenue from theater tickets, as well as DVD rentals and sales.

The attackers additionally swiped Sony personnel’s passwords and released internal communications that could prove embarrassing to the company. These include memos from employees criticizing the company’s movies as boring, unoriginal, and formulaic, and bashing actors like Angelina Jolie.

Also stolen was information about the salaries of 6,000 Sony Pictures workers, including data showing that of 17 employees making at least $1 million annually, only one is female and only one is African-American.

The hackers took and posted names, Social Security numbers, birth dates, and other personal data sufficiently sensitive to put 15,000 workers at risk of identity theft.

And they released data on personnel appraisals, firings, and layoffs, as well as confidential information, including Social Security numbers, for celebrities such as Sylvester Stallone.

The attack has been so damaging that the FBI is warning other companies about the Windows-targeting malware that was used.

Security researchers say it appears that the hackers were in Sony’s network for a while before launching their assault and that their malware was designed to spread via the company’s email server system.

To make matters worse, security researchers say Sony apparently inadequately secured its system. For example, most of the stolen sensitive information wasn’t password-protected. In addition, the hackers are sharing pilfered files using computer servers owned by Sony’s PlayStation Network.

Sony has said little so far about the attacks except that it’s working with law-enforcement agencies.

Hackers claiming to be with the Guardians of Peace later issued an implied threat, saying in an online post that people should avoid going to theaters where The Interview is playing.

Many large US cinema chains decided not to show the movie during its scheduled Christmas weekend opening, so Sony cancelled that release date.

Big E-Commerce Websites Crash under the Weight of Holiday Shopping Traffic

In the US, the day after the Thanksgiving holiday—which occurs on the fourth Thursday of November—is one of the busiest cybershopping days of the year.

The day—called Black Friday because it’s the time many businesses move from being in the red (losing money) to being in the black (profitable) for the year—lived up to its reputation.

In fact, it produced so much traffic that the websites of several major e-tailers—including electronics giant Best Buy, tech stalwart Hewlett-Packard, and office retailer Staples—crashed or suffered slowdowns.

On a blog published by Dynatrace—a division of the Compuware Corp. that
focuses on application performance management—technical evangelist David Jones said factors such as internal technical problems, site complexity, and a spike in mobile traffic caused the website malfunctions.

The issues occurred even though many companies are using multiple content-delivery networks to handle traffic regionally and thereby reduce the overall amount of traffic hitting any single e-commerce site.

Hewlett-Packard’s HP Shopping site crashed due to a problem with the company’s internal cloud system. This is potentially embarrassing because the company is promoting itself as a major cloud-service provider.

Best Buy’s website—which initially performed normally—went offline briefly due to an unidentified internal error. However, the site refreshed itself and returned to normal operations in a couple of hours.

Staples’ website suffered several slowdowns. Shoe retailer Foot Locker also experienced Black Friday e-commerce woes, apparently because of problems with the configuration that a content-delivery network provider used.

The website for Cabela—which sells hunting, fishing, and outdoor gear—experienced brief instability and outages through Black Friday due to unidentified internal factors. The company solved the problems fairly quickly and operations returned to normal.

Lawmakers Approve Plan that Could Break Up Google in Europe

In a move apparently aimed at Google, the European Parliament has adopted a proposal that supporters say would increase competition by forcing companies to separate their search-engine operations from their other commercial services.

Proponents say this would keep companies from using their search engines to produce biased results that promote their other businesses.

Opponents say the plan is unfairly

FATHER OF THE HOME VIDEO-GAME CONSOLE DIES

Ralph Baer, who invented the first console that let people play video games at home, died recently at his home in Manchester, New Hampshire, at the age of 92.

Baer, whose Jewish family escaped Nazi Germany right before World War II, began researching ways to play video games on a TV screen in 1966, while an engineer at defense contractor Sanders Associates.

He eventually designed hardware and software for the Brown Box—now on display at the Smithsonian Institution—which Sanders patented. The company licensed the technology to Magnavox, which used it in 1972 to develop the Odyssey, the first commercial home gaming console.

This helped transform gaming from an activity people undertook only on large machines to one people could play at home on TV, thereby kicking off what has become a multibillion industry.

The $100 battery-powered Odyssey used overlay sheets to simulate color graphics and had no sound capabilities. It sold about 100,000 units in 1972. This was five years before the Atari 2600 became the first million-unit-selling video game console. Atari had licensed Baer’s technology from Magnavox.

Baer, who was born in 1922, immigrated with his family to New York City from Germany in 1938. After working in a leather-goods factory, he saw an advertisement for a correspondence class in radio electronics and signed up.

Baer became a radio service technician until World War II, when he served in the US military intelligence service. He then obtained a bachelor’s degree in television engineering and got the job at Sanders, which he held until retiring in 1987 with 50 US and 100 international patents.

Baer also developed numerous toys and video games. In 2006, US President George W. Bush awarded him the National Medal of Technology for his contribution to the video-game industry. The National Inventors Hall of Fame inducted him in 2010.

Ralph Baer, who invented the first gaming console people could use at home, died recently.
aimed at a US company and would hurt innovation and competition.

The European Parliament voted 384 to 174 in favor of the proposal, which the European Commission would have to approve before it could take effect. The office of the European Commissioner for Competition plans to review the newly approved proposal and talk to interested parties before deciding what to do next.

If the European Commission passes the plan, Google—along with other search-engine companies—would have to break up their operations in the huge European market.

Google—which hasn’t publicly commented on the parliament vote—appears to be the plan’s target.

In the past, European Union officials have expressed concern that the company has unfairly used its dominance in the search-engine market to provide query results that promote its other services, to the detriment of competitors. About 90 percent of European Web searches are performed via Google.

Numerous members of the US Senate and House of Representatives have asked European officials not to break up Google.

For example, Congressman Bob Goodlatte, chair of the US House Judiciary Committee, wrote officials that competition is important but that the move against Google appears to be political, which could actually hurt competition. Other members of Congress said in a letter that the plan could “deter continued innovation and investment from US-based Internet companies.”

This marks the latest dispute between Google and European officials who, in the past, have investigated and fined the company for allegedly unfair business practices and privacy violations.

Advanced Malware Spied on Victims for Six Years before Discovery

Security vendor Symantec has discovered sophisticated malicious software that has been spying on individuals, governments, academic researchers, companies, and telecommunications infrastructures since 2008.

In a white paper, Symantec called the Regin malware “groundbreaking and almost peerless.”

Company researchers said it was used on targets primarily in Russia and Saudi Arabia, but also in countries such as Afghanistan, Austria, Belgium, India, Ireland, Mexico, and Pakistan. The malware reportedly was used to spy on numerous European Union companies.

Regin consists of various modules and divides its attacks into five stages. The malware ultimately collects passwords and screenshots from victims’ computers, monitors network traffic, gathers information from memory, retrieves deleted files, and takes over machines’ point-and-click capabilities.

According to Symantec, users could customize Regin and add new features and capabilities. For example, in one case, it was configured to analyze mail from Microsoft’s Exchange email databases.

Researchers said the attackers apparently used Regin to gather intelligence, not to steal intellectual property.

In one case aimed at specific individuals, the malware scoured airline and hotel computers to learn the dates when target victims were traveling and the hotels at which they were staying. It then searched various telecommunications systems to identify the people they spoke with.
Symantec says the malware infects victims in various ways, some still unidentified.

For example, the attackers have used social engineering to direct targets to fake versions of popular websites, which then uploaded Regin.

Researchers noted that the malware was so complicated that it probably took months or perhaps years to write and that the developers encrypted some of its modules and used other techniques to make it difficult to trace.

Security experts say the multistage approach and general complexity is like previous espionage tools—such as Flame and Stuxnet—believed to be developed by government hackers. However, they haven’t yet been able to identify who designed Regin.

They said they are aware of only 100 infections by the malware, first used to spy on individuals in 2008 before being withdrawn in 2011 and then updated and rereleased in 2013 to eavesdrop on bigger targets.

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**Gaming Companies Worried that Using Virtual Reality Could Make Players Sick**

Several new technological developments have caused excitement that game developers might finally incorporate virtual reality (VR) into their products.

For example, Oculus VR has unveiled several prototypes of its Oculus Rift virtual-reality head-mounted display and plans to release a commercial version next year, along with a software developer’s kit. The product could be used with games from various manufacturers.

Sony Computer Entertainment is developing Project Morpheus—a VR headset that would work with the Sony PlayStation 4 and PlayStation Vita game consoles—which could be available in 2015.

Players, console makers, and game developers have said VR could enhance the playing experience, which could ultimately increase device and game sales.

However, some major game publishers have not yet supported making the considerable investment necessary to introduce the technology into their products.

Two of the biggest publishers—Take-Two Interactive Software and Electronic Arts—say they are concerned that VR could give some players motion sickness.

According to Take-Two, not only does the technology currently cause nausea in some users but developers must also figure out how game controllers should work within a VR environment.

Electronic Arts—which has experimented with VR—says that the technology has potential but that prototype headsets have caused motion sickness in people, including those only slightly prone to such problems.

However, both companies say that the problem doesn’t seem
insurmountable and that Oculus VR and Sony should continue to work on it. Improvements in image persistence and resolution have already helped reduce motion-sickness problems.

Oculus says that advancements in eye-tracking and other technologies could play an important role in making VR more acceptable for use in gaming but that the technology might always make some people sick.

Some experts speculate they used denial-of-service attacks on Tor to force its traffic over connections that the authorities own and operate, thereby letting them see the senders’ IP addresses.

The ability of law-enforcement agencies to bypass Tor’s protection calls the anonymizing system’s effectiveness into question. However, some experts say the targeted websites’ owners may have made the errors that allowed investigators to locate them.

Tor lets users who download the necessary software surf the Web anonymously so that government agencies, companies, and others can’t easily uncover their IP address. The system accomplishes this by routing its Internet traffic through a worldwide volunteer network of about 5,000 nodes.

Typically, the service is used by people wanting anonymity such as government whistle-blowers and citizens of nations with repressive governments. However, criminals have also employed Tor.

“Today we have demonstrated that, together, we are able to efficiently remove vital criminal infrastructures that are supporting serious organized crime. And we are not just removing these services from the open Internet. This time we have also hit services on the darknet using Tor where, for a long time, criminals have considered themselves beyond reach. We can now show that they are neither invisible nor untraceable,” said European Cybercrime Center director Troels Oerting.

The countries involved in Operation Onymous were Bulgaria, the Czech Republic, Finland, France, Germany, Hungary, Ireland, Latvia, Lithuania, Luxembourg, the Netherlands, Romania, Spain, Sweden, Switzerland, the UK, and the US.

Researchers: Many Children’s Apps Violate Users’ Privacy

A study by Carnegie Mellon University (CMU) computer scientists found that many Android applications for kids invade their privacy by gathering large amounts of personal information about them.

The researchers—led by associate professor Jason Hong, director of CMU’s Computer Human Interaction: Mobility Privacy Security group—analyzed about 1 million free apps. They awarded A, B, C, or D grades based on how the programs track visitors and whether users expect such tracking based on the nature of the app. The results are posted on the project’s website (http://PrivacyGrade.org).

According to Hong, “These apps access information about a user that can be highly sensitive, such as location, contact lists, and call logs, yet it often is difficult for the average user to understand how that information is being used or whom it might be shared with.”

He continued, “Our privacy model measures the gap between people’s expectations of an app’s behavior and the app’s actual behavior. Most people expect apps such as Google Maps to be able to access their location, but most are surprised and troubled to learn that a game [also does].”

The majority of the most popular apps received higher grades. But 1,000 applications—including many for kids—received the lowest rating.

The problem, the researchers said, is that some developers want to make money from their free apps and thus add code that collects data they can sell to advertisers. In some cases, the study noted, developers aren’t trying to be malicious but don’t consider how intrusive these practices can be.

The CMU project—conducted in part with financial assistance from...
Google, which developed and manages Android—has several limitations.

For example, it grades only free apps. And, the researchers acknowledge, their privacy model and analytical tools may need some fine-tuning.

They used a program to scan Android apps to identify the programs’ privacy practices, as well as algorithms that compared those practices with user expectations.

Developers can comment on or disagree with grades their apps received from the researchers via a feedback form on the Privacy Grade.org website.

Hong said he would like to conduct a similar study of iPhone apps but doesn’t yet have a contact at Apple to work with.

New Bluetooth Version Offers Online Connectivity, Could Advance Internet of Things

A standards group has adopted a new version of Bluetooth that would enable direct Internet connections for the first time. The technology could enable all types of devices to connect online.

Bluetooth 4.2 could thus prove important as the Internet of Things (IoT)—in which many types of everyday devices can connect to the Internet and to one another online—becomes widely adopted.

In addition to Internet connectivity, the new version of the short-range, low-power wireless technology—which the Bluetooth Special Interest Group (SIG) recently adopted—offers more speed and privacy than earlier versions.

It will let Bluetooth Smart sensors connect to the Internet via IPv6 over Low-Power Wireless Personal Area Networks (6LoWPAN) technology. This approach lets even small objects—like those that could become part of the IoT—access the Internet via a gateway.

Bluetooth 4.2 will use packets with 10 times the capacity of those used in earlier versions of the technology. This will enable connection speeds that are 2.5 times faster and reduce transmission errors. Also, larger packets’ greater efficiency will lower power consumption and increase devices’ battery life.

The new standard will also allow users to encrypt transmissions, which would be important for people who want to use their devices for secure activities such as unlocking their homes’ front doors.

To improve privacy, the specification will force beacons—Bluetooth-based technology that retail stores are increasingly using to send promotional messages to shoppers’ mobile devices—to obtain permission from users before tracking and contacting them.

Despite the improvements, industry observers say Bluetooth can still be difficult to pair with devices.

Scientists Build Molecular-Level Flash-Storage System

To improve the performance of computing and memory chips, engineers have made their circuitry and transistors smaller and smaller, allowing them to pack more on each unit.

Continuing this trend will be difficult, scientists say, because it would cause chips to experience problems such as increasing charge leakage and greater susceptibility to flaws. In addition, the manufacturing process would become more difficult and expensive.

Because of this, engineers are working on producing processor elements out of molecular-level elements, rather than traditional electronic components.

For example, researchers from the University of Glasgow and the University of Rovira i Virgili have developed a molecular system that could work as flash memory, which is nonvolatile, the researchers covered a wire with one layer of their caged molecules and applied a large negative charge. After the electricity was shut off, the charge remained along the wire throughout a 336-hour test. This indicated that a device using this technology could store and then provide data even after being turned off.

Users could read data from the device by applying a small charge and could delete stored information by applying a large positive charge.

Current problems with the new technology include high energy consumption and slow write and read speeds.

This scanning electron microscope image shows a 5-nanometer wire coated with cages of tungsten oxide molecules containing two selenium trioxide molecules. Researchers have demonstrated that this device might be able to function as high-performance flash memory.

Selected CS articles and columns are also available for free at http://ComputingNow.computer.org
Enabling the Internet of Things

Roy Want, Bill N. Schilit, and Scott Jenson, Google

Merging the virtual World Wide Web with nearby physical devices that are part of the Internet of Things gives anyone with a mobile device and the appropriate authorization the power to monitor or control anything.

The Internet of Things (IoT) paradigm enables interconnectedness among devices—anytime, anywhere on the planet—providing the Internet’s advantages in all aspects of daily life. Analysts predict that the IoT will comprise up to 26 billion interconnected devices by 2020, a 30-fold increase from 2009 (www.gartner.com/newsroom/id/2636073).

The conventional Internet has proved valuable in almost all endeavors by giving people the ability to interact with global information and services. The majority of this interaction happens through the World Wide Web, with client computers running a browser and communicating with cloud-based servers. However, the Internet is not limited to the Web: a wide diversity of other protocols are employed to make use of global Internet connectivity. The IoT is considered to be the next logical evolution, providing extensive services in manufacturing, smart grids, security, healthcare, automotive engineering, education, and consumer electronics. Many of these systems already have a Web presence but use protocols that are largely Web independent.

Practical issues with the IoT vision must be addressed, including how to handle dramatic increases in network scale and how to determine device proximity, sometimes referred to as localized scalability.1 In an IoT world, preferentially discovering things nearby and letting users interact with them is a powerful mechanism for overcoming a global network’s scale and complexity. Other important IoT enablers are peer-to-peer connections, low-latency real-time interaction, and integration of devices that have little or no processing capability.

THE IOT VISION

The Web provides an important interaction model for the IoT by letting users get device-related information and in some cases control their devices through the ubiquitous Web browser. The conventional Web is a convenience we enjoy as we search for information, respond to email, shop, and engage in social networking; the IoT would expand these capabilities to include interactions with a wide spectrum of appliances and electronic devices that are already ubiquitous in the early 21st century.2 We refer to devices that are part of the IoT and directly accessed, monitored, or controlled by Web technologies...
as the Physical Web: Physical Web = Web technology + IoT.

Identifiers are the key to enabling any kind of interaction among devices. From an IoT perspective, IPv6’s 128-bit addresses serve as identifiers for a global network of devices. Alternatively, Uniform Resource Identifiers (URIs), which include both locators and names, provide a higher-level concept that bridges those devices to existing Web technology. The Uniform Resource Locator (URL) is used in conjunction with a Distributed Name Service (DNS) to route and connect to services. Uniform Resource Names (URNs), such as globally unique IDs, are resolved by scheme-specific methods. A distinguishing aspect of the Physical Web is to consider URIs as the primary identifier.3

Many researchers and practitioners in this field, including the authors of this article, expand the IoT definition to include enabling an Internet presence for any person, place, or thing on the planet, thereby pushing our notion of the Physical Web beyond smart devices. Clearly, an Internet presence cannot occur without processing and networking, so instead of providing them directly, an Internet service can provide information and perform actions via other nearby devices serving as a gateway to that proxy service.4,5

Gateway devices will enable billions of people, places, and things to participate in the IoT—most people today already carry one. The smartphone, the most popular computing device of all time, with more than 1 billion users [www.idc.com/prodserv/smartphone-os-market-share.jsp], is well equipped to serve as this pervasive portal.

Figure 1 shows the two distinct interaction modes that smartphones can enable in the IoT. Through direct interaction, a smartphone can query the state of an IoT device in its proximity and then provide a bridge between low-level peer-to-peer protocols, such as Bluetooth or Wi-Fi, and Internet protocols, such as HTTP and TCP. One example is the Fitbit fitness monitor, which uploads a user’s step count through his or her phone over a 4G network to the user’s account in the cloud. Through proxy interaction, mobile users who happen to be near an IoT-enabled object or device can look up associated information published by interested parties through a Web service using their smartphone, just as they would when performing a Web search. One example is a movie poster that enables nearby people to automatically access a webpage on their smartphone and buy electronic tickets online.

**DOES THE IOT ALREADY EXIST?**

The IoT is a popular buzzword in the computing industry; it appears at the heart of the original Internet paradigms, such as Cisco and microprocessor giants such as Intel. It even serves as the title or theme of conferences, such as the “Internet of Things” World Forum (http://iotinternetofthingsconference.com).

However, the phrase represents ideas that have existed since the beginning of the Web or been written about in whitepapers from well-known research laboratories such as (Xerox) PARC and HP Labs. So why isn’t the IoT a standard part of the way we do business today? Why is it still the subject of speculation and vision statements in keynote addresses at well-known computer industry events such as the annual Consumer Electronics Show?

The answer appears to be that the IoT exists for a small number of technologies that have the ingredients for a successful business case. In general, these early systems have tended to be closed ecosystems, using private APIs and locking up the data. This is counter to the spirit of open systems at the heart of the original Internet standards, reflecting instead the more recent commercial successes of major networking companies such as Cisco and microprocessor giants such as Intel.
proprietary business entities such as Apple’s App Store and Facebook. You can actually buy home automation systems that connect to the Internet through your home’s Wi-Fi. These systems are usually built with a bridge that controls the automation components through proprietary protocols on one side and communicates with open protocols to a proprietary Web service on the other. Users can then employ desktop computers or smartphones as a client to control their home by interacting with the Internet service, effectively providing user interface hardware at no cost to the IoT device manufacturer.

A significant hurdle to fully realizing the IoT relates to scale—specifically, expanding the Internet to IoT scale means that the address space for the Internet will need to increase by several orders of magnitude. Therefore, another requirement for supporting the IoT is a larger device address space than that provided by IPv4. To enable this kind of expansion, the Internet Engineering Task Force (IETF) has been working on the IPv6 standard for some time. The latest opportunity for RFID technology is in the form of near-field communication (NFC) as a support for electronic payments. Although only a small number of smartphone products include NFC transceivers, the potential for this capability to propagate to all future smartphones is high. It would also enable phones to read passive NFC tags that can store a URI, while still being cheap, small, thin, and attachable to almost anything. In September 2014, Apple announced the iPhone 6 would include NFC support for ApplePay. With Apple’s significant smartphone market share in the US, this move could influence other handset manufacturers to follow suit, pushing NFC into becoming a key IoT enabler.

ENABLING TECHNOLOGIES FOR THE IOT

As Figure 2 indicates, tagging an object to reference a proxy Web service can be achieved through a variety of technologies, but the early primary contenders have had issues that hindered their adoption.

RFID and near-field communication

In the early 2000s, RFID was considered one of the most likely technologies to accelerate the formation of the IoT. A new UHF RFID tag standard was developed by EPC Global (http://epcglobal.org), with a goal of further automating retail transactions and replacing barcodes with a tag that was machine readable at a distance of up to 10 feet. But after several trials with leading vendors such as Walmart and Tesco, the EPC standard met with limited uptake principally because, in practice, a significant number of tags were undetectable due to factors in retail environments such as poor product/tag orientation and the presence of materials that interfered with the wireless identification process.

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Optical tags and quick response codes

Another contender for low-cost tagging is the optical or printed tag—in particular, the most popular 2D optical standard, the quick response (QR) code. The success of the QR code standard is directly related to the ubiquity of its reader, an application of the high-resolution camera found in all modern smartphones. A QR code is extracted and decoded from a scene using image-processing techniques yielding a number, text, or URI. QR codes are already printed on many products,
including newspapers, magazines, billboards, and coupons; they even appear on prime-time television ads.

However, in practice, many QR advertising campaigns result in a poor customer response. The reasons relate to the requirement that a preinstalled application is required to read QR codes—which can be a barrier for some users—as well as difficulty in positioning the phone so that the camera can focus and accurately decode the image. Some advertisers also feel that a visible QR code spoils the aesthetics of their campaigns (https://www.techdirt.com/blog/wireless/articles/20120307/06130018010/qr-codes-ugly-overused-doomed.shtml).

**Bluetooth low energy**

One of the more promising new technologies in the device tagging space is Bluetooth low energy (BLE), part of the Bluetooth v4.0 standard (Bluetooth Smart) and adopted by the Bluetooth Special Interest Group in 2010. Consequently, Bluetooth silicon vendors have included BLE in their latest chipsets, and all smartphones released in the last few years have BLE hardware, with various levels of capability depending on operating system support.

Bluetooth silicon can be pared down to only include the BLE aspects of the standard, removing the need for compatibility with classic Bluetooth. This results in a small, low-cost silicon implementation that can be used as a low-power electronic tag. Tags based on BLE can signal their presence by transmitting an advertising packet once per second at a power budget that enables them to operate for up to one year on a lithium coin cell battery (about the size of a US quarter, with 240-mAh capacity).

This new technology standard, along with the availability of inexpensive BLE tag hardware and tag readers already integrated with smartphone hardware, has been a considerable catalyst in this space. Many established computer companies, and a significant number of startups, are experimenting with products and business opportunities associated with these tags. As with the other tagging technology, this is also an enabler for the IoT, but with more opportunities for ubiquitous deployment, higher-accuracy tag reads, and the ability to blend in invisibly with a product.

**THE PHYSICAL WEB**

In the Physical Web, people, places, and things have webpages to provide information and mechanisms for user interaction. The notion of open Web technologies as the bridge to the physical is not new: access points, routers, solar panels, electricity meters, and coffee shops have Web landing pages, for example. However, it is the breadth and depth of the stack surrounding the Web that make this an appealing vision for the IoT’s evolution. To be sure, HTTP will not be an exclusive protocol for communication with things in the same way that it is not an exclusive protocol for the Internet—there are plenty of use cases where Web protocols do not have the desired properties, such as the Real-Time Streaming Protocol (RTSP).

Like the conventional Web search engine to which you submit a query and it returns text snippets and links to relevant “things,” the Physical Web would return search results. However, because the IoT is the world that we can see, hear, and touch, search results would not only be ordered by conventional ranking algorithms but also by proximity, and thus results could be shown as lists, enhanced maps, or floor plans. Searching the physical Web at home would bring up thermostats, DVRs, TVs, home audio systems, routers, and water and electrical meters as results. You might see a snippet and a link to the manual for a nearby microwave oven, along with other links that control or provide information about devices in your house. There would be a lot to show, but no more than the results of any Web search today; search engines are good at ranking and providing the most relevant items first.

Webpages are a great technology for human-to-machine (H2M) interaction, but many use cases for the IoT are machine to machine (M2M). One solution that has already had great success in combining human and machine-readable content in open Web technologies is the use of structured data embedded by webmasters into their pages. The data formats used by Schema.org and others let user agents and cloud services act intelligently, parsing data for events, organizations, people, places, products, reviews, and so on and acting on them either interactively or proactively. Structured data could also lead to more uniform user interfaces across devices, so that when users learn one interface, they do not have to relearn it for another device—for example, setting the time on an appliance that has a clock.

Open Web technologies, including HTML, Ajax, HTTPS, and OpenID, and structured data apply equally well to the IoT. However the open Web does not have an effective mechanism for locating objects in the physical world. One approach that looks particularly appealing is the use of radio beacons that broadcast URLs at very low power and over a small geographic radius.
One of the first projects to promote this idea was HP’s Cooltown, which used infrared beacons to transmit URLs. More recently, BLE provides a similar low-power beacon mechanism that can also integrate a URL emitted in short periodic advertisement packets (www.uribeacon.org).

One way to bridge the gap between the physical and virtual is to attach beacons to all our objects. These beacons would broadcast a URL along with other information to help with ranging. It sounds like a huge investment, but beacons currently cost less than US$, and the price is likely to drop, thus future manufactured “smart” objects are likely to integrate this capability. By utilizing proximity URL beacons, the potential for interacting with the Physical Web is not only more practical, but has greater utility than both NFC and QR codes.

CLOUD COMMUNICATION VERSUS PEER TO PEER

One of the long debates in computer science has been whether to build centralized systems or to make them fully distributed. Much of the Web today takes a centralized approach for its services, but it is not clear that this makes sense for much of the IoT. Figure 3 compares the approaches, with cloud-based services representing the centralized paradigm.

Benefits of cloud computing

The computing world has shifted paradigms several times, from the centralized mainframe computer to the decentralized PC running standalone applications back to today’s centralized cloud services. The computing industry is gravitating toward more centralized cloud services primarily because they are easier to manage. Advantages include the economics of scale when building datacenters, automatic backup of all data, and enforced physical security. However, modern client devices are both capable and flexible. Laptops utilize high-performance multicore technology, and even smartphones contain powerful processors. We have the option of running simple clients connected to powerful cloud services or powerful local apps that run on their own. The decision comes down to our tolerance for tradeoffs in latency, security, privacy, and cost. If interaction latency and connectivity are not a problem, cloud computing is an attractive paradigm. In recent times, the detrimental effect of malware on home computers has made the cloud even more attractive.

Based on these observations, it seems like a good idea for the IoT architecture to register every device with a cloud service and communicate with that service alone. Users or other computers would then interact with this service to determine the device’s status or control its behavior. However, there are other factors to consider.

Benefits of peer-to-peer

Although the cloud model is clean and straightforward, the requirements for full Internet communication might be too costly or burdensome for what in many cases are simple low-performance devices. In practice, any hardware that can connect directly to the Internet would require a physical Ethernet, Wi-Fi radio, or cellular modem, all of which elevate the device’s cost and power consumption. In practice, it might be better to have one bridging device that supports Wi-Fi and enables simple peripheral IoT devices to talk to the bridge. Many low-performance communication standards such as ZigBee, 6LoWPAN, Bluetooth Classic, and BLE have evolved to fill that gap—with no clear winner. As with the opportunity for tagging devices, the new BLE standard could well dominate this low-end space, but it will take time for this to play out.

IoT devices, unlike the traditional Internet, benefit from the concept of proximity as we described when introducing the Physical Web. However, it is not just the knowledge of nearby objects that is useful: colocated devices have the opportunity to cooperate

FIGURE 3. Alternative approaches for the IoT. (a) Peer-to-peer, with gateway to an IoT service; and (b) centralized IoT service. Because the IoT will connect many devices with constrained networking capabilities, P2P networking may become more prevalent and as common as cloud-based solutions are now.
with each other in real time and fulfill a task that would not be possible with any single device. A simple example is the sharing of peripherals. A computer that finds itself close to another device with a bigger and better screen could wirelessly share it, for example, to take advantage of its display when playing a movie. Likewise, a computer could utilize a component that it does not have if it is wirelessly discovered on another nearby device—examples include a sensor, camera, or mouse.

Proximate sharing will be an important aspect of the IoT, but this will not be easy to accomplish. Devices need to discover each other, trust each other, and then make a connection. Furthermore, sharing is achieved by protocols and data formats that need to be standardized and supported by both ends of the connection. In a world in which there are many more commercial players than in the early days of the Internet, this becomes a difficult proposition. The traditional Internet has evolved a core set of standardized protocols, but in the undefined IoT world, many standards and proprietary solutions are still up in the air. To illustrate how difficult this can be, consider the Digital Living Network Alliance (DLNA; http://dlna.org), which was established to enable multivendor consumer electronics to discover each other and share content and services. To date, DLNA has only been integrated with a small percentage of networked products because, in practice, larger companies are driven by the financial rewards of dominating a market with their own proprietary ecosystem.

Hybrid IoT solutions
Innovative solutions to latency problems associated with existing cloud-based networking attempt to combine various ideas. One approach, called edge computing, moves some of the cloud processing closer to devices that require real-time interaction, thus reducing the number of network hops and hence latency. An example of edge computing is the cloudlet paradigm, which provides a means of rapidly enabling real-time services in the fixed infrastructure to be used by mobile devices, such as smartphones and wearables, just one network hop away using Wi-Fi. This is achieved through a virtual machine (VM) running on a powerful nearby workstation, and dynamically provisioned with software and services customized for that application. When the task is complete, the resources can then be freed up, allowing a new VM, or multiple VMs, to be instantiated on the cloudlet. A cloudlet lets IoT devices interact in real time with cloud-like services, even though they are far removed from a datacenter.

THE LONG TAIL OF THE MANY POTENTIAL USES OF THE IOT CHALLENGES THE SCOPE AND BREADTH OF TODAY’S SMARTPHONE APPS.

WHAT THE IOT MEANS FOR APPS
Today, any new IoT product almost always comes with a smartphone app to control it. This is a consequence of two dominant forces: native smartphone apps offer the only practical means to access and communicate with smart devices, and there has been so much recent financial success with mobile apps that they are now expected. People assume that they will always use apps for every possible interactive experience with IoT devices.

This approach unfortunately creates problems as the IoT landscape grows and matures. Although it is easy to imagine a phone with a few dozen applications on it, things become more problematic with millions of IoT devices. In the very near future, you will likely pass thousands of smart devices every day, each one capable of interaction. It does not scale to have to install an app before using each one. You will also likely want to delete apps as you install others, because there will be many devices that you will interact with only once.

This becomes even more evident when you factor in how smart devices will have a significant long-tail effect. Instead of a few big apps that you use every day for many tasks, you will have a huge range of small-device apps that offer the tiniest of interactions, such as just controlling an on/off switch. In fact, many devices will eschew interactivity altogether and only offer a snippet of data, for example, when the next bus is arriving. The long tail of the many potential uses of the IoT challenges the scope and breadth of today’s smartphone apps, requiring only micro-interactivity or micro-information.

To enable this new Physical Web for the IoT, we need a way for any user, with any smartphone or tablet, to walk up to any IoT device and interact with it (without a specialized app). We need a richer extension of today’s Web, allowing each smart device to wirelessly broadcast a URL to its surroundings. Proximity is the context that can be used to filter this to a tractable number, allowing any smart device to list and then interact with other nearby smart devices. This is the basis of a discovery service that is the best of today’s native and Web apps, creating a new platform, a type of interactive lingua franca allowing devices of any type to offer data and interactivity to any other device.

The current model of native apps, while quite popular, is not up to the task of supporting the many and
varied use cases that the IoT will bring about. We need to extend well-known systems, such as the Web, to allow a significantly easier and more lightweight approach for enabling devices to interact with one another.

Context sensing
One of the ways an application can perform more effectively is through context awareness. Sensing what is around a host device (and its user) and the context in which it is used allows an app to adapt how data is presented and filtered; consider, for example, a local map application that automatically shows the user’s current position. The more context a device has, the more likely it can automatically provide a user with the required information. However, the worst thing a context-aware application can do is infer something on behalf of a user that turns out to be wrong. The future IoT will allow information to be collected from nearby physical sensors and Web services and then shared between devices on a scale that has not been possible before. As a result, the Physical Web will lower uncertainty and improve accuracy. A consequence is that future “smart devices” will become much smarter.

Actions and control
As a complement to sensing, the IoT offers us a way to control the physical world through displays, actuators, and switches. Many modern systems benefit from remote control because it simplifies physical interaction design and extends capabilities. In the Physical Web paradigm, anything with a display, actuator, or switch can be controlled from a browser or through a Web service, thus making it easy to integrate related information into control decisions. For example, emerging Web-connected irrigation systems might provide an interface for specifying the plants in your garden and use Web services to determine expert watering recommendations.

Privacy and security
One of the primary challenges for the future will be avoiding the darker consequences of a world with globally connected devices. The Physical Web could enable hackers to control our devices unless precautions are taken. The conventional Web already has security measures in place that can be applied to the Physical Web, but it is unclear if these will be suitable or even adequate for all IoT applications. In addition to hacking, social threats can result when knowledge is leaked in unexpected ways. For example, knowledge that a house is in an energy-saving mode could be a good indication that nobody is home and thus invite a burglar. These challenges will become more pressing as use of the Physical Web continues to grow.

Merging the virtual Web with the IoT will enable really smart devices, providing smarter automation and services. Associating a Web URI with every person, place, or thing forms the basic mechanism for bridging these two technologies. A key enabler is the ability to discover proximate objects, and BLE beacons containing URIs are a useful tool. Web browsers can readily display Web information along with descriptions of nearby IoT objects; they are a promising familiar on-ramp to the IoT.

OUTLOOK

FUTURE OPPORTUNITIES AND CHALLENGES

While the IoT applications will be varied and difficult to predict, some clear opportunities will arise for ubiquitous information gathering, context sensing, and control, which will likely be key enabling building blocks. However, some of the real challenges will be in the areas of privacy and security.

Ubiquitous information
Users often need help when they encounter an unfamiliar device. Traditional products were sold with a user manual—later, they might have included an informational CD. More recently, a customer support URL is provided that points to online documents, and even in the event that this is lost, a simple Web search for the model number will usually locate the online manual. In the IoT future, this problem can be solved by the Physical Web enabling all products to transmit a wireless machine-readable URL that can be received by a nearby smartphone or tablet with little effort from the user.
There is a reason people are excited about the IoT: it feels like a big opportunity to improve how we design and build products. Making the IoT as accessible and useful as the Web is likely an even bigger opportunity.

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Second-Generation Big Data Systems

Fadi H. Gebara, H. Peter Hofstee, and Kevin J. Nowka, IBM Research–Austin

More varied data channels, increasingly diverse analytic methods, and new deployment models—along with some fundamental technology shifts—will significantly impact the next generation of big data systems.

While big data systems will continue to be defined by three primary characteristics—scalability, resiliency, and programming ease—the next decade will undoubtedly bring significant and rapid evolution in how such systems are developed and how they operate. Many changes are already under way:

- The predominant Hadoop distributed file system (HDFS; http://hadoop.apache.org) is approaching its limits, as new data sources come to the fore and as iterative and interactive analytics grow in importance.
- New systems like Apache Spark (http://spark.apache.org) leverage memory to store and call up intermediate results; when intermediate objects must be persisted, flash technology seems likely to supersede hard-disk storage, and flash-as-memory (or data-object stores) will naturally reduce the OS and serialization overhead associated with storing objects in files.
- Compared with the limited potential for disk bandwidth improvement, significant increases in network bandwidth will make it increasingly attractive for centralizing storage.
- Maximizing cloud-based infrastructure-as-a-service (IaaS) efficiencies for enterprise workloads places greater and more complex demands on big data system flexibility, reliability, and security.

These and other trends will shape next-generation big data systems in important ways.

ENVIRONMENTAL TRENDS

To begin with, the evolving landscape against which we view big data will continue to have implications well into the future.

Multiple new data sources

Big data is generally characterized in terms of the four Vs—volume, velocity, variety, and veracity (www.ibm.com/bigdatahub.com/infographic/four-vs-big-data)—and the focus has usually been confined to datasets that are slow-changing, unstructured, primarily text-based, and assumed to be trustworthy.
Today, however, streaming data is often combined with static data. Structured datasets are now central, with interfaces linking to table- and graph-based stores. Moreover, data derives from many media and is no longer primarily text-based. And as solutions increasingly require a combination of multiple data types and sources, we cannot assume that all data is equally trustworthy.

This explosion of big data sources is fundamentally changing how organizations make crucial business decisions. Rather than starting with a question and then developing methods to collect data appropriate for answering that question as in the past, today enterprises can leverage large and disparate datasets—collected both within and outside the enterprise—to rapidly develop new insights and create new services.

**More diverse analytic methods**

As data types multiply, analytic methods are adapting as well. Traditional batch analytics—running offline without specific time constraints—now have available increasingly rich datasets that can provide remarkably precise information, as the sidebar “Retailers Know You Better than Your Mom Does” suggests.

Other analytics are evolving to deliver immediate responses to questions as they are posed, even when drawing on static—and often pre-structured and pre-analyzed—datasets. The IBM Watson system (www.ibm.com/smartplanet/us/en/ibmwatson) and some data warehousing and business intelligence applications such as IBM PureData for Analytics (www-01.ibm.com/software/data/puredata/analytics) fall into this category.

We also see a growing category of analytics that provide near–real-time responses to data arriving in real time—demanding high velocity updates and short query times on complex data representations. IBM InfoSphere Streams (www-03.ibm.com/software/products/en/infosphere-streams) and Apache Storm (http://storm.apache.org) are current examples.

One challenge in exploiting these more diverse analytic methods is that iterative and graph-based algorithms must be more efficiently supported. Traditional MapReduce systems, for example, do not fully support iterative algorithms because no data is preserved in memory between MapReduce stages; consequently, each stage reads and writes input from HDFS.

Another challenge is interactivity, which up until now has been considered outside the big data domain. While there are limits to the amount of new information a system can digest instantaneously, we see no reason why an infrastructure that scales cannot be devised so that it delivers an immediate response to a question or derives new insights from new data. In some cases, users can opt to forgo query accuracy in order to obtain potential responses; the goal of these big data runtime tools is to efficiently parallelize the workload to ensure “reasonable” response times with strong reliability. In such cases, the fact that the analytics define what is “reasonable” has broad system implications.

**New deployment models**

New deployment strategies suitable to big data applications must also be considered. To a considerable extent, much big data “exists” in the cloud; however, utilizing cloud-based infrastructures for a broad set of applications still requires a significant transition. For example, as big data proliferates in enterprises that leverage cloud-based IaaS, “elastic” platform service—service that fluctuates according to user demand as opposed to service provisioned continuously—is becoming the norm.

At the same time, new demands are being made on premise-based big data infrastructures as well. As these are mainstreamed, the impulse will be to integrate big data systems into a company’s overall infrastructure, while still meeting enterprise requirements for reliability, maintainability, user support, and security.

**TECHNOLOGICAL SHIFTS**

In addition to these environmental trends, several technological shifts are impacting big data system design and deployment.

**Multicore technology.** Microprocessors now increase performance chiefly...
RETAILERS KNOW YOU BETTER THAN YOUR MOM DOES

Have you ever wondered why online advertising seems to be targeted specifically to you, why so many items you’re interested in happen to be on sale just as you need them? As it turns out, this very question lies at the heart of big data. Over the last decade, sophisticated new analytics tools along with increasingly diverse data sources—social media, on-site browsing preferences, and so forth—have given retailers seemingly magical powers as they compete for your business.

For example, Target made headlines in 2012 for correctly identifying a pregnant teenager before her family knew about her condition. The company can analyze customers’ purchasing habits by monitoring credit card data, coupon usage, customer help lines, and emails for specific activities associated with pregnancy. In fact, they’ve identified 25 items that, when purchased in certain combinations and a particular order, lead not only to a very accurate prediction about when a woman is pregnant but also to a close estimate of her due date. Target’s big data analytics allows advertising that’s laser-focused for those precise times when a customer is most receptive.

In fact, Target is now so adept at such prediction that its marketers intentionally insert filler ads in between highly targeted ones just so people have the impression that they’re receiving generic advertising—rather than suspect any privacy invasion.

And Target is not unique. Many retailers employ big data solutions based on the workflow diagrammed in Figure A. The abstraction here shows a variety of data coming into the retailer—mobile GPS data, social media feeds, purchase history, supply chain data, sales data, and the like. The data must then be prepared for consumption by downstream analytics. In the filtering and extraction stage, supply chain and sales data are loaded into the data warehouse; then, user locations and user data are loaded into the deep analytics engines; and, finally, real-time position data is loaded into the streams engines.

Used in concert, the deep analytics and streams engines and the data warehouse can target ads for special prices on specific items to shoppers in particular locations based on store supply, item popularity, and purchase likelihood.

References

![Graph showing network bandwidth growth over time](image)


Through additional cores or multiple hardware threads within cores. Cores on a chip share memory—typically, coherent memory; communication via shared memory is far more efficient than conventional messaging between cores on separate chips.

**Multiple processors.** Heterogeneous processing is gaining acceptance as a means to increase efficiency by specializing computation on dedicated elements. This trend encompasses a wide variety of specialized functions ranging from single-thread energy-efficient cores to data-parallel units such as GPGPUs (general-purpose computing on graphics processing units) to reconfigurable logic.

**Increased network bandwidth.** Network bandwidth has been growing at a much faster rate than hard-drive storage bandwidth, as the charts in Figure 1 illustrate. In a typical system today, network bandwidth may well be comparable to internal hard-drive bandwidth—a radical departure from only a decade ago, when network bandwidth on a typical node was significantly lower than internal disk bandwidth.

**Flash technology.** Flash storage is now the clear winner over disk storage in terms of read/write costs (I/O operations per second) and is approaching the cost of enterprise storage per byte.\(^3\)

**IMPLICATIONS FOR BIG DATA SYSTEMS**

So what does this all mean?

As workloads evolve from one-dimensional applications—search and the like—to much more complex workflows, second-generation big data systems must achieve not just scalability, resiliency, and usability, but also incorporate appropriate structures to support multiple analytic methods on varied data types, as well as the ability to respond in near real time.

Figure 2a illustrates a logical view of the big data system stack. At the bottom is a common data layer that allows each analytics engine access to the required data; this layer also facilitates data sharing among the analytics engines while providing resilient persistent storage. In the middle is a resource scheduler that efficiently divides and distributes workload tasks among available infrastructure resources. At the top are the analytics engines; these are the frameworks that translate the user’s analytics codes into consumable tasks for the resource manager to distribute.

Figure 2b shows the first-generation embodiment for this logical view. First-generation big data systems were designed to provide capability based mainly on scalable and resilient batch analytics; *workflow* as an aspect of big data—illustrated in Figure A of the sidebar—was given little attention. Now, equally enabled by technological trends and driven by workload demands, a new paradigm is rapidly emerging. Figure 2c outlines this second-generation embodiment for big data systems.

**Data layer**

Originally, HDFS provided both long-term storage and intermediate results staging. Its cluster-based, shared-nothing architecture afforded resilience through replication and also allowed computations to be scheduled close to data.

However, two significant trends are forcing a change in HDFS’s role:

- In-memory computation models such as Spark are based on a new abstraction, resilient distributed datasets (RDDs), which allows intermediate results to be kept in memory—thus significantly reducing overhead in iterative analytics. While intermediate results can be committed to HDFS, this now occurs much less frequently.
Network bandwidth is growing much more rapidly than hard-drive bandwidth; thus, the benefits derived from having disks locally attached are quickly diminishing. Centralized storage achieves reliability with fewer than three copies of the data; already, the network infrastructure overhead required to support storage decentralization adds little cost vis-à-vis the savings realized from centralized storage efficiencies.

As a result, HDFS now functions primarily as a long-term store from which applications read their initial inputs and to which they write their final results, as well as an interoperating point between applications. In second-generation systems, the data layer is therefore stratified into (1) a layer to provide longer storage and a consistent data model for inputs and outputs and (2) another layer for storing intermediate objects shared by the various analytics engines.

**Resource scheduler**
A wider set of analytics algorithms and greater variety in memory/storage and compute technologies significantly increase the demands made on the resource scheduler. To maintain programming ease, the resource scheduler in second-generation systems must determine when the penalty for re-computing a result outweighs the cost of moving intermediate objects to more reliable forms of memory or storage.

**Analytics engines**
In second-generation big data systems, data objects can be shared between a greater variety of analytics engines: engines that process streaming and online data, engines that learn and build models, predictive engines, cognitive engines, and so forth. More, and more varied, data sources also require support for a wider range of algorithms—a neural network algorithm to classify images, for example. At the same time, this greater variety presents new opportunities for optimization, through heterogeneous computation and other innovations.

In addition, because data volumes for these new modalities far exceed the amount of text, great pressure is placed on storage efficiency. Therefore, data compression—in some cases, even

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**FIGURE 2.** Big data system evolution. (a) Logical view of a big data system stack. (b) First-generation embodiment. (c) Second-generation embodiment. HDFS: Hadoop distributed file system.

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domain-specific data compression—is essential in these second-generation big data systems.

Much of the buzz currently generated around big data results from the new correlations enterprises are able to derive from the data streams they can now collect—and even among sets of previously analyzed data. The key is finding correlations across as many dimensions as possible. Think of astronomers using multiple telescopes to observe the same celestial object, with each frequency band revealing new insights: some show clouds of interstellar dust, while others permit a glimpse of what lies behind. With enough observation, a ground truth can emerge.

So, just as they are achieving wide adoption, big data systems are undergoing significant change—something we see continuing into the future. Heterogeneous processing and reconfigurable logic will drive another wave of change (though we hope not in the programming models). Nonvolatile memory is more than likely to find its place in the data layer between memory-based objects and the file system. Data modalities and analytical engines will continue to expand.

All this will result in a platform that analyzes historical data, reacts to current data, and predicts future data—while still maintaining the key attributes of scalability, resilience, and usability fundamental to big data systems.

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Cybersecurity: From Months to Milliseconds

Peter Fonash and Phyllis Schneck, US Department of Homeland Security

Computer technology is the nexus of our critical infrastructures, yet it remains extremely vulnerable to cyberattacks. A proposed Integrated Adaptive Cyber Defense architecture promises to create a healthy cyber ecosystem by automating many risk decisions and optimizing human oversight of security processes too complex or important for machines alone to solve.

Great efficiencies have been achieved with the integration of computers into our daily lives. Advances in information and communications technology (ICT) enable us to automate business processes, manage critical infrastructures, and establish pervasive connectivity among users and systems. This technology has become so inexpensive that we are moving to the next phase of integration, interconnecting a plethora of devices in the Internet of Things (IoT) that will allow full control of embedded systems in homes, vehicles, and public and private infrastructure, resulting in even greater effectiveness and cost savings.¹

The IoT is expanding quickly. As Figure 1 shows, Cisco predicts that it will grow from about 14 billion devices today to more than 50 billion by 2020.²

Many “things” in the IoT provide greater convenience or safety. For example, users can remotely activate their home thermostat to warm the house shortly before arrival, check door locks or review surveillance camera footage while away, or receive a reminder from their refrigerator to buy milk on the way home. Embedded automotive systems can monitor and control critical functions such as tire pressure, door openings, proximity to other vehicles, and vehicular health via remote connectivity to the car manufacturer. Medical IoT applications let doctors remotely monitor a patient’s heartbeat³ and patients better self-manage diabetes.⁴

While new and emerging IoT technologies offer many benefits, they can also result in serious harm if not properly protected. For example, a maliciously activated automated insulin injector could lead to death. In fact, cybersecurity firm Cylance has identified more than 300 medical devices vulnerable to remote cyberattack.⁵ Likewise, a hacker could remotely take control of a vehicle’s automated systems and cause it to crash.

Because of our increasing dependency on computer technology for business, critical infrastructures, communications, and various IoT devices, major cyberattacks...
could cripple our economy, disrupt our infrastructure, and cause loss of life. Accordingly, dramatic cybersecurity improvements are a necessity. While we cannot eliminate every cyber threat, we can manage them by protecting assets more effectively and efficiently according to their value. This approach requires a paradigm shift from how we perform cybersecurity today.

To attain true cybersecurity effectiveness, we must accelerate our detection and response capabilities from people time to machine time—from months to milliseconds. Today, there is almost always a “human in the loop” actively managing the process; although that can help avert unintended consequences, it also means that the attack is often over before preventative action can be taken. This calls for automating many risk decisions and optimizing human oversight of cybersecurity processes too complex or important for machines alone to solve.

CURRENT CYBER LANDSCAPE

Today’s cyberattacks are extremely varied and sophisticated. Three key factors contribute to this challenge: the increasing speed at which attackers can successfully attack; the wide range of attackers and attacks to defend against; and the disparate, piece-meal approach implemented in most current cybersecurity solutions.

Time to attack and defend

Of fundamental concern is the long delay between the launch and discovery of cyberattacks, a situation that must improve.

Figure 2 compares attacker efficiency, as measured by the time [in days or fractions of days] it takes an attacker to complete a successful infiltration, to defender efficiency, as measured by the time it takes to discover an attack. The solid lines represent a linear regression of the actual data. Over 10 years, attackers successfully improved their efficiency in compromising systems from less than 75 percent successful intrusions occurring within days in 2004 to around 90 percent efficiency in 2013. However, the efficiency to detect attacks within days only improved from about 15 to 20 percent over the same time period. Clearly, then, during the past decade attackers have improved efficiency at a greater rate than defenders. The growing “innovation gap” between the two lines in Figure 2 clearly highlights the need for new approaches to cybersecurity defense.

Breadth of attackers and attacks

Verizon’s 2014 Data Breach Investigations Report (www.verizonenterprise.com/DBIR) states that “2013 may be remembered as the year of the retailer breach, but a comprehensive assessment suggests it was a year of transition from geopolitical attacks to large-scale attacks on payment card systems.” Cyberattackers are characterized by their resources and capabilities, intentions and motivations, degree of access, and risk aversion. They include:

- nuisance hackers who use publicly known attacks on unpatched targets of opportunity;
- organized criminals seeking financial gain who use known attacks, slightly alter known attacks to avoid antivirus detection, or develop new attacks;
- sophisticated hackers with a wide variety of intentions and motivations;
- terrorists who seek financial gain to fund their operations or use cyberattacks as a tool to harm their adversaries; and,
- nation-states with varying capabilities, resources, and motivations.

Attackers’ intentions drive their target selections. For example, nuisance hackers and organized criminals typically target average citizens and retail companies, while sophisticated hackers, terrorists, and nation-states often attempt to infiltrate foreign government agencies and their contractors as well as companies possessing intellectual property of significant economic value. Well-resourced attackers will often target a large organization’s most vulnerable partners as well.
Cybersecurity investments

Cybersecurity investments currently follow a piecemeal approach in which disparate proprietary point solutions are linked together uniquely for each enterprise. The situation is akin to the US housing construction market before the 20th century when few building codes existed and each home was custom-built, resulting in higher installation and labor costs, and safety problems such as faulty wiring and vulnerability to severe weather, fire, and earthquakes. We need the equivalent of building codes for cybersecurity and modular, scalable, interchangeable solutions.

However, assessing the appropriate level of cybersecurity investment and correctly integrating available products and services is problematic. This is exacerbated by the constant evolution of technology and attacker tactics. Although organizations have made progress in quantifying the cost benefits of cybersecurity investments, determining whether such investments are commensurate with an organization’s risk remains an immature process.

Characteristics of a Healthy Cyber Ecosystem

These three factors call for the creation of a healthy cyber ecosystem. “Like natural ecosystems,” noted a March 2011 white paper written by the US Department of Homeland Security (DHS), “the cyber ecosystem comprises a variety of diverse participants—private firms, non-profits, governments, individuals, processes, and cyber devices (computers, software, and communications technologies)—that interact for multiple purposes. Today in cyberspace, intelligent adversaries exploit vulnerabilities and create incidents that propagate at machine speeds to steal identities, resources, and advantage.” As attackers constantly probe for the weakest link in a defense, “cyber devices [must] collaborate in near-real time.” In other words, they must be able to learn from their activities, creating and sharing that intelligence through collaborative community-driven initiatives such as Trusted Automated eXchange of Indicator Information (TAXII; https://taxii.mitre.org) and its Structured Threat Information eXpression (STIX; https://stix.mitre.org) language.

Motivated by concerns that cyberattacks are becoming “more frequent, more widespread, and more consequential,” the DHS white paper outlined three essential building blocks of a healthy cyber ecosystem. First, automated mechanisms are needed to detect cyberattacks and intrusions and mitigate them at machine speeds. Second, semantic, technical, and policy interoperability among automated defense systems is essential to promote shared situational awareness and facilitate rapid machine-to-machine exchange of threat and incident data. The National Strategy for Trusted Identities in Cyberspace (www.nist.gov/ntic) describes technical and semantic interoperability as “the ability for different technologies to communicate and exchange data based upon well-defined and testable interface standards,” while policy interoperability is “the ability for organizations to adopt common business policies and processes (e.g., liability, identity proofing, and vetting) related to the transmission, receipt, and acceptance of data between systems.” Third, authentication is required to ensure that all parties participating in cyber defense, whether human or machine, are who they claim to be.

Since the white paper’s release, two other necessary capabilities have been identified. First, individual cyber elements must be more resilient to attack and better able to maintain the integrity of their functionality and mission support through reduction of latent weaknesses that attackers could exploit. Second, mechanisms and infrastructure for machine-speed sharing of information must be developed. In this area, TAXII/STIX shows promise.
TODAY’S CHALLENGES

Successfully protecting the IoT will require creation of a scalable and sustainable cyber ecosystem within the IoT that actively adjusts to and mitigates threats and malicious activities while being reliable, robust, and affordable. When fully established, the future cyber ecosystem will give people around the world the freedom to live, work, and play safely and securely in cyberspace, provided they take a few common-sense defensive precautions. Achieving this goal of a healthy cyber ecosystem requires addressing the following challenges: scalability, sustainability, affordability, resiliency, capability, interoperability, standards, automation, and adaptability.

Scalability, sustainability, and affordability

Today’s cybersecurity processes fail to scale largely because they require too many professionals and experts to stay abreast of the latest vulnerabilities and required patches, monitor and analyze all manner of network activities, respond to alerts, understand what is happening at any given time, decide whether and how to respond, and implement response and recovery actions. Scalability demands that we automate the full spectrum of cybersecurity operations—sensing, sense-making, decision-making, and acting—to the greatest extent possible, shifting experts’ role from being in the loop (in the critical path of all cyber-defense activities) to on the loop (monitoring and supervising largely automated defense and response functions). Not all cyberattacks can be addressed using automated processes, but moving from mostly human-speed processes to mostly orchestrated machine-speed processes would enable the powerful cadre of cyberprofessionals to concentrate their efforts on those classes of attacks that today are beyond the means of automated responses.

Scalability also demands that we make the individual elements of the cyber ecosystem more resilient to attack, with fewer inherent weaknesses and flaws for exploit by attackers. Today’s cybersecurity processes associated with development, acquisition, and operations are unsustainable largely because the supporting commercial solutions often fail to integrate fully and effectively with one another, and/or are dependent upon costly, centralized government data feeds. To achieve scalability and sustainability, the cyber ecosystem will increasingly need to replace centrally managed government data feeds with federated commercial ones. Trusted and authoritative information providers must eventually prepare and disseminate most of the vital cybersecurity data in standardized machine-consumable formats.7

Sustainability and affordability demand that we proactively improve the security, resiliency, and effectiveness of our IoT by reducing the attack surface through supply-chain and software-quality improvements, thereby reducing cost; and by fostering technology innovation through the use of integrated, adaptive, interoperable tools and federated data feeds, which are based on a common data model and international standards provided by a vibrant commercial market.

Resiliency and capability

Within the cybersecurity community, there is a strengthening movement toward designing cyberspace systems to be resilient—to be able to withstand and rapidly “bounce back” from adverse events. Deborah Bodeau and Richard Graubart6 define cyber resiliency as “the ability of a nation, organization, or mission or business process to anticipate, withstand, recover from, and evolve to improve capabilities in the face of adverse conditions, stresses, or attacks on the supporting cyber resources it needs to function.” In addition to the long-term strategic goal of improving the overall quality, reliability, and integrity of software and ICT, there is a need to implement cyber resiliency engineering, a “sub-discipline of mission assurance engineering which considers (i) the ways in which an evolving set of resilience practices can be applied to improve cyber resiliency, and (ii) the trade-offs associated with different strategies for applying those practices.”

Cybersecurity capabilities that effectively and efficiently protect the nation’s IoT will emerge from the interactions of many discrete components, each contributing a needed function or service that is distributed across many heterogeneous devices and networks. These components need to contact and authenticate each other, establish secure communication channels, exchange data within defined access limits, and then use the data they have exchanged. To the extent that they do so successfully, the cybersecurity components of the cyber ecosystem are said to be interoperable and operate as an integrated set of capabilities.

Interoperability, standards, automation, and adaptability

One way cybersecurity staff can achieve interoperability among disparate components is to acquire all products and services from a single vendor. While this may be beneficial in the short term, it could later lead to vendor lock-in—a situation in which the cost...
OUTLOOK

A CYBER ECOSYSTEM IS NOT TRULY HEALTHY UNLESS IT CAN RESPOND EFFECTIVELY TO WHAT IS KNOWN AS WELL AS TO WHAT IS ABNORMAL.

of switching to a competing product becomes prohibitive, thus committing the consumer to the deployed solution even if a demonstrably more useful or functional alternative exists. Industry standards can help prevent certain forms of vendor lock-in. When a system of systems (like a cyber ecosystem) can be formed by integrating functional components that conform to standard interfaces, communication protocols, and data formats, it becomes possible to relatively easily replace any individual component with a new one, without regard to vendor. (Industry standards offer other benefits as well; limiting dependence on proprietary solutions is just one of the most common motivations.)

However, standards are no panacea. Unless multiple vendors are competing vigorously on price, quality, and support to deliver standards-conformant products and services, industry standards by themselves offer little value to the consumer. There is no advantage to having freedom to choose without having meaningful choices. Fortunately, successful industry standards can and often do help create the conditions that sustain a vibrant market.

Today, automated cybersecurity defense depends on vast and growing volumes of human knowledge and insight distilled at high labor cost into bundles of data that are formatted and structured for machine consumption, then disseminated over government-maintained channels. Significant government outlays over the years helped lay the foundation for a healthy cyber ecosystem, but such funding cannot continue indefinitely given current budget constraints. Moreover, central authorities, whether government-funded or not, cannot possibly keep up with the growing scope of automated cybersecurity defense content-development efforts.

A healthy cyber ecosystem must support adaptive responses to risks associated with both identified and suspected threats. As soon as a system vulnerability or pattern of malicious activity becomes known, trustworthy and actionable information needs to be broadly disseminated to all stakeholders—in standard formats, using common interfaces and secure communication protocols such as STIX and TAXII, with the requisite identity and access management controls—and then acted upon as soon as is practicable. Although this is much easier said than done, it is the best understood and most easily managed scenario in the entire cyber ecosystem.

Unfortunately, persistent and innovative phishing and social-engineering exploits, as well as the active underground market in zero-day attacks, require cyber-ecosystem participants to be ever alert to the possibility that malicious external or insider attackers may have penetrated a network’s defensive layers. Vigilance of this sort demands integrated, coordinated, and finely tuned capabilities using commonly understood concepts and terminology to accurately distinguish the ordinary from the anomalous, selectively increase scrutiny where warranted, actively test whether newly observed behavior is merely a novel manifestation of normal operations, and modify network settings to safely thwart malicious objectives without undermining operational missions or business functions. A cyber ecosystem is not truly healthy unless it can respond effectively to what is known as well as to what is abnormal and might indicate an attack or intrusion in progress.

THE FUTURE: INTEGRATED ADAPTIVE CYBER DEFENSE

Integrated Adaptive Cyber Defense (IACD) is the concept that commercial and government security solutions will be based on an open architecture for automated, adaptive, and dynamic cybersecurity assessment, mitigation, and defense at the enterprise, intra-enterprise, and inter-enterprise levels. This flexible, standards-based architecture, shown in Figure 3, will allow rapid insertion and integration of existing as well as future automated cyber-defense technologies and infrastructures. It must support automated messaging using a common data model and standardized exchange mechanisms, and be capable of applying agreed-upon rules to initiate actions within and across the collection of enterprises participating in the cyber ecosystem; that is, it must...
support “whole enterprise” information exchange and action, as well as information exchange and action among semiautonomous business units and between enterprises. Message receivers must be able to identify and authenticate the source of each message, and to adjudicate whether a request for action can be performed automatically or only after review and approval by authorized parties.

Integrated capabilities include a communications medium with standard interfaces, message transport protocols, and message sets that support federated machine-speed exchange of cybersecurity information. Standard interfaces and common data syntax and semantics enable compatible components to connect to and interoperate through the communications medium. Standard protocols and data formats let components output and ingest data in a way that other standards-conformant components can understand. Standard message sets enable all connected components to communicate with one another among different enterprises. Messages must be tamper-resistant and include credentials that allow senders’ identities and authorizations to be reliably determined. Components must be able to process and act on received messages within contextually determined time limits appropriate to the overarching cybersecurity objective. Depending on the context, cyber-relevant time could be nanoseconds, microseconds, seconds, minutes, or perhaps even hours.

Interoperable, modular commercial cybersecurity tools will provide integrated services across six logical functional areas:

- **Sensing** involves monitoring the cyber environment using devices or people to obtain snapshots of current operational states and risk exposures attributable to exploitable weaknesses in installed ICT/software.
- **Sense-making** involves applying rule sets, recognizing patterns, and using advanced algorithms to assess the dynamic cyber environment in many contexts. It is performed by interoperable tools, with or without human-on-the-loop review as dictated by circumstances. Sense-making takes advantage of federated information-sharing capabilities.
- **Decision-making** involves formulating candidate response actions that empower enterprise decision-makers to evaluate alternatives and select the best course of action (COA). Decisions are made by automated tools, with human-on-the-loop review as dictated by circumstances. Decision-making selects among available response actions, while leaving the action decision itself
OUTLOOK

Acting involves implementing selected COAs in cyber-relevant time. Preventative and response COAs should be executed automatically to the greatest extent possible, with automated detection and identification of patterns of attacks and correlation to known weaknesses and vulnerabilities in ICT/software with appropriate machine-speed mitigations. Human operators should be notified and given situational awareness of executing COAs, but the operators should be involved in the process only when needed to ensure that automated actions are properly authorized and to manage any impacts on critical business or mission functions. As this is an immature area requiring more research, the only COAs that will be used initially are those with well-understood impacts, such as sending an automated email or adding a firewall block.

Federated information-sharing (shared situational awareness and shared analysis) of cybersecurity data—not only within but also among disparate enterprises—is a critical enabler of automated COAs. Human operators need accurate insight into the current security state of their networks as well as other networks on which their businesses or missions depend. The insight offered by a common operational picture (COP) lets operators properly understand why automated COAs are being recommended or invoked to protect ICT/software-enabled systems with latent weaknesses and vulnerabilities from detected or suspected exploits or attacks, and helps them coordinate responses with peers who may be coping with the same or similar security conditions.

Management functions allow operators to view data such as packet streams, alerts, and reports, and to select actions in which organizational policy requires human approval. They also provide automated workflow and overall control of capabilities and tools that support and perform cybersecurity functions while ensuring privacy of personal information. This automated workflow is applicable to all actions on a risk-assessed basis, from clicking on a URL to opening an email attachment. Cyber risk assessment is commonly referred to as reputation scoring. Orchestration of human-originated actions and the enabling and blocking of them based on an analysis of the sender or source reputation and object history is an aspect of IACD functionality.

Centralized, enhanced situational awareness will help human operators perceive and evaluate security activities and trends, provide a “weather map” of looming “cyberstorms,” and reveal the susceptibility of an organization’s ICT/software to specific threats and malware. Current technologies such as big data analytics, reputation-based scoring, visualization, presentation, and dissemination are limited; cooperative action is needed to promote and guide development of new capabilities that can eventually be incorporated into the cyber ecosystem. A federated ability to integrate, analyze, and disseminate information in milliseconds is needed.

The IACD architecture will make use of an array of technical standards to ensure component interoperability and openness to any conformant automated cyber-defense product or service with a common set of foundational concepts about what is being exchanged. Standards must be designed with the consensus of government, industry, and the general public to ensure widespread adoption. The goal is for all security customers to use IACD to either implement their own solutions or purchase a turnkey service from a vendor.

Establishing the architecture will be a complex and technically demanding activity carried out incrementally. Centralized, enhanced situational awareness will help human operators perceive and evaluate security activities and trends, provide a “weather map” of looming “cyberstorms,” and reveal the susceptibility of an organization’s ICT/software to specific threats and malware. Current technologies such as big data analytics, reputation-based scoring, visualization, presentation, and dissemination are limited; cooperative action is needed to promote and guide development of new capabilities that can eventually be incorporated into the cyber ecosystem. A federated ability to integrate, analyze, and disseminate information in milliseconds is needed.

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Establishing the architecture will be a complex and technically demanding activity carried out incrementally. Each step will yield new lessons, and must be guided by insights gained from smaller-scale, lower-risk, and more narrowly focused research and development that inform and evolve the larger architecture.
The above envisaged IACD capabilities will help achieve a secure cyber ecosystem but will require a substantial commitment of resources and the coordination of government, academia, and international and industry partners over many years. Four goals critical to cyber resiliency that are the most feasible to accomplish over the next 5 to 10 years are the development of a standards-based architecture that supports rapid technology insertion, capabilities for automated COAs, a weather-map capability with federated data feeds, and trusted information-sharing at machine speeds using common terminology and foundational concepts. However, such efforts will come to naught without a persistent focus on affordability, risk reduction, scalability, effectiveness, and efficiency.

Increased use of automation offers the greatest prospect of containing costs and reducing risks, but automation is no silver bullet—it depends on our ability to distill expert human knowledge and skill in cybersecurity sensing, sense-making, decision-making, information sharing and analytics, and acting into forms amenable to manipulation and execution by machines. As the cyber ecosystem’s IACD emerges and evolves, care must be taken at all times to avoid simply creating a different set of comparable (or worse) costs and risks.

Scalability, effectiveness, and efficiency are also key considerations. IACD’s various implementations must be scalable to fit the needs of small as well as large organizations; be more effective than current methods in anticipating, preventing, disrupting, and countering attacks and intrusions; and make more efficient use of human and machine resources while protecting privacy. Demonstrating this will require new metrics for quantifying and evaluating the costs and benefits of alternative cybersecurity solutions. The overall principle is to enable all Internet technologies to play a role in protecting traffic and IoT components. We must do with numbers and data correlation what biology does with chemicals to create a dynamic immune system with automated detection and response. We must optimize the use of humans on the loop for complex or politically driven incidents that cannot be addressed by automation and for “antibiotic-resistant” intrusions that can result from the use of automation against common attacks.

Our efforts to evolve the cyber ecosystem must result in solutions that promote adaptability and agility of response. As the tactics, techniques, and procedures of cyber adversaries continuously adapt and evolve, so too must the cybersecurity defense mechanisms and methods implemented within the cyber ecosystem driven by IACD.

REFERENCES

OUTLOOK

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Interoperable Privacy-Aware E-Participation within Smart Cities

Constantinos Patsakis, University of Piraeus
Paul Laird, Michael Clear, and Mélanie Bouroche, Trinity College Dublin
Agusti Solanas, Rovira i Virgili University

Sharing data via information and communications technology is a fundamental goal of e-government, but data fusion and data mining could reveal sensitive personal information. A proposed cryptographic protocol guarantees citizens’ privacy through data aggregation and fosters e-participation in a scalable and interoperable way.

E-government uses information and communication technology to facilitate access to information, services, and expertise and ensure citizen participation in and satisfaction with the governmental process. ICT simplifies and expedites transactions among people, businesses, and government agencies in a transparent and cost-efficient way.

The adoption of e-government offers benefits at different levels, but it arguably has the greatest impact at the municipal level, that closest to the people. This can be seen in the growing popularity of smart cities, those “strongly founded on information and communication technologies that invest in human and social capital to improve the quality of life of their citizens by fostering economic growth, participatory governance, wise management of resources, sustainability, and efficient mobility, whilst they guarantee the privacy and security of citizens.”

ICT enables citizens to play an active role in collecting and sharing information—in other words, as intelligent sensors. Thanks to such e-participation, local governments can make more informed decisions and thereby improve quality of life. In this model, illustrated in Figure 1, information flows from the citizens to the government and then back to the citizens in a closed loop.

To encourage municipalities to adopt e-government and foster e-participation, it is necessary to provide citizens with the ability to contribute detailed information efficiently using a wide range of interoperable devices and protocols. The data’s granularity and immediacy, as well as the vast amount of information sources, require infrastructures with very demanding financial, technical, and personnel requirements. However, an additional, nonmonetary, cost of even greater concern to citizens is privacy.

Citizens might be reluctant to share information...
depending on its nature. However, even if this is not the case, a great deal of private information could be revealed through data mining and data fusion techniques. In many instances, some data considered redundant could reveal sensitive personal details when fused with other information. E-government services therefore must be privacy-aware for citizens to trust and embrace them.10,11

Toward this end, we have developed a cryptographic protocol designed to manage the huge amount of personal information that could be generated through e-participation in a scalable, interoperable manner that guarantees citizens’ privacy.

CHALLENGES AND OBJECTIVES
Any e-participation solution for municipalities in which numerous citizens will interact with e-government faces four challenges:

- **Performance**: The system’s algorithms and infrastructures should be able to accommodate time-dependent data.
- **Interoperability**: Citizens should be able to interact with the system using various types of personal devices that follow open e-government standards.
- **Privacy**: The system should guarantee the privacy of personal information it collects and stores.
- **Scalability**: The system must be able to cope with a large and progressively growing number of citizens.

Several researchers have examined these challenges. For example, one recent paper describes the three core functionalities of municipal-scale ICT platforms as urban communications abstraction, unified urban information models, and open urban services development.12 While these functionalities highlight the need for interoperability, their urban character underscores the importance of scalability. Performance and privacy are combined under the umbrella of communications abstraction, where both are considered the default for communications because every user presumes that his or her provider will try to increase performance without decreasing privacy. Unfortunately, the three well-known Vs—volume, velocity, and variety—impose serious limitations that prevent current solutions from addressing all of the challenges simultaneously. For instance, a solution can be interoperable, scalable, and high-performing but not provide privacy, or it might provide performance, privacy, and interoperability but not scale efficiently.

We believe that e-government can manage fine-grained data in a manner that addresses all four challenges at the same time. The system can either aggregate data or provide anonymous statistics, both of which are invaluable, especially if the data can be delivered in or near real time. Our proposed cryptographic protocol focuses on e-government services that exploit urban sensing information stemming from the fixed sensors of a smart city’s infrastructure, such as weather, pollution, traffic, and mobile sensors pre-equipped with GPS, as well as information gathered from citizens through participatory sensing. Information from fixed sensors can be considered public, but data gathered from citizens needs to be anonymized without decreasing the data’s utility or disclosing citizens’ identities. The protocol can also handle sensitive time-series data.

One of the main goals of our proposed scheme is openness, which provides the necessary transparency to stakeholders to justify why certain decisions were made and motivates citizens to participate more actively in city management. It also allows interoperability, as private companies can use open standards to develop their solutions; even if the underlying technology remains secret, other stakeholders can easily interoperate with the data. If a scheme is also privacy-aware, it allows the publication of open government data, leading to further service development and exploitation by organizations, companies, and individuals. Thus, it could be said that data should
be open—accessible to everyone—and at the same time private in the sense that citizens’ privacy is preserved.

**MOTIVATING SCENARIO**

For context, consider a city with several commercial areas containing numerous shops and restaurants that provide goods and services. The municipality would like to know how many people are in each area to better distribute its resources, such as police and street cleaners, and serve its citizens in real time.

In this scenario, businesses might need to inform the municipality about their current number of customers. However, doing so might provide their competitors with vital information to plan campaigns that could direct customers elsewhere, so some businesses might be reluctant to provide this information.

With our proposal, businesses could privately share the number of their clients. The system could then aggregate this data and reveal the total number of customers in a given area of the city in real time to the proper municipal authorities. In this way, the city could better allocate its resources depending on citizens’ activities while keeping private individual business’s customer numbers.

**CRYPTOGRAPHIC PROTOCOL**

Although there are many variants of cryptographic primitives, certain structures have proved very efficient or secure and are widely used by many algorithms. One of these is the elliptic curve, a well-known algebraic structure that generates an abelian group. The main advantage of an elliptic curve is that generates an abelian group.

The group $G$ may be instantiated by a cyclic group of prime order $p$. DDH is one of the strongest cryptographic assumptions, like single-round KDK. A cyclic group is one generated by a single element, called a generator, which is denoted by $g$ for the group $G$. The group $G$ may be instantiated by different types of groups such as an elliptic curve over a finite field. An elliptic curve offers more efficiency for the same levels of security compared to other groups. In fact, multi-round KDK requires elliptic curves due to its heavy reliance on pairings, which makes it far less efficient in practical applications than PCL.

One can assume that KDK is based on a fixed matrix $A$ with its entries being $\{-1, 0, 1\}$, determining the exponents used to compute a value $v^r$. More precisely, KDK defines a matrix $A$ of the following form:

$$A = \begin{bmatrix} 0 & -1 & -1 & -1 \\ 1 & 0 & -1 & -1 \\ 1 & 1 & 0 & \ldots & \ldots \\ \vdots & \vdots & \vdots & \ddots & \ddots \\ 1 & 1 & 1 & \ldots & 0 \end{bmatrix}$$

In the first step of the protocol, each user $U_i$ publishes a value $v_i = g^r$, keeping the value $x_i$ secret. Then, each user has to compute a value $w_i$. To compute this value, each user $U_i$ raises user $U_j$’s public key $v_j$ to the power that cell $A_{ij}$ indicates. Then, $w_i$ is defined as a product of these values. The user then publishes the following value:

$$v_i^{(r)} = w_i^{A_{ij}} \cdot g_i^{m_i^{(r)}}$$

where $m_i^{(r)}$ is the value that user $U_i$ wants to send for aggregation in round $r$. If the aggregator multiplies all the $v_i$ values, he or she will compute $g \sum m_i^{(r)}$. Therefore, if the
value $\sum m^{(r)}_i$ is well bounded and not very large, it can be easily extracted using an exhaustive search.

It is clear that $A$ is a skew-symmetric matrix: $-A = A^T$. PCL’s main goal is to generate a new skew-symmetric matrix $A(k)$ in a deterministic manner for each round $k$ so that users do not have to republish information often. Furthermore, $A(k)$ has coefficients in $\mathbb{Z}_p$, instead of $\{-1, 0, 1\}$; depending on his or her collusion tolerance, the user may select how many zeros each row will have. The more zeros in row $i$, the fewer computations user $U_i$ has to make and the bigger tolerance he or she has. Here we assume a function $x : \mathbb{Z}_p \times \mathbb{Z} \to \mathbb{Z}_{p^n}$ that takes a random seed and a random number, and then outputs a pseudorandom skew-symmetric matrix over $\mathbb{Z}_p$. Note that the seed can be predetermined or derived from users’ public keys.

The main steps of PCL are as follows:

1. Party $P_1$ generates a secret key $x_1 \in \mathbb{Z}_p$ and computes his or her public key $u_1 = g^{x_1} \in G$. He or she broadcasts $u_1$.
2. For every round $r \in \{1, \ldots, \ell\}$:
   - Party $P_1$ chooses his or her input $m^{(r)}_i \in \{0, \ldots, \beta\}$.
   - Compute $A^{(r)} \leftarrow x(s, i)$.
   - Compute $w \leftarrow \prod_{s\neq i} u^{x(s)}_s \in G$.
   - Compute $\nu^{(r)} \leftarrow w^{-r} \cdot g^{m^{(r)}} \in G$.
   - Broadcast $\nu^{(r)}$.
3. The protocol produces an output of $\ell$ elements, namely the sum of the inputs in each round. To compute the sum $\sigma$ for round $r$:
   - Compute $z \leftarrow \prod_{s\neq i} \nu^{(r)}$.
   - Use Pollard’s lambda algorithm to compute the discrete log $\sigma_i \in \{0, \ldots, n\beta\}$ of $z$ with respect to $g$ in $G$. The time complexity of Pollard’s lambda algorithm is $\sqrt{n\beta}$.
   - The final output is $\{\sigma_1, \ldots, \sigma_{\ell}\}$.

It can be easily observed that for any $1 \leq r \leq \ell$,

$$\prod_{j=1}^{n} \nu^{(r)}_j = g^{\sum_{j=1}^{n} m^{(r)}_j}.$$ 

PCL can be extended to support blind aggregation. This means that users submit their data in a more obfuscated form so that the aggregator computes an obfuscated form of the summary, which can only be recovered by another entity. This provides a differentiation between the entities. Users submit their data to the aggregator, which forwards the obfuscated result to the data consumer. The information cannot be intercepted throughout the procedure. Moreover, due to the nature of the protocol, the aggregator need not be fully trusted, which significantly decreases data exposure. An overview of the protocol is illustrated in Figure 2.

**FIGURE 2.** The proposed PCL protocol. In the initialization phase, users publish their public shares, which are used in each of the $r$ rounds to produce obfuscated values. These values are then multiplied by the aggregator to calculate the sum of the values.

The protocol correctly, but might collude to recover the input of others. Because the protocol’s security is based on the DDH assumption, it can be considered immune to outsider threats.

Privacy is customizable using the extended protocol because users, depending on their trust of others, can select their level of collusion tolerance. The main advantage of this feature is that, depending on the amount of collusion users are willing to tolerate, the efficiency of the protocol scales accordingly. The original scheme only considers the amount of rounds that PCL can execute without publishing new information. However, the extended protocol allows users to define how many adversaries can be tolerated to collude. This provides a significant boost in performance. For instance, in Byzantine attacks where the tolerance is around one-third of colluding users, PCL performance is tripled because the necessary calculations are reduced by a factor of three.

**SCALABILITY AND PERFORMANCE**

As indicated earlier, our proposed protocol offers a special feature where—in the result can be obfuscated from the aggregator, meaning many local aggregators could be installed to perform aggregation on a local scale. Depending on the type of data to be aggregated, a local aggregator can
host up to hundreds or thousands of users without significant processing requirements. Moreover, due to the nature of the protocol, the local aggregator cannot find the values of individuals or access the resulting aggregated value. The local aggregators thus act as “anonymous proxies” between users and the system, resubmitting the aggregated information without disclosing users’ identities. This means that PCL can be used to provide scalability, as Figure 3 shows.

Several of the protocol’s features help boost its performance, aside from user-customizable privacy tolerance. Elliptic curves allow the scheme to use small groups and publish minimal information each time it is needed. Moreover, the use of elliptic curves has been widely accepted as a cryptographic standard for devices with low processing resources, as the computations, such as point addition and scalar multiplication, can be performed very efficiently without much effort. The lack of pairings, used widely in the KDK protocol, provides an additional performance boost, as these are very slow when used on devices such as sensors. In addition, PCL enables the reuse of published information for several rounds, diminishing bandwidth cost.

To better understand the protocol’s efficiency, note that time complexity is linear to the number of users. The reason is that at any step we have to make n multiplications and one exponentiation. Running one round of the protocol for 1,000 users with full privacy on a common laptop takes around 45 milliseconds, while a non-optimized version on a mobile phone (without elliptic curves) takes around 330 ms.

We developed an Android application to further test PCL efficiency. The tests were performed on a Samsung GT-I9001 with Android 2.3.3. In these tests, a user submits a value using GT-I9001 with Android 2.3.3. The experimental results, summarized in Table 1, clearly indicate that computational cost is minimal, enabling submission of data in near real time depending on application needs. Moreover, our implementation used the less efficient approach of the multiplicative group mod q without multithreading, which means that these measurements can be drastically improved.

### INTEROPERABILITY

Interoperability can be understood in many ways. The European Parliament defined it in 2009 as “the ability of disparate and diverse organizations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organizations, through the business processes they support, by means of the exchange of data between their respective ICT systems.”

E-government protocol interoperability allows manufacturers to easily deploy their solutions and thus encourages e-participation. More citizens will embrace a solution that is platform- and device-independent. Our protocol can readily be implemented in many platforms. But it can also be integrated in more efficient and interoperable ways, especially in the case of devices with low processing capabilities, such as sensors.

Currently, sensors are widely deployed in urban areas to facilitate the needs of smart cities and e-governments. Numerous manufacturers and devices support many protocols, creating a heterogeneous mixture that makes sensor discovery and access a nontrivial task. Many proposed interoperability solutions follow a bottom-up approach, such as Device Description Language (DDL). 16

One widely adopted approach is SensorML (www.opengeospatial.org/standards/sensorml), which was created in 1998 and quickly standardized by the Open Geospatial Consortium (OGC). Initially, SensorML was used to describe the geometric, dynamic, and radiometric properties of dynamic remote sensors. OGC generalized it even more, targeting the development of standard sensor models and standardized descriptions of sensors and their data. Currently, SensorML is one of the most commonly used standards for sensor description. The concept behind SensorML was to generate an XML scheme that encodes metadata for describing sensors, sensor platforms, sensor tasking interfaces, and sensor-derived data. XML was adopted for publishing sensor descriptions to support interoperability, as the vast majority of programming languages can support XML with their parsers. In this sense, SensorML arguably provides an XML wrapper for publishing

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**FIGURE 3.** Scalability can be achieved through local aggregators. Each aggregator calculates the sum of its neighborhood and forwards the blind sum to the central authority.
formal descriptions of sensors’ capabilities, locations, and interfaces.

We propose the use of SensorML, which exposes a RESTful interface. Each sensor exposes two additional methods, GetPublicShare and SendPublicShare. The aggregator discovers and registers the devices using SensorML, and, whenever data are required, it calls the SendPublicShare method to each sensor. Upon receiving this call, the sensor will generate its public share for the first round and reply with that value. Whenever the aggregator receives all the public shares, it creates a vector of all the values and sends them, as parameters, to the GetPublicShare method. Each sensor can then calculate the new share, embed its measurement, and return the result to the aggregator. While SensorML simplifies the procedure of describing and managing sensors, the RESTful interface provides ease of functionality. Given sensors’ low processing capabilities, the combination of SensorML and the RESTful interface is superior to other options like SOAP because the computational and communication overhead is significantly lower.

With the wide adoption of ICT, many aspects of our daily lives are changing. E-government is a clear example of the way ICT can improve efficiency, interoperability, privacy, and participation. We support the idea that smart cities can contribute to the better deployment of e-government strategies at the municipal level. In this context, we propose the use of a cryptographic protocol and infrastructure that allow the private sharing of information to promote e-participation, which allows municipalities to make better decisions based on fresh data privately contributed by citizens.

Our solution satisfies the four challenges that we identified: it is efficient, it is interoperable thanks to the use of open standards, it protects citizens’ privacy, and it is scalable. Further research will focus on applying our scheme to specific scenarios like smart health, urban sensing, and pollution monitoring.17

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TABLE 1. Average time per round and per user for different lengths of primes and sets of users.

<table>
<thead>
<tr>
<th>Number of users</th>
<th>Average time per round/user</th>
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</tr>
</tbody>
</table>

Number of users: 512 bits (length of prime) 1,024 bits (length of prime)

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Number of users: 512 bits (length of prime) 1,024 bits (length of prime)
OUTLOOK

ABOUT THE AUTHORS

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See www.computer.org/computer-multimedia for multimedia content related to this article.
A major appeal of cloud computing is that it abstracts hardware architecture from both end users and programmers. This abstraction allows underlying infrastructure to be scaled up or improved—for example, by adding datacenter servers or upgrading to newer hardware—without forcing changes in applications. The long-dominant x86 processor architecture, along with high-level, portable languages such as Java, PHP, Python, and SQL, has helped assure the continued viability of such abstraction. Meanwhile, exponential growth in microprocessor capability, mirroring Moore’s law, has helped to improve performance for most applications that execute on general-purpose processors, including those deployed on clouds.

However, as transistors continue to shrink, concurrent limitations on power density and heat removal and the inability to scale down operating voltage any further mean that it’s no longer possible to increase microprocessor performance by adding identical, general-purpose cores.

HETEROGENEOUS DATACENTER ARCHITECTURES

These limitations, however, can be addressed by incorporating heterogeneity into processor architectures. Heterogeneous processing elements are able to improve efficiency through specialization: computations that match the specialized processing elements’ capabilities can be accelerated, and units not currently active can be turned off to save power. Examples already being developed in the computing industry include graphical processing units (GPUs), vector- or media-functional units similar to the SSE4 instruction set, and encryption units, as well as highly parallel coprocessors such as Intel’s Xeon Phi.

Future datacenter architectures will likely resemble that shown in Figure 1, with multiple processors (each of...
which may also have heterogeneous internal components, accelerators, interconnects, and storage systems that, together and individually, provide greater efficiency for specific applications or in particular scenarios. Companies like Microsoft and PayPal that depend on large-scale datacenters are investigating heterogeneous processing elements like these to improve product performance.2,3

Developing cloud computing technology compatible with datacenter heterogeneity will require finding ways to optimally exploit varied special-purpose processing elements without losing the advantages of abstraction. To this end, each of the three main cloud services models faces various challenges, as summarized in Table 1.

### INFRASTRUCTURE AS A SERVICE

At the lowest level, infrastructure as a service (IaaS) exposes physical and virtual resources to the end user. Virtual machines (VMs) and bare-metal provisioning offer nearly complete OS instance control.

Traditionally, virtualization has imposed a high overhead for performance-sensitive workloads. Today, however, technologies such as single-root I/O virtualization (SR-IOV) and peripheral component interconnect (PCI) passthrough enable direct access to accelerators and networking devices, typically with overhead of 1 percent or less.4

Still, as datacenters become more heterogeneous, IaaS deployments will have to expose increasingly varied components, like those shown in Figure 1. Extending homogeneous cloud flexibility to heterogeneous IaaS deployment requires further research in several areas:

- optimal tradeoffs in virtualization performance and functionality (security vis-à-vis isolation, for example),
- sharing schemes for compute accelerators,
- scheduling techniques to determine job assignments for most efficient resource allocation,
- power and utilization optimization techniques,
- migration mechanisms for jobs having state in accelerators as well as in host processors, and
- cost and prioritization schemes.

Finding ways to exploit new interconnect technologies, such as software-defined networking, and parallel file systems in the context of heterogeneous compute elements also presents interesting research opportunities.

### PLATFORM AS A SERVICE

At the level of platform as a service (PaaS), heterogeneity is necessarily

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**Table 1.** Heterogeneous datacenter architectures: support requirements for three cloud service models.

<table>
<thead>
<tr>
<th>Service model</th>
<th>Description</th>
<th>Heterogeneous datacenter architecture support required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure as a service (IaaS)</td>
<td>Users provision virtual machines</td>
<td>Heterogeneity exposed to users Bare metal provisioning Virtualized processors, accelerators, networking, and storage</td>
</tr>
<tr>
<td>Platform as a service (PaaS)</td>
<td>Programmers target API; framework allocates resources</td>
<td>Heterogeneity may be exposed to programmers Framework manages and schedules heterogeneous resources</td>
</tr>
<tr>
<td>Software as a service (SaaS)</td>
<td>Application allocates resources or is developed on top of PaaS</td>
<td>Heterogeneity not visible to users Application or back-end manages heterogeneous resources</td>
</tr>
</tbody>
</table>

---

**Figure 1.** Typical future heterogeneous datacenter architecture. Such centers will contain multiple components: specialized servers and accelerators, including graphical processing units (GPUs), field-programmable gate arrays (FPGAs), and digital signal processors (DSPs); varied storage systems such as a network file system (NSF), Hadoop distributed file system (HDFS), and the like; and flexible interconnects. GigE: Gigabit Ethernet; IB: InfiniBand.
exposed to the framework; it may also be exposed to the programmer, or it may be hidden by libraries or back ends that target heterogeneity. Goals for future research include:

- heterogeneity-aware scheduling at the platform level,
- heterogeneous resource allocation among multiple platforms or frameworks sharing the same datacenter,
- software architectures for accelerated libraries, and
- frameworks for application programming that may or may not expose heterogeneity to the programmer.

An example of research targeting programmability improvements for heterogeneous hardware is Microsoft’s Catapult framework. This software−firmware interface and implementation for a field-programmable gate array accelerator was designed to improve the performance of the Bing search engine.3 It provides a valuable use case in exploiting heterogeneous hardware for a commercial datacenter application. Deployed on Bing production servers, Catapult improved Bing’s page-ranking throughput by 95 percent per server.

SOFTWARE AS A SERVICE

The software as a service (SaaS) model provides developers the most flexibility because heterogeneity can be hidden within the application software and not exposed to end users. Still, developers building SaaS platforms must keep in mind heterogeneous architectures like those that IaaS and PaaS deliver, and so must address issues involving implementation portability and scalability. Challenges in this area will likely be specific to the software service under development, but will involve making engineering choices about whether to use existing IaaS and PaaS interfaces or to devise custom implementations that target heterogeneity.

CALL FOR COLUMN CONTRIBUTIONS

We welcome short articles (1,200 to 1,500 words) for publication in this column that discuss your ideas for advancing cloud computing or share your experiences in harnessing the cloud. We also solicit articles on topics such as fog computing, cloudlets, cloud forensics, cloud aggregation and integration, service level agreements, and legal issues. Send your proposal/submission to the Editor, San Murugesan, at cloudcover@computer.org.

POSSIBLE TOPICS

- The software as a service (SaaS) model provides developers the most flexibility because heterogeneity can be hidden within the application software and not exposed to end users. Still, developers building SaaS platforms must keep in mind heterogeneous architectures like those that IaaS and PaaS deliver, and so must address issues involving implementation portability and scalability. Challenges in this area will likely be specific to the software service under development, but will involve making engineering choices about whether to use existing IaaS and PaaS interfaces or to devise custom implementations that target heterogeneity.

REFERENCES


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JOHN PAUL WALTERS is a project leader and computer scientist at the USC Information Sciences Institute. His research interests include cloud computing, multicore and accelerator programming, and fault tolerance. Contact him at jwalters@isi.edu.
Proliferating malware poses significant concerns for victims and security experts alike, and as the number of devices ripe for infection escalates, the amount of at-risk data will only continue to grow. A new form of mobile malware that uses information-hiding techniques to cover up malicious activities has been discovered in Android devices. While iOS devices such as iPads and iPhones have remained relatively secure, we discovered a way to hide information on the iOS system. We present our findings to help security experts better detect potential malware on the iOS platform.

The Apple operating system has so far proved resistant to information-hiding techniques, which help attackers communicate covertly. However, Siri—an iOS service that controls iPhones and iPads via voice commands—could change this trend. 

Rumorizing malware poses significant concerns for victims and security experts alike, and as the number of devices ripe for infection escalates, the amount of at-risk data will only continue to grow. A new form of mobile malware that uses information-hiding techniques to cover up malicious activities has been discovered in Android devices. While iOS devices such as iPads and iPhones have remained relatively secure, we discovered a way to hide information on the iOS system. We present our findings to help security experts better detect potential malware on the iOS platform.

BACKGROUND

Information hiding enables attackers to communicate without being noticed by a third-party observer. Originally introduced for written secrets, information hiding is now a key element in effectively assessing network security. Desktop malware that has recently employed information hiding with some success includes Duqu and Alureon\(^1\) (using pictures to transmit stolen data to remote servers), Trojan.Zbot\(^2\) (downloading a jpeg that embeds a list of IP addresses to be inspected), and Linux.Fokirtor\(^3\) (injecting data within Secure Shell traffic to leak information to its command-and-control server).

Because smartphones contain a range of personal and sensitive data, they have become a preferred target for stealing confidential information. Desktop malware that has recently employed information hiding with some success includes Duqu and Alureon\(^1\) (using pictures to transmit stolen data to remote servers), Trojan.Zbot\(^2\) (downloading a jpeg that embeds a list of IP addresses to be inspected), and Linux.Fokirtor\(^3\) (injecting data within Secure Shell traffic to leak information to its command-and-control server).

Recently, though, Android's open source nature allowed hackers to develop malware called Soundcomber,\(^5\) which covertly transmits the keys pressed during a call (for example, when a

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Understanding Information Hiding in iOS

Luca Caviglione, National Research Council of Italy
Wojciech Mazurczyk, Warsaw University of Technology

The Apple operating system has so far proved resistant to information-hiding techniques, which help attackers communicate covertly. However, Siri—an iOS service that controls iPhones and iPads via voice commands—could change this trend.

The Apple operating system has so far proved resistant to information-hiding techniques, which help attackers communicate covertly. However, Siri—an iOS service that controls iPhones and iPads via voice commands—could change this trend.
user enters his or her PIN to access a financial service.

As iOS increases in popularity, it’s also attracting more malware developers. In April 2014, jailbroken iPhones and iPads were infected via a malicious dynamic library called Unfod.dylib.6 When running, the library listens to outgoing Secure Socket Layer (SSL) connections to steal a user’s Apple ID and password, which are then leaked in plaintext. Although in this instance the absence of stealthiness partially mitigates the threat’s effectiveness, it’s only a matter of time before we’ll see new forms of malware that use information hiding to compromise the Apple ecosystem.

We ourselves discovered a method—which we call iStegSiri—that we believe is the first attempt to covertly leak data from an iPhone or iPad without installing additional applications. Understanding this method can help security experts recognize and prevent similar future attacks.

CLOAKING INFORMATION

Information hiding makes it possible to cloak a communication’s very existence; thus, it’s different from cryptography, in which a transmission’s content, though unreadable, is still overt. The two mechanisms are often used jointly—for example, to assure that a conversation remains unreadable. Data hiding is derived from steganography, which originally involved techniques like invisible ink or tattoos.1

To exchange secrets, the two endpoints must agree on a scheme in advance and embed the secret message within a carrier: the more popular the carrier, the better the masking capacity. Too many alterations would reveal the embedded information’s presence, thus limiting the amount of data that can be covertly transmitted. For example, a carrier that injects secrets in the least significant bit (LSB) of a known set of an image’s pixels can be discovered due to its visible artifacts.

For attackers exchanging secret data, current network datagrams and sophisticated Internet-scale services offer the ideal choice.7 While early techniques focused on modifying unused fields of TCP/IP headers (for example, the IPv4 type of service field, which is rarely set by routers), more recent and sophisticated data-hiding methods include exploiting the traffic produced by popular services such as Skype or BitTorrent.8 From this perspective, modern smartphones offer a variety of new carriers, including cloud services, storage services like Dropbox, and voice-based services like Siri.

SIRI

Originally released as a standalone application in 2010, Siri has been offered as a native iOS service since 2011. It allows users to interact with their iPhone or iPad in two ways: by activating Siri and then giving commands such as creating a note or making a phone call, or by switching at any time from keyboard to voice for entering text. The translation of voice input to text is performed remotely in an Apple-operated server farm. The iPhone or iPad samples the voice, sends it to a remote facility, and waits for a response containing the recognized text, a similarity score, and a time stamp. Figure 1 depicts this usage pattern and architectural blueprint.

Because Apple has complete control over the application distribution pipeline, the diffusion of information-hiding methods has been efficiently tamed. Still, attackers can use Siri because information hiding doesn’t require the device’s alteration—or, in fact, any awareness on the device’s part—or the installation of additional software components.

METHOD, LIMITATIONS, AND COUNTERMEASURES

Siri processes a user’s voice with the Speex codec, and the related data is transmitted to Apple as a sort of one-way voice-over-IP stream encrypted and encapsulated within HTTP. The main idea behind iStegSiri is controlling the “shape” of such traffic to embed secrets. For example, iStegSiri relies solely on specific audio patterns captured by Siri via the hosting device’s built-in microphone. Figure 2 depicts a scenario where iStegSiri is used to build a covert channel between an infected device and a botmaster to extract sensitive information (for example, a credit card number or Apple ID and password).6

Specifically, iStegSiri is based on three steps. In step 1, the secret message is converted to an audio sequence based on the proper alternation of voice and silence. In step 2, the sound pattern is provided to Siri as the input via the internal microphone. Consequently, the device will produce traffic toward the remote server that requires audio-to-text conversion. In step 3, the
SECURITY

Figure 2. An infected smartphone utilizes Siri to control the “shape” of the network traffic embedding the secret data.

recipient of the secret communication passively inspects the conversation and, by observing a specific set of features, applies a decoding scheme to extract the secret information.

Steps 1 and 2 require properly matching the offered audio and the produced throughput. A set of trials and past measurements demonstrated the feasibility of this approach. Algorithms used for synchronization, latency reduction, and packetization delay prevented forging the shape of the whole flow, even with a minimal degree of accuracy. To overcome this, we split the overall traffic into different components using a set of ranges for Siri’s protocol data units (PDUs). PDUs in the range of 800–900 bytes represented talk periods, while PDUs in the range of 800–900 bytes represented inactive periods.

With this partition, we were able to arbitrarily encode 1 and 0 within the traffic. In other words, alternating talk and silence periods increased or decreased the number of PDUs belonging to each defined range. Nevertheless, some form of voice activity detection (VAD) impedes high symbol rates, or the speed at which voice and silence alternates. In our trials, the shortest working values were one second and two seconds for voice and silence, respectively.

To complete Step 3, the covert listener must capture the traffic and decode the secret. The former can be achieved in several ways, including transparent proxies or probes that dump traffic for offline processing. The decoding algorithm implements a voting-like method using two decision windows to determine whether a run of throughput values belongs to voice or silence (1 or 0).

Figure 3 depicts the outcome of a covert transmission. We found that iStegSiri can send secrets at a rate of about 0.5 bit per second. For instance, a typical 16-digit credit card number can be transmitted in about 2 minutes.

An attacker looking to exploit iStegSiri can access Siri functionalities in jailbroken devices through a library called Libactivator, or by directly accessing the private APIs provided by Apple in a plain environment. The malware can produce the audio track used to encode the secret at runtime—for example, by replicating a single sample via software—without having to inflate the size of the executable. Nevertheless, even if we used the microphone for the performance evaluation, audio data can be directly routed from the malware to the codec; it doesn’t have to be played back audibly by the user.

As designed, iStegSiri has two main limitations, neither insurmountable for hackers:

- It requires access to Siri’s inner workings; this means that only jailbroken iOS devices can currently be used. However, iStegSiri showcases the principle of using real-time voice traffic to embed data. Therefore, it can be further exploited on existing similar applications such as Google Voice or Shazam, or implemented in future applications by taking advantage of coding errors.

Because information-hiding methods use very specific technological traits, no current off-the-shelf products effectively detect covert communications. This forces security experts to craft dedicated countermeasures for each method. With iStegSiri, the ideal countermeasure acts on the server side. For example, Apple should analyze patterns within the recognized text to determine if the sequence of words deviates significantly from the used language’s typical behaviors. Accordingly, the connection could be dropped to limit the covert communication’s data rate. This approach wouldn’t rely on the device, so additional functionalities or battery consumptions wouldn’t be required. We plan to further our research to develop an efficient countermeasure to mitigate this threat.

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3. B. Prince, “Attackers Hide


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Figure 3. iStegSiri’s crafted voice stream (a) results in corresponding classes of traffic (blue=voice, red=silence), which (b) successfully detects secret data bits at the receiving side.
Measuring Great Jobs and Great Lives: The Gallup-Purdue Index

Mitchell E. Daniels Jr., Purdue University

A new approach to computing the true value of a college degree includes career and personal success after graduation.

Ask most colleges and universities to put a value on the degrees they award, and they’ll typically point to job placement rates, graduate school attendance levels, and alumni salaries. Although these datapoints are more informative than measures based on expenditures per student or peer surveys, they don’t always answer the more fundamental question: how has the degree contributed to a graduate’s well-being and career success?

Even our best measures have failed to inform us about whether a college degree positively contributes to a life well lived or a person’s engagement in the workplace. The lack of adequate measures has accompanied, or perhaps caused, ongoing public doubt about the value of a college degree. In fact, the 2014 Phi Delta Kappa (PDK)/Gallup poll of 1,001 Americans age 18 years and older found the percentage of Americans who believe college is “very important” fell from 75 to 44 percent over the past four years.

The survey is new, but the criticism isn’t. Due to the growing doubts and demands for improved accountability, last year Purdue University sought to find a way to prove the value of the degrees it offers.

PREDICTIVE GALLUP

Our search led us to Gallup, which has spent 30 years surveying roughly two million people from around the world about their well-being.

Gallup’s research shows the important interaction among five key measures of well-being:

- having a sense of purpose,
- maintaining strong and supportive relationships,
- effectively managing personal finances to reduce stress and increase security,
engaging in the community, and
• maintaining good health.

Gallup gathers survey responses relating to these measures and can analyze the information to predict conflict even in scenarios in which traditional measures might not work, such as during the Arab Spring uprisings beginning in late 2010. Although traditional national economic indicators such as GDP showed that Tunisia was doing reasonably well, the Gallup-Healthways Well-Being Index (http://info.healthways.com/wellbeingindex) revealed growing potential for conflict in the lives of average Tunisians.

Through its years of research, Gallup has been able to establish a strong association between individuals who are actively engaged at work and those who are involved in, enthusiastic about, and productive in their jobs. Likewise, their research has shown that taking pleasure in your job is one of the most important contributors to well-being.

EDUCATION BELLWETHER
In December 2013, Gallup and Purdue teamed up to develop the Gallup-Purdue Index—a tool to explore how Gallup’s research could be used to measure higher education’s contribution to career satisfaction and quality of life.

With grant funding from the Lumina Foundation (a private foundation seeking to improve higher education), Purdue faculty and Gallup researchers developed the Gallup-Purdue Index, a Web survey administered to 31,117 graduates age 18 years or older coming from US colleges and universities. The sample consisted of 29,560 baccalaureate-degree completers and 1,557 associate-degree completers living in all 50 states in the US, as well as in the District of Columbia. The surveys were completed between 4 February and 7 March 2014 (for the full report, see http://products.gallup.com/168857/gallup-purdue-index-inaugural-national-report.aspx).

The Gallup-Purdue Index provides a method to capture and analyze how US college graduates are faring in terms of career satisfaction and workplace engagement. Furthermore, graduates believing that their institution was passionate about the long-term success of its students were 2.4 times more likely to be engaged at work and 1.9 times more likely to be thriving in all well-being categories.

Graduates’ levels of well-being and workplace engagement weren’t related to the type of institution they attended, but rather to the types of experiences they had at college. Additionally, graduates were more likely to be thriving if their campus experience made them feel supported and engaged. Specifically, six experiences were associated with workplace engagement and well-being:

• having at least one professor who made them excited about learning,
• believing that their professors cared about them as a person,
• having a mentor who encouraged them to pursue their goals and dreams,
• working on a project that took a semester or more to complete,
• having an internship or job that allowed them to apply what they learned in the classroom, and
• being extremely active in extracurricular activities and organizations.

Graduates who felt supported by faculty while in college and participated in high-impact practices were much more likely to be thriving in all well-being categories and workplace engagement. In fact, these students were more likely to feel supported by their faculty, engaged and thriving at work, and faring better in their overall well-being.

COLLEGE EXPERIENCES EXAMINED
Graduates’ levels of well-being and workplace engagement weren’t related to the type of institution they went to a public or private institution, but rather to the types of experiences they had at college. Those believing that their institution prepared them for life after college were 2.6 times more likely to be engaged at work and 2.5 times more likely to be thriving in all well-being categories.
more likely to be engaged at work and thriving in the areas of well-being, as shown in Table 1.

Of the five well-being categories in the Gallup-Purdue Index, the majority of graduates were thriving in at least two. “Purpose well-being” was the most prevalent, with 54 percent of respondents thriving in this category. The outcomes for all five measures are shown in Table 2.

However, 17 percent of all graduates weren’t thriving in any element of well-being, and only 11 percent of all graduates were thriving in all five elements.

An individual’s workplace engagement increases with the number of well-being categories in which he or she is thriving.

Overall, 39 percent of the graduates surveyed who were employed full time (not including the self-employed) were engaged in their jobs—meaning they were involved in, enthusiastic about, and productive in their work. An additional 49 percent of graduates weren’t engaged—meaning they were intellectually and emotionally disconnected from their work.

Another 12 percent were actively disengaged, meaning they were so unhappy with their job that they shared their unhappiness with colleagues and sought to damage the organization, thereby jeopardizing their performance and that of their colleagues.

**LONG-TERM IMPACT OF STUDENT LOAN DEBT**

Another clear finding from the Gallup-Purdue Index was that student loan debt was negatively related to whether a graduate is thriving. Among the graduates surveyed who received their degree between 1990 and 2014, the survey showed that

- 59 percent had borrowed money for educational expenses,
- 27 percent borrowed $25,000 or less,
- 21 percent borrowed between $25,001 and $50,000, and
- 11 percent borrowed more than $50,000 for their undergraduate education.

Graduates who borrowed more than $50,000 were significantly less likely to be thriving in four of the five well-being categories—purpose, financial, community, and physical—compared with graduates who didn’t borrow any money. The only category

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**TABLE 1.** Comparative effect of perceived faculty support and participation in high-impact activities on the likelihood of success.

<table>
<thead>
<tr>
<th>Faculty support type</th>
<th>Increase in work engagement</th>
<th>Increase in well-being in all categories</th>
<th>Graduates responding positively to factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentor</td>
<td>2.2 fold</td>
<td>1.7 fold</td>
<td>22 percent</td>
</tr>
<tr>
<td>Professor who cared about them as a person</td>
<td>1.9 fold</td>
<td>1.7 fold</td>
<td>27 percent</td>
</tr>
<tr>
<td>At least one professor who excited them</td>
<td>2.0 fold</td>
<td>1.5 fold</td>
<td>63 percent</td>
</tr>
<tr>
<td>All of the above</td>
<td>2.3 fold</td>
<td>1.9 fold</td>
<td>14 percent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High-impact activity type</th>
<th>Increase in work engagement</th>
<th>Increase in well-being in all categories</th>
<th>Graduates responding positively to factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having an internship or job</td>
<td>2.0 fold</td>
<td>1.5 fold</td>
<td>29 percent</td>
</tr>
<tr>
<td>Working on a project that took a semester or longer</td>
<td>1.8 fold</td>
<td>1.1 fold</td>
<td>32 percent</td>
</tr>
<tr>
<td>Extremely active in extracurricular activities</td>
<td>1.8 fold</td>
<td>1.4 fold</td>
<td>20 percent</td>
</tr>
<tr>
<td>All of the above</td>
<td>2.4 fold</td>
<td>1.3 fold</td>
<td>6 percent</td>
</tr>
</tbody>
</table>

**TABLE 2.** Gallup-Purdue Index well-being categories and outcomes.

<table>
<thead>
<tr>
<th>Category</th>
<th>Respondents thriving in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose well-being</td>
<td>54 percent</td>
</tr>
<tr>
<td>Social well-being</td>
<td>49 percent</td>
</tr>
<tr>
<td>Community well-being</td>
<td>47 percent</td>
</tr>
<tr>
<td>Financial well-being</td>
<td>42 percent</td>
</tr>
<tr>
<td>Physical well-being</td>
<td>35 percent</td>
</tr>
</tbody>
</table>
in which graduates who borrowed heavily were about as likely to be thriving as graduates who didn’t borrow any money was social well-being (see Table 3).

From the beginning, the Gallup-Purdue Index was also intended to be a tool for colleges to see how their graduates compare to the national sample in terms of well-being and workplace engagement, and to guide meaningful performance improvements.

This inaugural administration of the Gallup-Purdue Index provides the higher education community insight into the aspects of college life that contribute most to career success and well-being after graduation. The Gallup-Purdue Index is a tool with significant potential to shed light on the strengths and weaknesses of our collective higher education community and to hold us accountable for what we’re promising—and hopefully delivering—to our students.

Purdue has committed to conducting the Gallup-Purdue Index over the next five years and has integrated the most recent findings with its Purdue Moves program (www.purdue.edu/purduemoves/index.html) to improve areas most strongly tied to graduates’ future success, including freezing tuition.

As we refine the Gallup-Purdue Index and expand our efforts to link its findings to specific programmatic efforts on campus, we see great opportunity for not only learning how we can better serve our current students, but also how we can propel them toward great careers and great lives.

MITCHELL E. DANIELS JR. is the president of Purdue University and former governor of Indiana. Contact him at president@purdue.edu.

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**TABLE 3.** Percentage of graduates (1990–2014) thriving in five elements of well-being, by amount of student loan debt.

<table>
<thead>
<tr>
<th></th>
<th>No debt</th>
<th>$25,000 and below</th>
<th>$25,001 to $50,000</th>
<th>More than $50,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose well-being</td>
<td>49 percent</td>
<td>46 percent</td>
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<td>Social well-being</td>
<td>47 percent</td>
<td>45 percent</td>
<td>42 percent</td>
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<td>Financial well-being</td>
<td>40 percent</td>
<td>31 percent</td>
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<td>Community well-being</td>
<td>43 percent</td>
<td>42 percent</td>
<td>35 percent</td>
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<tr>
<td>Physical well-being</td>
<td>34 percent</td>
<td>30 percent</td>
<td>26 percent</td>
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**IEEE Software** seeks practical, readable articles that will appeal to experts and nonexperts alike. The magazine aims to deliver reliable information to software developers and managers to help them stay on top of rapid technology change.

**Author guidelines:**
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www.computer.org/software
Transforming Business through Science Fiction Prototyping

Ari Popper, SciFutures

As science fiction prototyping is more widely adopted, we can expect to see more radical innovations in the world.

FROM THE EDITOR

The concept of science fiction prototyping grew from a personal process I used in my work as a futurist. At the request of several persuasive university professors, I elaborated on the idea in a textbook, Science Fiction Prototyping: Designing the Future with Science Fiction, which focuses mainly on computer science and engineering. The textbook is now used by design, business, and law students in more than 50 universities worldwide. I’m humbled by the visions that have bubbled up from these curious and serious minds.

Science fiction prototyping has also moved into the business world, and no practitioner is more adept at helping companies and organizations benefit from the process than Ari Popper of SciFutures. We first met Ari in this column last year (“Secret Science Fiction,” May 2013), and I asked him to update us on his work and how he’s using science fiction prototyping to innovate and change the future of businesses. —Brian David Johnson

A few years ago, I was struggling to figure out my next career move. I had successfully established the North American division of a global market research company with more than 30 Fortune 500 company clients, yet I felt something was missing. Uncertain what to tackle next, I was advised to explore “doing what you love, regardless of financial considerations.” I decided to try my hand at writing science fiction while still heading up the market research company. It turned out to be great advice.

My experience in a writing class gave birth to SciFutures—a foresight and innovation firm powered by science fiction. SciFutures—which works closely with Lowe’s, the Hershey Company, Ford Motors, and other blue chip
firms—combined my love of science fiction with my professional experience helping clients solve business challenges. After three years, I’m stunned to see how science fiction prototyping is changing organizational culture and creating disruptive innovations.

SCIENCE FICTION AND DISRUPTIVE TECHNOLOGIES

It’s undeniable that we live in remarkable times, driven largely by emerging disruptive technologies. The world is changing rapidly, and businesses that can adapt will enter a period of radical growth and significant value creation. A huge prize awaits corporations that can quickly harness and implement these powerful disruptive technologies. Terms for this process vary: blue sky innovation, disruptive innovation, even creative destruction (though I prefer “creative creation” since “destruction” implies turmoil and distress, but radical change isn’t necessarily negative).

Whatever the terminology, very few corporations can readily adapt. I’ve found this is due to several factors, including an inability to fully understand or communicate what radical change involves, uncertainty about the potential societal impact of emerging technologies, and the fact that corporations are risk-averse and hardwired to reject initiatives with uncertain outcomes. Science fiction prototyping can address these barriers.

The simple act of writing science fiction stories grounded in science fact facilitates our understanding of, appreciation for, and ability to integrate these technologies and their likely impacts. Fans of the genre will probably agree that science fiction succeeds when it conveys the effects of future technologies on characters readers can relate to. We engage with a story when the characters share our own basic aspirations and concerns.

Moreover, storytelling is a powerful way to change ingrained beliefs: researchers at the Ohio State University have shown that fiction is more effective at changing beliefs than nonfiction. The more realistic the portrayal of human interaction with emerging technologies, the more enjoyable the art is and the more likely we are to viscerally appreciate radical futures. In other words, good science fiction wrestles with complexity and succeeds when it simplifies and translates this complexity into human applications.

SCIENCE FICTION PROTOTYPING IN BUSINESS

Using science fiction prototyping in a corporate setting is a powerful way to generate new intellectual property. It provides a platform—and a process—to envision, create, and name new business tools, products, and services that are born from disruptive technologies. And because these products and services are brought to life through an engaging narrative, they will likely be relevant to real people with real needs.

A successful science fiction prototype will inspire and align a wide variety of stakeholders within and outside an organization. I have yet to find a better way to share a complex corporate innovation strategy than with a science fiction graphic novel, custom sci-fi movie, or illustrated short story that renders the likely impact of a new technology or ecosystem of technologies on real people in an engaging narrative format.

One of our services at SciFutures is to help clients create inspirational and transformative narratives of the future. Half the battle is getting folks to understand complexity; the other half is getting teams aligned. Having a common idea or mythology about a preferred future and a clear understanding of the corporation’s role within that future is proving to be very valuable. Once we establish the narratives and choose compelling disruptive ideas, we quickly build and test prototypes. Another successful example of this process is a class at MIT Labs where students read science fiction novels and then build prototypes from those stories.

The SciFutures team was recently in Toronto for the ribbon cutting of two Lowe’s stores’ Holorooms—home improvement simulators that use state-of-the-art augmented reality technologies to help customers envision complex home renovation projects (see Figure 1). The idea was born out of a science fiction prototype and inspired by the Star Trek holodeck. The fact that we were able to successfully launch a complex, disruptive, and highly technical innovation for a large corporate retailer is testament to the power of the original narrative. It captured and aligned the imaginations of a highly structured and conservative culture.

The idea of using science fiction prototyping was new to me and arose independently during a creative writing class. However, futurists such as Brian David Johnson at Intel...
were already applying science fiction prototyping\(^3\) to corporate culture. We are standing on the shoulders of giants and making great progress, yet science fiction prototyping is still in its infancy. As this tool is more widely adopted, we can expect to see more radical innovations in the world. Perhaps more importantly, as long as these stories are optimistic and inspirational, I believe we will also begin to see a radical and positive transformation in our society.\(^7\)

REFERENCES


**ARI POPPER** is the cofounder and CEO of SciFutures, a foresight and innovations agency that produces fictional narratives for companies using formats such as graphic novels and builds science fiction-inspired prototypes. Contact him at ari.popper@scifutures.com.
I took a deep breath and tried to remember what my IEEE Computer Society coach on parliamentary procedure had explained: “First, let the motion be introduced [and seconded]! Then the discussion starts. All members get a chance to speak. Nonmembers are allowed to speak at your discretion, but you can’t be arbitrary. You can stop the discussion when everyone has had a chance to speak once. [But what if there are still relevant points being made?]”

This February 2014 meeting wasn’t my first as chair of the IEEE 1680.4—Standard for Environmental Assessment of Servers working group, but it was the first vote I’d led on a controversial and contentious topic. And the member bringing the topic to a vote was bent on not including conflict minerals (that is, tantalum, tungsten, tin, or gold from certain African countries that might benefit armed groups responsible for human rights violations), because she believed they were out of the standard’s scope. Other members who’d already expressed their views were equally set on including conflict minerals in the standard. There was no way to avoid debate.

Understanding the IEEE standards development process has helped me negotiate situations such as these. Here, I’ll explain that process and share some relevant lessons I’ve learned.

**CREATING THE ENVIRONMENTAL ASSESSMENT STANDARD**

As Figure 1 shows, IEEE 1680.4 is the fourth in a series of environmental standards intended to provide clear and consistent environmental performance criteria for electronic product design. This family of standards allows manufacturers to secure market recognition for their efforts to reduce electronic products’ environmental impact and lets purchasers select products that meet the standards.¹

According to IEEE 1680.4’s approved project charter, the working group is charged with establishing a measure of environmental leadership for “computer servers as defined in the Energy Star Server specifications, including managed servers and blade servers.”²

Having a clear mission is a good start, but what of the process to get there? Could I count on established policies and procedures to help me and the working group achieve this goal? My career as a technologist and enterprise IT architect has taught me that good outcomes are possible only when the right framework is in place.

Luckily, the IEEE CS and the IEEE Standards Association (IEEE-SA) have implemented such a framework. Based on long experience developing thousands of standards, IEEE has codified a standards development life cycle (SDLC) that allows for clear roles, responsibilities, and expectations. This cycle (Figure 2) is a guide that allows the working group to navigate through the entire project, from project inception to publication.

**Leveraging the Standards Life Cycle for Green IT**

Jennifer Costley, Ashkan Advisors
cycle, as Figure 2 illustrates, and provided specific guidance for each step. Anyone familiar with software development life cycles will recognize the four steps: planning, creation, testing, and deployment. Having successfully navigated the planning step—initiating the project and mobilizing a working group—my group was now deep into the creation step—drafting the standard.

The set of “guiderails” provided by the IEEE CS Standards Activities Board’s Policies and Procedures (P&P) document has been an invaluable resource for the working group. A mandatory document under the IEEE process, the P&Ps not only answer important questions about working group operations—for instance, how much notice is required for meetings—but also establish the basis for the group’s participation and decision making. The P&Ps provide that any interested person can participate in standards development and has the right to express his or her position and have that position considered. In addition, any decision requires consensus, defined as “at least a majority agreement” among all parties interested in the project.

So I proceeded, confident that by following the IEEE CS parliamentary adviser’s advice and heeding the P&Ps to ensure I was conducting an open meeting, I could help steer the working group to a valid outcome. After an engaged discussion, the membership voted down the motion to omit conflict minerals from the standard.

**LESSONS LEARNED**

Although much work remains, the working group has come a long way since that meeting. New to standards development before, I now have a much deeper appreciation for the hard work involved in arriving at a good outcome. From my experience, and that of the working group members who’ve long been involved in standards development, I’ve learned some valuable lessons that I think are applicable to all development projects, not just standards.

**Define as you go**

Commonly used terms, such as product and manufacturer, are more easily interpreted if they’re defined during the drafting process. It’s more difficult to come back later and create a definition outside the original context. Terms used in multiple contexts should be taken to a top-level authority for resolution. Provide alternative definitions based on context only as a last resort. Whenever possible, use existing and authoritative definitions; ISO/IEC/IEEE Standard 24765 provides an expansive glossary of computing terms.

**Reuse and repurpose when possible**

In addition to relying on the IEEE standards development framework, our working group has had access to three existing standards in the 1680 series and the 1680 umbrella standard, IEEE 1680-2009. Starting with the equivalent language from existing standards saves time and helps ensure consistency. For example, IEEE 1680-2009 covers the requirements for IEEE 1680.4’s implementation.

**Consider operational implications**

Many criteria defined in the 1680 standards require manufacturer processes to support their assessment. It might appear to be a good idea to develop incrementally better language for these criteria—for example, referencing a newer set of recycling standards in the criteria for product end-of-life management in IEEE 1680.4 than was used in IEEE 1680.1, the computer standard. However, if one organization is responsible for compliance across all the

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**Figure 1.** IEEE 1680—Standard for the Environmental Assessment of Electronics. This family of standards is used in more than 40 countries.

**Figure 2.** IEEE standards are developed using a time-tested, effective, and trusted process that follows a six-stage life cycle.
1680 standards, the likely result will be duplicate work and parallel processes. Consider not just the benefits but the costs of improvement.

Make decisions binding
Make decisions only when you’re prepared to be bound to them. Despite the meetings’ highly structured nature, the decision process allows for both nonbinding “straw polls” that reflect a general agreement on direction and binding motions that can hold for the remainder of the process. Know which method to apply, and when.

Address contentious issues early
A working group is backed by several subgroups, each covering one of the mandated areas in the standard’s scope. For instance, the IEEE 1680.4 subgroups include one addressing materials selection and another that looks at environmental aspects of the server’s end of life. Subgroups are open to members and outside observers and include subject-matter experts. At times, these discussions can be contentious, especially when developing criteria on evolving topics such as the use of postconsumer plastics. Working group members are encouraged to participate actively in the subgroups’ extended discussion, rather than wait until the subgroup approves the draft criteria and brings them to the working group. Just as recommended software development processes urge early consideration of high-risk areas, other development efforts need to address contentious issues early to ensure a solid foundation for further development.

Make sure that all interested parties participate
Good development projects involve all parties who will be impacted by the outcome. The IEEE process identifies stakeholders and attempts to bring them to the table early. Stakeholders can be very passionate about their views, and part of the leader’s job is to make sure that all views—not just those expressed most passionately—are put before the group for consideration.

Use governance
As an IT architect, I’ve learned the value of governance in managing complex decision processes. Figure 3 shows IEEE’s process: every working group’s draft standard must be approved in a balloting process that requires “a balance of interests without dominance by any single interest category.”5 This process is initiated by a sponsor—in this case, the IEEE CS—and lets anyone contribute comments; it further requires that all comments receive a response.6 The IEEE-SA Standards Board verifies that IEEE’s process was correctly utilized before a standard is published. Although this review lengthens the overall process, it helps ensure a fair and objective outcome.

The IEEE 1680.4 working group is striving to create a draft that can be sent to the IEEE CS for balloting. Based on prior IEEE 1680 standards’ wide acceptance and positive benefits7 and the success of the IEEE standards process, I’m confident that the end result will be a high-quality and highly relevant standard.8

REFERENCES

JENNIFER COSTLEY is a principal at Ashokan Advisors. Contact her at jcostley@ashokanadvisors.com.
OUT OF BAND

A Paperless Gamble

Hal Berghel, University of Nevada, Las Vegas

For the first time in nearly half a century, a printed copy of Computer won’t be shipped as an included member benefit. I offer some thoughts on the matter.

As our 2015 IEEE Computer Society membership renewal form made clear, a mailed hardcopy of Computer no longer will be a core member benefit, as it has been since 1968. Print copies—for those members opting to purchase them—will now cost an additional US$149. To paraphrase the legendary New Zealand philosopher-politician Fred Dagg, “We don’t know how unpropitious are these circumstances.”

In my view, including a print copy of a flagship publication as a member benefit is part of the cost of doing business for any professional society. In the present situation, not only is the print copy withhold, but the charge for it as an option is exorbitant. I fear that in 10 years’ time this decision will have produced undesirable consequences for the CS.

DIGITAL INK

I’m not a print Luddite, and I’m not against online publishing. To the contrary, I envision the ultimate extension of future digital publishing to be an interwoven fabric of thought threads rather than a slowly expanding repository of static documents-cum-metadata—the latter being subsumed under what we now call digital libraries. As things stand, content continues to be controlled exclusively by the content provider. The information consumer is passive as far as the creation of the artifact is concerned.

Even if information retrieval is nonlinear (as with hyperlinks), the traversal remains prescriptive.

For many years I’ve argued that this is an unacceptable restriction that ensures suboptimal information uptake. There should be a way to distill information into nonprescriptive presentations to more closely mirror information consumers’ interests, rather than simply formatting an author’s brain dump. The information consumer could attach information from one source to another and digitally reassemble the information into new, more relevant thought frames. Of course, a looming digital challenge is how to retain links back to the original sources so that authorship metadata will always be available and the thought threads can become multidirectional from any node.¹ ² ³ (For more on my vision of digital publishing see “A Cyberpublishing Manifesto.”)

Years back, I developed a few prototypes of such a system using the alternate data streams built into earlier versions of Microsoft Windows file managers. If you’re familiar with ADS data structures, you can imagine how bidirectional authorship chains might work.³ You can’t implement such a model with a straightforward application of a cut-copy-paste
With this in mind, the migration to digital print is all but inevitable. For the past six years, Computer’s publishing philosophy has focused on digital content enrichment, including convergence formatting via PDF so that all content would be compatible with both print and digital formats. Multimedia content has been expanded and enhanced, including Chuck Severance’s Computing Conversations column, featuring video interviews and so on. Software simulations and voiceover slide presentations are now a Computer staple. These features are noteworthy digital enhancements and innovative uses of computer.org bandwidth in service to CS members. Kudos to former Editor in Chief Ron Vetter and the Computer staff for all the value that’s been added to the magazine’s digital edition.

So, if I’m committed to new digital publishing technologies, especially those creating data structures to extend collaboration in support of thought frames and nonprescriptive, nonlinear information traversal, why would I defend the inclusion of a mailed Computer hardcopy as a CS membership benefit? The answer gets at the heart of what it means to be a member of a professional society. For want of a term, let’s call this brand effusion.

PROFESSIONS AND THEIR ASSOCIATIONS

Peter Denning has spent many years ruminating about what constitutes a profession. He has this topic pretty well nailed down at this point. According to Denning, the four hallmarks of a profession are

1. A durable domain of human concerns,
2. A codified body of principles,
3. A codified body of practices, and
4. Standards for competence, ethics, and practice.

Over the past few decades he’s validated these points within the computing profession; and, by most accounts, IT and computing professions satisfy these criteria.

But what is it to be an association serving such a profession?

Let’s drill down a bit into Denning’s analysis. He distinguishes between a discipline and a profession. Disciplines are fairly well-defined areas of scholarship, and traditional university areas of study are disciplines in this sense. Disciplines also contrast with crafts, trades, and guilds, members of which share an affinity and perhaps an organizational membership but aren’t bound together by a well-defined, widely accepted body of knowledge that would qualify as a discipline in a diversified, well-rounded university or college. On this account, computer science and computer engineering would be disciplines within the profession of computing, while sundry tech support could have very different expectations in terms of services. Societies must also understand that if they’re to be successfully inclusive, there must be some overarching service or brand that all members can relate to. That includes symbolic information-rich vehicles for communication that are shared among all members.

DIGITAL LIBRARIES 101

I was on the ACM Publications Board as its digital library was evolving and taking shape. The ACM DL was one of the first—if not the first—complete offerings of this type for a professional society. It was designed to simultaneously satisfy several membership demands.

First and foremost, it attempted to provide quicker delivery of scholarly research to interested members via networking. When it launched in the early 1990s, ACM’s and the IEEE Computer Society’s academic and institutional subscribers were connected to the Internet, so the timing was right.

Second, it sought to reduce the cost of information delivery. By the time of the DL launch, most of ACM’s leadership felt that digital delivery was inevitable, and that such delivery would significantly reduce the marginal cost of publications to the point where it would be economical to bundle digital collections to consortia of libraries, universities, and so on at a fraction of the individual subscription cost. Two very attractive consequences were also anticipated: first, the effort

As great as digital libraries and online publications are, they don’t satisfy our criteria of being information-rich communications vehicles sharable within affinity groups.
would ultimately save ACM money, and second, as a result of the new cost structure, it could offer more publications to serve increasingly smaller niche audiences.

In addition, there were collateral advantages. SGML-derivative document structures could render easily for both print and digital output via Postscript/PDF/LaTeX and HTML (well, not so much in LaTeX, but that’s another story). Moreover, the peer-review system could be automated by means of the same digital infrastructure as the

innovators in the included disciplines rely on DLs and websites far more than other members. So neither the DLs nor the websites are ideal candidates to carry brand identity.

P
art of what it is to be a professional is to network with other professionals in related areas. And the success of such networking requires self-identification with the group. Sociologists explain this in terms of social identity theory. Our

production system. Finally, the entire repository would be indexed and searchable virtually without limit. This experience has since been replicated many times by professional societies worldwide with widespread success.

The reasons for the ACM DL’s successes are now pretty obvious to all: separation of production costs from the subscription base, lower overall marginal production costs, amortization of expenses over a subscription base that can expand after production, ability to economically deliver information and content to ever-narrowing constituencies (because publication content comes from volunteer editors and reviewers, the cost of content generation to the organization is essentially in the editing and layout), integration of peer review with the production process, and so forth. DLs translate into more cost-effective information delivery to members, pure and simple.

As great as DLs and online publications are, they don’t satisfy our criteria of being information-rich communications vehicles sharable within affinity groups. Only a subset of a society’s membership relies on the DL and digital push products as primary information feeds. Simply put, researchers and self-image is a function in part of the many groups with which we identify. Part of such self-identification and shared experience involves shared communication and association with a brand, and that’s where the print version of Computer comes in. In other organizations that I’ve been associated with, their printed magazines have been in more or less continuous circulation. It’s part of the professional hand-off process for potential members, colleagues, and interested students: Computer helps the profession focus on the relevant issues of the day.

Computer remains the CS’s most visible brand. Think of it as an organizational logo with content. The fact that it will still be available in digital form via the CS Digital Library and IEEE Xplore isn’t the same: you can’t circulate a copy to a kindred spirit with an earmark or sticky note attached using Xplore. You don’t get attracted to an affinity group through indexable and searchable databases. Facebook is ubiquitous; SQL isn’t. Members of organizations associate themselves with objects of common interest that are portable across social situations. Computer qualifies; DLs don’t. Neither do membership cards. DLs are the ideal

vehicle for technical research publications, but not for casual reading by colleagues. It’s both inconvenient and impersonal to share mutually interesting information from opposite sides of a Web paywall. The barrier is too high to be effective for bonding.

Now for the coup de grâce of my argument: Berghel’s Digital Epidemiology Hypothesis. Reading the print edition of Computer is 97.6 percent safer than reading it on a mobile platform—hardcopy is a poorer habitat for bacteria and viruses. Eliminating the print copy as a member benefit may lead to a sudden increase in E. coli dispersal in high-tech offices globally. If there’s a sudden outbreak of MRSA in Silicon Valley, don’t say I didn’t warn ya! (The validation of my hypothesis is left to the reader, but remember to wash your hands after reading—unless you’re reading the print copy, that is!)

REFERENCES

HAL BERGHEL is an ACM and IEEE Fellow and a professor of computer science at the University of Nevada, Las Vegas. Contact him at hlb@computer.org.

Selected CS articles and columns are also available for free at http://ComputingNow.computer.org
IEEE COMPUTER SOCIETY UNVEILS TOP 10 TECHNOLOGY TRENDS FOR 2015

In December 2014, the IEEE Computer Society announced its 10 top technology trends for 2015. Cybersecurity will remain a critical concern, with increased focus on security for cloud computing and deeply embedded devices. Interoperability and standards will also be top priorities.

“Researchers have been working to address these issues for a number of years. However, 2015 should see real progress in these areas,” said incoming IEEE Computer Society President Thomas M. Conte, an electrical and computer science professor at Georgia Tech. “We’re reaching an inflection point for 3D printing, which will revolutionize manufacturing, and the exponential growth in devices connected to the Internet makes interoperability and standards critical.”

The top trends include wearable devices, the Internet of Anything, building security into software design, “software-defined anything” interoperability and standards, cloud security and privacy, 3D printing, predictive analytics, embedded computing security, augmented-reality applications, and digital health opportunities for smartphones.

For more information about the top 10 technology trends for 2015, please visit www.computer.org/web/pressroom/2015-top-tech-trends.

IEEE APPOINTS NATIONALLY RECOGNIZED SCIENTIST AND SECURITY EXPERT TO CHAIR CYBERSECURITY INITIATIVE

IEEE and the Carnegie Mellon University Software Engineering Institute (SEI) announced in November 2014 that nationally recognized scientist and security expert Greg Shannon has been named chair of the IEEE Cybersecurity Initiative. Shannon is chief scientist for the CERT Division at SEI, where he regularly partners with government, industry, and academia to develop advanced methods and technologies to counter sophisticated cyberthreats.

As IEEE Cybersecurity Initiative chair, Shannon will shape and lead a technical agenda that brings unique solutions to cybersecurity challenges by providing tools and data for computer security education, offering guidance on secure software coding and software assurance engineering, and facilitating adoption throughout the cybersecurity industry.

“With IEEE’s ubiquitous impact on cyber technologies, I’m delighted to chair this initiative and harness IEEE’s experience, technical leadership, and resources to address society’s pervasive cybersecurity and privacy challenges,” Shannon said.


NIIT AND IEEE COMPUTER SOCIETY ENTER GLOBAL ALLIANCE TO ENHANCE EMPLOYABILITY OF ENGINEERS

Leading global talent development corporation NIIT and the IEEE Computer Society entered into a global alliance to provide training to create quality engineers who meet the industry’s requirement for job-ready talent. The training is based on the Guide to the Software Engineering Body of Knowledge (SWEBOK).

According to the recently published National Employability Report—Engineers Annual Report 2014, only 18 percent of engineers are employable as software engineers in IT services, and fewer than 4 percent are trained to be directly deployed on projects. This means there is an acute demand in the industry for a well-trained talent pool certified by a neutral, internationally recognized body.

NIIT and the IEEE Computer Society will provide three courses based on the SWEBOK certification: the SWEBOK Certificate Program, the Certified Software Development Associate credential, and the Certified Software Development Professional credential.

“With an aim to bring engineers at par with the global industry standards, we plan to train over 40,000 engineers in SWEBOK training programs in next three years,” said Amitabh Lahiri, president of NIIT Limited. “This partnership will help deliver quality engineering programs to students across India,” said Harish Mysore, IEEE’s director of India operations. “Employers will value the IEEE and NIIT joint certificates globally,” he added.

For more information, please visit www.computer.org/web/pressroom/NIIT-and-IEEE-Computer-Society-Enter-into-Global-Alliance-to-Enhance-Employability-of-Engineers.

NEW EDITOR IN CHIEF APPOINTED FOR IEEE TRANSACTIONS ON BIG DATA

Qiang Yang, a professor in the Department of Computer Science and Engineering at Hong Kong University of Science and Technology, has been appointed editor in chief of IEEE Transactions on Big Data beginning 1 January 2015. Dr. Yang was founding head of Huawei Noah’s Ark Research Lab from 2012 to 2013, and his research interests include data mining and artificial intelligence.

Yang received a PhD in computer science from the University of Maryland, College Park. He’s a Fellow of the Association for the Advancement of Artificial Intelligence, the American Association for the Advancement of Science, IEEE, and the International Association of Pattern Recognition.
IEEE Transactions on Big Data will soon be accepting manuscript submissions for peer-reviewed articles with big data as the main focus. The articles will provide cross-disciplinary research ideas and applications results for big data including novel theories, algorithms, and applications.

For more information about Yang and IEEE Transactions on Big Data, please visit www.computer.org/web/pressroom/New-Editor-in-Chief-Selected-for-IEEE-Transactions-on-Big-Data.

CHANGES TO IEEE COMPUTER SOCIETY BYLAWS AVAILABLE ONLINE

The IEEE Computer Society Board of Governors recently approved the first reading of amendments to the Computer Society’s bylaws. Article XI Standing Committees—Section 9: Nominations Committee was revised to clarify the requirements for committee members. The relevant sections with proposed changes are available for review at http://bit.ly/yyDx. Deletions are marked in strikeout text. Only relevant segments of the bylaws in question are reproduced.

Changes to existing Society bylaws that receive first- and second-reading approval by the Board of Governors are listed by title in Computer, with links to a website location hosting the actual documents. The documents remain accessible at this location until the changes receive final approval.

Members can send comments to Anne Marie Kelly at amkelly@computer.org until close of business on 23 January 2015.

IEEE Computer Society | Software Engineering Institute

Watts S. Humphrey Software Process Achievement Award

Nomination Deadline: January 15, 2015

Do you know a person or team that deserves recognition for their process improvement activities?

The IEEE Computer Society/Software Engineering Institute Watts S. Humphrey Software Process Achievement Award is presented to recognize outstanding achievements in improving the ability of a target organization to create and operate software.

The award may be presented to an individual or a group, and the achievements can be the result of any type of process improvement activity.

To nominate an individual or group for a Humphrey SPA Award, please visit http://www.computer.org/web/awards/spa
CALLS FOR ARTICLES FOR COMPUTER

Computer seeks submissions for an August 2015 special issue on irregular applications.

Irregular applications are characterized by unpredictable memory access patterns, control structures, and/or network transfers. They typically use pointers or linked list-based data structures such as graphs, unbalanced trees, and unstructured grids. These applications’ complex behavior makes it difficult to fully exploit their significant parallelism. In addition to performance concerns, dataset size presents a challenge in such applications because they often operate on massive amounts of unstructured heterogeneous data that is usually difficult to partition.

This special issue seeks to explore solutions for supporting the efficient design, development, and execution of irregular applications. Suggested topics include but are not limited to micro- and system-level architectures, network and memory architectures, innovative algorithmic techniques, languages and programming models, and case studies.

Articles are due 1 February 2015. Visit www.computer.org/web/computingnow/cocfp8 to view the complete call for papers.

CALLS FOR ARTICLES FOR OTHER IEEE CS PUBLICATIONS

IT Professional plans a September/October 2015 special issue on wearable computing.

Given the growing popularity of Google Glass, the Apple iWatch, Fitbit, and many other devices, wearable computing is a topic of significant interest and a technology being adopted in numerous applications and businesses.

Driven by advances in mobile computing and communications, ambient intelligence, and ubiquitous sensors, wearable computing facilitates a new form of human–computer interaction via small, on-body devices that are always on, ready, and accessible.

This special issue will review wearable computing trends and applications, and consider the engineering and operational aspects of wearable computing.

Articles are due 1 February 2015. Visit www.computer.org/web/computingnow/2015-itcfps to view the complete call for papers.

IEEE Transactions on Emerging Topics in Computing (TETC) plans a special issue on circuit and system design methodologies for emerging technologies for the first issue of 2016.

The demand for smaller, portable, low-power, and high-performance electronic systems has been the primary driver for CMOS technology scaling. As CMOS scaling approaches physical limits, we face challenges requiring the introduction of newer processes and materials. To become practical, however, new design methodologies must allow efficient modeling, design space exploration, and tradeoff analysis.

This special issue will examine these matters.

Articles are due 1 February 2015. Visit www.computer.org/cms/Computer_transactions/cfps/CFP_TETCSI_ESTDECS.PDF to view the complete call for papers.

IEEE Transactions on Emerging Topics in Computing (TETC) plans a special issue on emerging security trends for deeply embedded computing systems.

This special issue seeks submissions for an October 2015 special issue on wearable computing.

This calls for an examination of traditional security mechanisms, not only because of the nature of the threats, but also because of these computing systems’ resource limitations.

The focus of this special issue will be novel security approaches for deeply embedded computing systems, including cryptographic techniques.

Articles are due 1 February 2015. Visit www.computer.org/cms/Computer_transactions/cfps/CFP_TETCSI_ESTDECS.PDF to view the complete call for papers.

IEEE Internet Computing plans a November/December 2015 special issue on the Internet of You: Data Big and Small.

This special issue aims to explore today’s technologies and issues related to small data (individual-scale data sources, processing, and modeling) and huge datasets (community-level aggregation and analytics).

Abstracts are due 1 February 2015.
CALL AND CALENDAR

ICSE 2015

The 37th International Conference on Software Engineering (ICSE 2015) is sponsored by the IEEE Computer Society’s Technical Council on Software Engineering (TCSE), and the Association for Computing Machinery (ACM)’s Special Interest Group on Software Engineering (SIGSOFT).

The conference provides a forum for researchers, practitioners, and educators to present and discuss the most recent innovations, trends, experiences, and concerns in the field of software engineering.


Articles are due 1 March 2015. Visit www.computer.org/eb/computingnow/iccfp6 to view the complete call for papers.


In recent years, the world has witnessed rapid economic development and research progress in Asia. In the big-data era, this has provided a rich base for the quick development of both research in and applications for visualization and computer graphics.

This special issue will cover recent advances in new methods, designs, and systems for scientific visualization; information visualization and visual analytics; new computer graphics algorithms and systems; and case studies describing success and failure in applying visualization to real-world problems in Asia.

Articles are due 1 March 2015. Visit www.computer.org/web/computingnow/gacfp6 to view the complete call for papers.

IEEE Transactions on Emerging Topics in Computing (TETC) plans a special issue on advances in mobile cloud computing for the first issue of 2016.

There has been a phenomenal burst of research in mobile cloud computing. Mobile applications demand greater resources and improved interactivity for a better user experience. Resources in cloud computing platforms such as Amazon, Google AppEngine, and Microsoft Azure offer a way to remedy mobile devices’ lack of local resources.

The objective of this special issue is to cover the most recent R&D on mobile cloud computing technologies and to provide industry and academia an opportunity to showcase their recent progress in this area.

Articles are due 1 March 2015. Visit www.computer.org/cms/Computer.org/transactions/cfps/cfp_tetcsi_amcc.pdf to view the complete call for papers.


Technological advancements such as those used in cloud computing; mobile devices; and big, open, and linked data bring with them great opportunities for enriching and broadening the educational experience.

For instance, virtual learning environments are becoming commonly used in communications between students and teachers. At the same time, mobile computing is expanding the reach of learning content and frameworks.

Although there are many future visions for education, great efforts will be needed to reach a profound integration between well-established technologies and emerging ones.

By building on a solid scientific and methodological foundation where theory and practice converge, this special issue aims to present both the current trends that characterize the learning and teaching domains of today, as well as the expected evolution that will shape the education of tomorrow.

Articles are due 1 March 2015. Visit www.computer.org/cms/Computer.org/transactions/cfps/cfp_tetcsi_ete.pdf to view the complete call for papers.

IEEE Security & Privacy plans a January/February 2016 special issue on the interconnected Web ecosystem.

The Web is being fused into the human experience in a number of interesting ways, leading to the creation of an intricate system of systems. For example, infant monitoring devices provide parents with real-time information on their smartphones about their baby’s breathing, skin temperature, body position, and activity level.

Unfortunately, this Web-enabled interconnectedness has opened a host of serious security, privacy, and dependability concerns. A single flaw or feature in Web technology could have significant, unforeseen negative consequences on myriad interconnected systems. This special issue will address these challenges.

Abstracts are due 1 March 2015. Articles are due 1 April 2015. Visit www.computer.org/web/computingnow/spcfp-jan-feb-2016 to view the complete call for papers.

IEEE Software plans a November/December 2015 special issue titled “Refactoring: accelerating software change.”

Modern software is rarely written from scratch. It usually incorporates...
code from previous systems and is itself reincarnated in other programs. Software also isn't static; it constantly changes as bugs are fixed and features are added. These changes are usually performed by more than one programmer, and not necessarily by the code's original authors.

Refactoring—improving code's internal structure without altering its external behavior—supports this highly dynamic software life cycle. This special issue will focus on the real-world application of research, practical experiences, success stories, and lessons learned.

Articles are due 1 April 2015. Visit www.computer.org/software/cfp6 to view the complete call for papers. IEEEEE Internet Computing plans a January/February 2016 special issue on Internet economics.

The breadth of economic activity on the Internet is exploding. The resulting economic systems lead to a plethora of new research questions, both theoretical and data-driven, touching on both analysis and design.

This special issue will address theoretical and applied research related to the modeling, analysis, and design of Internet-specific economic activities and incentive systems. The issue will be interdisciplinary in nature and will include any research related to economic aspects of the Internet.

Articles are due 1 May 2015. Visit www.computer.org/web/computingnow/icfp1 to view the complete call for papers.

IEEE Transactions on Emerging Topics in Computing (TETC) plans a special issue on big data benchmarks, performance optimization, and emerging hardware for the second issue of 2016.

Organizations and governments need to generate value from big data. In doing so, they face a challenge in selecting systems to utilize their data, which requires effective benchmarks. They also must determine how to optimize the systems for both specific and comprehensive workloads.

Meanwhile, researchers are working on innovative data management systems, hardware architectures, and operating systems to improve performance.

This special issue’s focus will be on architecture and system support for big data systems. Articles are due 1 June 2015. Visit www.computer.org/cms/Computer.org/transactions/cfps/cfp_tetc_bdbpoeh.pdf to view the complete call for papers.

FEBRUARY 2015


MARCH 2015


APRIL 2015


MAY 2015


Department of Computer Science and Engineering

LECTURER POSITION

The State University of New York at Buffalo Department of Computer Science and Engineering (CSE) invites candidates to apply for a non-tenure track lecturer position beginning in the 2015-2016 academic year.

Housed in the School of Engineering and Applied Sciences, the CSE department offers both BA and BS degrees in Computer Science and a BS in Computer Engineering. The department has 34 tenured and tenure-track faculty and 4 lecturers, and approximately 640 undergraduate majors, 570 masters students, and 150 PhD students.

The department is strongly committed to hiring and retaining a lecturer for this career-oriented position, renewable for an unlimited number of 3-year terms. Lecturers are eligible for the in-house titles of Teaching Assistant Professor, Teaching Associate Professor and Teaching Professor.

Applications should have a PhD degree in computer science, computer engineering, or a related field, by August 15, 2015. The ability to teach at all levels of the undergraduate curriculum is essential. Also desirable is a background in computer science education, a commitment to K-12 outreach, and addressing the recruitment and retention of underrepresented students.

Duties include teaching and development of undergraduate Computer Science and Computer Engineering courses (with an emphasis on lower-division), advising students, and participation in department and university service. Contribution to research is encouraged but not required.

Review of applications will begin on January 15, 2015 and continue until the position is filled. Applications must be submitted electronically via http://www ubjobs.buffalo.edu/ and must refer to posting number 1400806. The University at Buffalo is an Equal Opportunity Employer.
software development of web-based user interface components. Design and implement efficient and highly usable user interfaces. Position is based out of company headquarters but may be assigned to unanticipated job site in the U.S. as determined by management. Mail resume to: OpenX Technologies, Inc., Attn: HR Services, 888 E Walnut Street, Pasadena, CA 91101. Must reference requisition number 9009V.

FUJITSU NETWORK COMMUNICATIONS, INC. has a Support Engineer (Req. #FNC02671) job opportunity available in Richardson, TX. Plan and configure customer circuits on a DWDM and COE (Connection-Oriented Ethernet) optical transport and data network to deliver mobile backhaul service and double-play or triple-play services across an FTTX (Fiber to the Premise) network. Mail resume to Fujitsu Network Communications, Inc., Staffing Department, 2801 Telecom Parkway, Richardson, TX 75082. Must reference Req. #.

HOTWIRE INC. currently has openings for the following opportunities in our San Francisco, CA office (various/levels/types): • Software Engineers: (728.965) Design, implement, and debug software for computers including algorithms and data structures. • Managers, Test: (728.965). Manage onsite QA test team responsible for functional testing of various Hotwire application verticals or decoupled products.

SIEMENS PLM SOFTWARE INC. has an opening in Milford, OH for Software Engineer to analyze reqs. of assigned enhancements in NX routing app. Email resumes to PLMCareers@ugs.com & refer to Job code UGS166, EOE.


ENGINEERING, TOSHIBA AMERICA ELECTRONIC COMPONENTS, INC. is accepting resumes for the position of Sr. Staff Software Development Engineer in San Jose, CA. Technically lead team of engineers resp for dsgn, dvlpmt & implement'n of kernel level SW & drivers that manage interactions b/w apps & storage cache. Mail resume to TAEC, Staffing Dept, 2590 Orchard Pkwy, San Jose, CA 95131. Must ref Req. #4002.

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SOFTWARE ENGINEERS 4 (SERVER) sought by Asurion, LLC in San Mateo, California to dvlp eff, maintbl code. BS in Cmptr Sci, Engrg, Math or rtd flld + 5 yrs of sftwr dvlp exp & 3 yrs of dvlp exp using Java sftwr. Exp in 3 of flwng areas: RESTful web serv, RDBMS skils, Multi-threaded apln, ApIn Serv (JBoss, WebSphere, WebLogic, Tomcat, etc.), Cloud apn dvlp, Caching tech (redis, memcached, hazelcast), Msg tech (ZeroMQ, RabbitMQ, Kafka), NoSQL tech (Cassandra, HBase), real-time streaming (apache storm). PERM US work auth. Aply @ www.jobpostingtoday.com (ref# 2058).

SYSTEMS ANALYST: Design & develop web application using Java, PHP 5.x, Ajax & MySQL 5.x, Oracle 11g, MS-SQL, Apache, Zend and Symfony within MVC framework on Linux platform. Analyze and evaluate software & relational data tables, test, troubleshoot and modify existing applications for improved performance. Will work in unanticipated locations. Req. 2 yrs exp. Send resume to Vyzer Solutions Inc, 101 W. Renner Rd, #260, Richardson, TX 75082.

MPHASIS CORP. has multi openings at various levels for the follow’g positions at its office in NY, NY & unanticipated client sites thr/o the US. 1. Info. Sys. Analyst* - Ana. & provide sys req & spec. 2. SW Dvlper* - Design, dvlp & modify SW syss. 3. Sys. Architect Dvlper* - Dvlp IT architecture. 4. Graphic UI Desgr* - Design UI & perform UAT. 5. N/W Infra Eng* - Maintain & TRBL n/w, design, dvlp, install n/w infra appl. 6. Business Operation Anyst* - Ana bus process thru app of s/w sol. 7. IT Mgr* - Plan & manage the delivery of IT proj. 8. Enterprise Svc Engagem’t Mgr* - E2E sale of IT svc/prod. 9. Eng Engagem’t Mgr* - Manage & direct business integration of proj activities. 10. Mkt Dvlpt Mgr* - Promote IT svc/prod. & impl bus plans. Must have a Bachelor/equiv and prior rel. exp. Solaris exp. Send resume & applied position to: recruitmentus@mphasis.com or 460 Park Ave. S., Ste# 1101, New York, NY 10016 Attn: Recruit.

ENGINEERING, AMERICAN HEALTH-TECH INC. is accepting resumes for the position of Sr. Software Engineer in Franklin, TN. Work with Systems Analysts, Product Managers and other Engineers to convert market requirements into technical specifications. Mail resume to American HealthTech Inc., Staffing Department, 1600 Utica Ave. S. #300, Minneapolis, MN 55416. Must reference Ref. SSE-SK.

Samsung Research America, Inc.

has the following opportunities (various levels) available in San Jose and Santa Clara, CA:

San Jose, CA:
- Sr. UX Researcher (Ref# SJ14L01)
- Software Engineer (Ref# SJ14L02)
- Sr. Software Engineer (Ref# SJ14L03)
- Sr. Graphics Driver Engineer (Ref# SJ14L04)
- Staff Interaction Designer (Ref# SJ14L05)
- Staff Engineer (Ref# SJ14L06)

Santa Clara:
- Software Engineer (Ref# SC14L01)
- Sr. Software Engineer (Ref# SC14L02)
- Staff Software Engineer (Ref# SC14L03)

Specific requirements apply. All of these positions will involve developing technologies for company’s computer, digital television, mobile telephone, printer, or other electronic products. Mail your resume referencing job title and Ref# to farhat.k@samsung.com
TECHNICAL
Cisco Systems, Inc. is accepting resumes for the following positions:

Austin, TX: Software/QA Engineer (Ref# AUS11): Debug software products through the use of systematic tests to develop, apply, and maintain quality standards for company products.

Lawrenceville, GA: Network Consulting Engineer (Ref# LV12): Responsible for the support and delivery of Advanced Services to company’s major accounts.

St. Petersburg, FL: Network Consulting Engineer (Ref# SPF1): Responsible for the support and delivery of Advanced Services to company’s major accounts.

Pleasanton, CA: Technical Solutions Architect (Ref# PL2): Overlay resource brought into an opportunity based on architectural specialization. Provide expertise on horizontal architectures for large opportunities.

Research Triangle Park, NC: IT Service Lead (Ref# RTP21): Responsible for the day to day execution, support, developing continual improvement opportunities and analysis of an IT Service, while laying the foundation for production and operational support and delivery.

San Francisco, CA: Inside System Engineer (CNG Staff) (Ref# SF5): Responsible for conducting online product demonstrations, answering technical questions, contributing to proposals and analyzing client needs and develop technical solutions in a pre-sales capacity. Travel may be required to various unanticipated locations throughout the United States.

San Jose/Milpitas/Santa Clara, CA: Diagnostic Engineer (Ref# SJ168): Design and develop diagnostic software for verification and validation in engineering and manufacturing. IT Manager (Ref# SJ147): Lead a team responsible for leading strategy definition, planning, implementation, operation, optimization and stakeholder management of all Payroll, Stock, Travel, Webex Social and Mobile applications, rendering platform service and offerings.

Systems Engineering Manager (Ref# SJ158): Provide business-level guidance to the account team or operation on technology trends and competitive threats, both at a technical and business level.

Whippany, NJ: Software Engineer (Ref# WH1): Responsible for the definition, design, development, test, debugging, release, enhancement or maintenance of networking software.

Project Managers-U.S. needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. Must be willing to work anywhere in the U.S. as the positions may involve relocation to various and unanticipated client site locations; any relocation to be paid by employer pursuant to internal policy. Equal Opportunity Employer M/F/D/V. Please apply online at: http://www.infosys.com/careers/apply-now/apply.asp. Select ‘Americas’ under ‘Job Opportunities’ and follow the link for ‘Experienced Professionals.’ Once a user account has been created, please follow the link for ‘Search Openings’ and enter the job # listed below in the ‘Auto Req ID’ box. Apply to each job # of interest.

Project Managers-U.S. (Enterprise Solutions) needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to help gather requirements, define architecture, and determine scope to deliver IT solutions for clients in the U.S. Healthcare sector. (Job# 6990BR)

Project Managers-U.S. (Enterprise Solutions) needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to help gather requirements, define architecture, and determine scope to deliver IT solutions. (Job# 6991BR)

Project Managers-U.S. (Testing) needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to perform activities to ensure that quality software work products are delivered on schedule, including coordination with clients in US Healthcare sector and internal teams across the globe. (Job# 6992BR)

Lead Consultants (Domain) - U.S. needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S., to anchor different phases of IT engagement including business process consulting, problem definition, discovery, solution generation, design, development, deployment and validation. (Job# 7030BR)

Technology Architects-U.S. needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S., to provide inputs on solution architecture based on evaluation/understanding of solution alternatives, frameworks and products. (Job# 6989BR)

Infosys Public Services, Inc. has multiple, full-time openings in Rockville, Maryland and various and unanticipated locations throughout the U.S. Must be willing to work anywhere in the U.S. as the positions may involve relocation to various and unanticipated client site locations; any relocation to be paid by employer pursuant to internal policy. Equal Opportunity Employer M/F/D/V. Please apply online at: http://www.infosys.com/careers/apply-now/apply.asp. Select ‘Americas’ under ‘Job Opportunities’ and follow the link for ‘Experienced Professionals.’ Once a user account has been created, please follow the link for ‘Search Openings’ and enter the job # listed below in the ‘Auto Req ID’ box. Apply to each job # of interest.

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Technology Architects-U.S. needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S., to provide inputs on solution architecture based on evaluation/understanding of solution alternatives, frameworks and products. (Job# 6989BR)

Technical Test Leads-U.S. needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to test assigned modules for software products for U.S. Healthcare sector clients. (Job# 6863BR)

Technology Leads-U.S. (Open Systems) needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to design, develop, test, and deploy specific modules for software products for clients in the U.S. Healthcare sector. (Job# 6864BR)

Technology Leads-U.S. (Mainframe) needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to design, develop, test, and deploy specific modules for software products for clients in the U.S. Healthcare sector. (Job# 6867BR)

Technology Leads-U.S. (Enterprise Solutions) needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to design, develop, test and deploy specific modules for software products. (Job # 6987BR)

Consultants (Domain) - U.S. needed in Rockville, Maryland, and various and unanticipated locations throughout the U.S. to help conduct IT requirements gathering, define problems, provide solution alternatives, create detailed computer system design documentation, implement deployment plan, and help conduct knowledge transfer with the objective of providing high-quality IT consulting solutions. (Job# 7025BR)
MULTIPLE ASSISTANT PROFESSOR POSITIONS: UCF Center for Research in Computer Vision Ad. CRCV is looking for multiple tenure-track faculty members in the Computer Vision area. Of particular interest are candidates with a strong track record of publications. CRCV will offer competitive salaries and start-up packages, along with a generous benefits package offered to employees at UCF. Faculty hired at CRCV will be tenured in the Electrical Engineering & Computer Science department and will be required to teach a maximum of two courses per academic year and are expected to bring in substantial external research funding. In addition, Center faculty are expected to have a vigorous program of graduate student mentoring and are encouraged to involve undergraduates in their research. Applicants must have a Ph.D. in an area appropriate to Computer Vision by the start of the appointment and a strong commitment to academic activities, including teaching, scholarly publications and sponsored research. Preferred applicants should have an exceptional record of scholarly research. In addition, successful candidates must be strongly effective teachers. To submit an application, please go to: http://www.jobswithucf.com/postings/34681 Applicants must submit all required documents at the time of application which includes the following: Research Statement; Teaching Statement; Curriculum Vitae; and a list of at least three references with address, phone numbers and email address. Applicants for this position will also be considered for position numbers 38406 and 37361. UCF is an Equal Opportunity/Affirmative Action employer. Women and minorities are particularly encouraged to apply.

SIEMENS PLM SOFTWARE INC. has an opening in Milford, OH for Software Engineer to analyze reqs. of assigned enhancements in NX routing app. Email resumes to PLMCareers@ugs.com & refer to Job code UGS166. EOE


PRECISION TECHNOLOGY, Plano TX, Team Lead/Process Engineer. Manage project team, mentor and oversee assigned projects, review process specification, develop new operation methods; implement continuous process improvement. IPC-A-610D, KIC2000 Profile, SPC analysis, AS9100C, MYDATA; BS+3yr(related)

STATE UNIVERSITY OF NEW YORK AT BINGHAMTON Department of Computer Science

The Computer Science Department at Binghamton University has six tenure-track positions beginning Fall 2015. Applicants should have a Ph.D. in Computer Science or related discipline, a strong research record, and a commitment to teaching. Qualified applications are invited from candidates with specializations in any of these four areas: (1) portable device/system design & energy-aware systems design (two positions), (2) healthcare information systems & data analytics for healthcare (two positions), (3) cybersecurity (one position) and, (4) computer networks (Associate level will also be considered).

The Department has established graduate and undergraduate programs, including 60 full-time PhD students and 27 Faculty members. Junior faculty have a significantly reduced teaching load for at least the first three years. Further details and application information are available at:

http://binghamton.interviewexchange.com/jobofferdetails.jsp?JOBID=53958

For the faculty positions in areas (1) and (2) above, the Department seeks a research scholar with research that will affiliate with the Binghamton University Transdisciplinary Areas of Excellence Initiative in Smart Energy (http://www.binghamton.edu/tae/smart-energy/) and Healthcare systems (http://www.binghamton.edu/tae/health-sciences/index.html) respectively.

Applications will be reviewed until positions are filled. First consideration will be given to applications received by February 20, 2015.

We are an EE/AA employer.

NWAMU, PC

Patent & Trademark Attorneys
Computer Science/Elec. Engineering

(866) 835-3540
info@Nwamu.com
www.Nwamu.com
salesforce.com, inc. has the following positions open in Palo Alto, CA:

Senior Member of Technical Staff (REF #J14W59): Design, architect, develop and test large-scale distributed systems and data pipelines for near-real time cloud-based Relationship Management applications.

Senior Software Engineer in Test (REF #J14T60): Work with the development and test engineering teams to automate testing and bridge the gap with manual testing.

Lead Member Technical Staff (REF #J14T61): Design and architecture large scale data infrastructure, including real time data pipelines and batch processing such as Hadoop.

Mail resume to salesforce.com, inc., P.O. Box 192244, San Francisco, CA 94119. Resume must include Ref. #, full name, phone #, email address & mailing address.
salesforce is an Equal Employment Opportunity & Affirmative Action Employer.
Apple Inc. has the following job opportunities in Cupertino, CA:

**Hardware Development Engineer [Req#9E53CF]** Des & dev mobile display elect that will sup liquid crystal dis develop in sys integ.

**Software Development Engineer [Req #9BGQBO]** Respon for WebKit browser engine develop, w/ focus on performance analysis & optimization.

**Software Development Engineer [Req#9DPTA9]**. Des, dev, impl & debug the user interface of the Mail & Notes Apps for Mac Operating systems.

**Reliability Engineer [Req#9CB299]** Des & dev reliability tests, sum test results & analyze fail. Travel req. 15%.

**Software Engineer, Applications [Req #9CLP97]**. Design and develop software for distributed processing modules.

**Hardware Development Engineer [Req#9CWSFS]**. Dev & ship the next gen of Human-Comp Interaction (HCI) HW (e.g. mice, trackpads, keyboards, remotes, etc.). Work on the design, implementation, integration & qualification of Human Int. Devices. Travel req'd 25%.

**Software Development Engineer [Req #9G2NR]**. Respon for design, implement, & maintenance of sw for low-latency audio & video comm & data transfer.

**IS&T Technical Project Analyst[Req#9GQ4CX]**. Analyze SAP financials module for implementation and improvement of existing system. Design & configure systems SAP Fin. for modules.

**Database Administrator [Req #9B6T6]**. Provide develop & prod database admin srvc for global apps.

**Engineering Technician [Req#9HEVCA]**. Respon for the testing and validation for battery systems.

**Software Development Engineer [Req#9HEVKN]**. Help improve how users view & nav the world using Maps test automation & assertion firmrks.

**Information Systems Engineer [Req#9KR5T7]** Des, architect & dev backend SW apps & comp to support multi-mil fin transactions.

**Software Engineer, Applications [Req#9C6UHW]**. Des & dvlp web & mobile apps to be used by Apple employees & customers in the retail area. Write SW code based on func specific & tech des, adhering to dvlpment tech & stdrds.

**Software Development Engineer [Req#9EKUM6]**. Des & impl device drivers for peripheral devices across all iOS HW platfrms. Travel req'd 20%.

**Software Engineer Applications [Req#9G8VL]**. Build Apple's next generation Employee Systems platform, suite of products and service layer for HR systems. Travel req'd 25%.

**Engineering Project Lead [Req# 9AE3SB]**. Oversee planning, dvlpmnt, imlmntation & maintnce of processes & ops for elect prdcts. Travel req'd 25%.

**Hardware Development Engineer [Req #9PN2T]**. Specify, dsgn & intgrate wireless hardware into Mac & iOS prdcts. Travel req'd 15%.

**Software Engineer, Applications [Req#9TU5]**. Des, architect, dvlp & maintain hi-perf SW systems to facilitate existing & new prod features.

**Systems Design Engineer [Req#9F4V6]**. Perform multi-radio systems co-existence perfmrnce eval & data analysis on prjcts for wireless technologies incl Wifi, BT, GPS and Cellular. Travel req'd 25%.

**Software Engineer Applications [Req#9QW5]**. Ensure availability, performance, maintenance & 3rd level support for enterprise Identity Management System. Drive security incident monitoring & incident mgmt.

**Hardware Development Engineer [Req #9CHTD4]**. Respon for lead develop & qualification activities to design & develop innovative Flat Panel Displays for Mac products. Travel req 13%.

**Operations Engineer Management [Req#9CLVOE]**. Des & dvlp fixtures for electron assembly & measurements. Travel req'd 40%.

**Network Engineer [Req#9HT22]**. Resp for delivery of LAN services w/in Apple networking environ.

**Test Engineering Manager [Req#9E3RR]**. Lead and oversee activities of the Acoustic Validation Team. Dev tests for acoustic functionality for new products.

**Engineering Project/Program Manager [Req#9F4R3]**. Analyze & improve the display problem for opto-electronic mobile devices. Travel req'd 40%.

Refer to Req# & mail resume to Apple Inc., ATTN: L.M., 1 Infinite Loop 104-1GM, Cupertino, CA 95014. Apple is an EOE/AA m/f/disability/vets.
Apple Inc. has the following job opportunities in Cupertino, CA:

Software Development Engineer [Req # 9K2SKU]. Respns for assist phases of assigned MES solutions, including reqs gathering, detailed design, develop, commission, doc, & user training.

Software Development Engineer [Req#9FU55E] Des data models for store large amounts of data.

Software Development Engineer [Req#9DQKV] Des & imple oper sys security SW mech for iPhone, iPad, Macs & Apple TV.

Hardware Development Engineer [Req # 9D2UME]. Respns for design & develop of new tech for audio apps in Apple products.

IS&T Technical Project Lead (SAP Functional Analyst) [Req #9LYS2Z]. Respns for prep of func design documentation used for SAP config.

Information Systems Engineer [9CYL78]. Provide solutions for App to App (A2A), Business to Business (B2B), Service Oriented Architecture (SOA) & Enterprise Service Bus (ESB) Integrations.

Systems Engineer [Req#9EE22FY]. Engineer Linux Systems on a large scale. Build computer server systems & troubleshoot problems.

Software Engineer, Applications [Req#96S2U]. Dev next gen of cloud support for Apple Ops Sys. Des, dev, & debug highly scalable server apps using Java.

Software Development Engineer [Req # 98P22W]. Respns for the design & develop of sw for the Siri server platform.

Software Engineer, Applications [Req # 9GU6GK] Test software for iCloud prdcts & services. Collab w/ crss-fnctional eng teams that define & implmnt core backend pltfmrms & sys that pwr Apple web services.

Software Development Engineer [Req # 9HUVGZ]. Respns for design & develop of sw to deliver dynamic map data to clients.

Hardware Development Engineer [Req#9EP2X6]. Lead the tech management & support of all HW validation during eng development for new iPhone/iPod projects.

Business Systems Analyst [Req#9BSXT]. Des & dev SAP Retail solutions for Apple Retail Logistics.

Senior Software Development Engineer [Req#9GPRSM]. Define and implement Cocoa and UIKit applications for iTunes Store content providers.

Application Engineer [Req#98N33M]. Responsible for Apple's Enterprise document archival & sw release system, PLM.

Software Development Engineer [Req#97U9M]. Design, develop & implement test tools & strat for QA of telecomm systems, focusing on GNSS/Cell tech.

ASIC Design Engineer [Req#9J9U8F]. SI model, simulate & characterize all high speed serial interfaces.

Software Development Engineer [Req#9JQ68]. Design & dev system sw apps &frameworks for Apple Watch.

Firmware Engineer [Req# 9LUNI]. Dsgn & dvlp embedded software/firmware for speakers, headsets & accessories.

Engineering Project Manager [Req#93N3NT]. Study, construct, implement, & support SW solns for Apple’s reseller channel partners. Build & review SW source code to id defects, compliance, & perf issues.

Senior Acoustic Validation Engineer [Req#9A3QEH]. Perf acoustic valid of Apple Mac prod thru dvlpment & implementation of tests & metrics.

Software Engineer, Applications[Req#9ELEQ]. Dvlp, create, implement, & support web app dvlpment of Sales Training App using large scale & high perfimming, object oriented internet tech.

Software Development Engineer [Req#9BENL4]. Own, manage, & improve SW & data release processes. Bld processes & tools for cont bld, automated testing & SW release mgmt for big data sys for Apple Maps.

Product Design Engineer [Req#9G5VM2]. Des & validate antenna/RF test instrumentation for mobile prod lines & supply chain. Travel req’d 20%.

Refer to Req# & mail resume to Apple Inc., ATTN: L.M., 1 Infinite Loop 104-1GM, Cupertino, CA 95014. Apple is an EOE/AA m/f/disability/vets.
State Transitions

David Alan Grier, George Washington University

Unlike almost every other challenge in the computing community, there’s nothing beyond good intentions to guide those transitioning from student to professional.

The baby had yet to arrive, but the rest of Michael’s new life was starting to become real. A year after finishing his doctorate, Michael was starting a teaching job at a university in a new city. The transition had been extended by an opportunity to work at an Internet company for six months. As a result, Michael didn’t fully appreciate his new identity. He described his roles, assignments, and responsibilities as if they belonged to someone else. As he talked, he was more like the graduate student I knew the year before than the professor I expected to see.

Michael started the transition as something of a rebel, a graduate student who shunned conventional research, instead looking at subjects that didn’t seem to have much to do with computing. He organized a seminar to explore the theory behind his work. Several colleagues and professors participated in the seminar from a distance, listening on Skype as the presentations jumped from game theory to psychology to sociology to economics. It was clear to all of us that some new creature was in the process of being born, but none of us was sure that it was actually part of computer science.

Michael’s rebellion started to ebb when he finally arrived at his new campus. I asked if he was going to continue to hold his seminar, but he deflected my question. There were new, unforeseen responsibilities: two senior professors had suddenly departed, leaving no one to direct a popular and fairly conventional set of classes. There were also doctoral students, committee assignments, National Science Foundation reviews, and conference deadlines.

When I asked Michael how he was coping with the new workload, he grinned, shrugged, and said, “I really don’t know.”

Three months after I last saw Michael, the baby arrived. The pattern was familiar to those who’ve observed the process: for a week or two, Michael’s life was chaotic but filled with new prospects; the most common of tasks held uncommon import. Yet, parenthood isn’t a role that accommodates rebels. It presses responsibilities upon us and instructs us how to live for others. Its lessons are often invisible, especially to those closest to the process. If Michael’s new son is like the rest of us, he’ll find it hard to imagine how his parents met, to appreciate that his father worked as a graduate student, of us, he’ll find it hard to imagine how his parents met, to appreciate that his father worked as a graduate student, or to conceive of how his father once pushed the boundaries of computer science. All he’ll know is the person who made the transition.

This year’s Errant Hashtag column will explore the transition from student to professional life.

The transition from student to professional is one of the most difficult problems in technical education. Yet, unlike almost every other challenge in the computing community, there’s nothing other than good intentions to guide those in the midst of it. We have no standards, no literature, and no structured curriculum for this problem. The good intentions are important, but they don’t create a professional.

This year’s column will explore this transition to professional life. It will tell the stories of young professors, software developers, security professionals, and others who are in the midst of establishing their careers. In the process, I hope to capture some insight without offering misplaced advice.

At first glance, the move from graduate student to professor would appear to be the easiest transition in one’s professional life. My friend Michael and his peers and colleagues are simply moving from one side of the teacher’s desk to the other. They have the same kind of colleagues they did before, do the same kind of work, and live in the same kind of environment. However, the move from student to professor isn’t as seamless as these observations suggest.

David Alan Grier
George Washington University, grier@gwu.edu

See www.computer.org/computer-multimedia for multimedia content related to this article.

DAVID ALAN GRIER is a professor of international science and technology policy at George Washington University. Contact him at grier@gwu.edu.
COMPSAC is the IEEE Signature Conference on Computers, Software, and Applications. It is one of the major international forums for academia, industry, and government to discuss research results, advancements and future trends in computer and software technologies and applications. The technical program includes keynote addresses, research papers, industrial case studies, panel discussions, fast abstracts, doctoral symposium, poster sessions, and a number of workshops on emerging important topics. With the rapidly growing trend in making computations and data both mobile and cloud-based, such systems are being designed and deployed worldwide. However, there still exists several challenges when they are applied to different domains or across domains. COMPSAC 2015 will provide a platform for in-depth discussion of such challenges in emerging application domains such as smart and connected health, wearable computing, internet-of-things, cyber-physical systems, and smart planet.

**Technical Symposia**

- Symposium on Embedded & Cyber-Physical Environments
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- Symposium on Technologies and Applications of the Internet
- Symposium on Security, Privacy and Trust Computing
- Symposium on Mobile, Wearable and Ubiquitous Computing
- Symposium on Web Technologies & Data Analytics
- Symposium on Human-Machine and Aware Computing
- Symposium on Novel Applications and Technology Advances in Computing
- Symposium on Computer Education and Learning Technologies
- Symposium on IT in Practice

Authors are invited to submit original, unpublished research work and novel computer applications in full-paper format. Simultaneous submission to other publication venues is not permitted. The review and selection process for submissions is designed to identify papers that break new ground and provide substantial support for their results and conclusions as significant contributions to the field. Submissions will be selected that represent a major advancement in the subject of the symposia to which they are submitted. Authors of submissions with a limited contribution or scope may be asked to revise their submissions into a more succinct camera-ready format; e.g., a short paper, workshop paper, fast abstract, or poster.

**CALL FOR PAPERS**

**COMPSAC 2015** will also feature a workshops program for topics closely related to the conference theme, *Mobile and Cloud Systems - Challenges and Applications*. Special sessions such as Fast Abstract and Industry Papers will be applicable especially for researchers and engineers who would like to present a new, early and work-in-progress ideas, method, and analysis. The Doctoral Symposium will provide a forum for doctoral students to interact with other students, faculty mentors, industry and government. Students will have the opportunity to present and discuss their research goals, methodology, and preliminary results within a constructive and international atmosphere.

**Important Dates for Authors:**

- January 17, 2015: Paper submissions due
- March 15, 2015: Paper notifications
- April 28, 2015: Camera ready and registration due

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