interface

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The Net Effect

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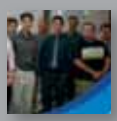
16 

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On the cover:
A portion of Web Trend Map 4, which plots the Internet's leading names and domains onto the Tokyo Metro System. The entire map, completed in April 2009, can be found at http://informationarchitects.jp/web-trend-map-4-final-beta.

net BENEFITS

by Anna Lynn Spitzer

Thinking about locating a news update or researching a medical question? If you're like most 21st-century information consumers, you'll go straight to the Web.

Beware. Malicious code on the Internet has swelled to the point where even trusted sites can contain corrupt content. A recent IBM report cites a 508 percent increase in the first six months of this year in the number of new malicious Web links reported on sites that included search engines, blogs and mainstream news pages.

Security is only one of a host of issues facing today's digital consumer, however. As new hardware and applications proliferate, the networks connecting them must continue to evolve in order to also provide reliability, privacy and mobility to an increasingly connected population.

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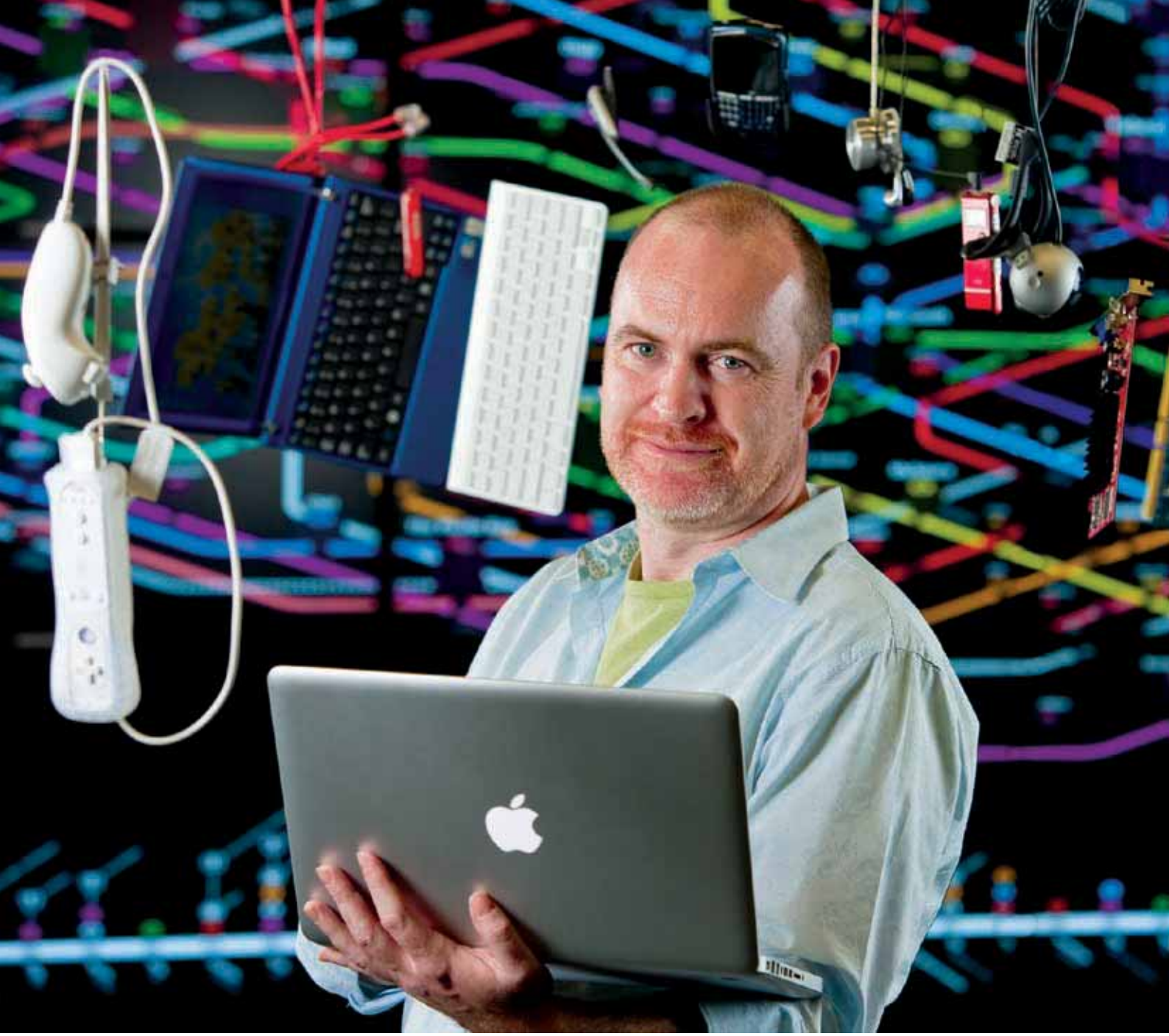


Paul Dourish: In a highly networked world, spatial constraints are an important consideration.

Surrounded

Computation is evolving at breakneck pace. Desktop and laptop devices have morphed into new and innovative technologies: sophisticated mobile handheld devices, wireless networks, wearable sensors, digital photography and smart environments.

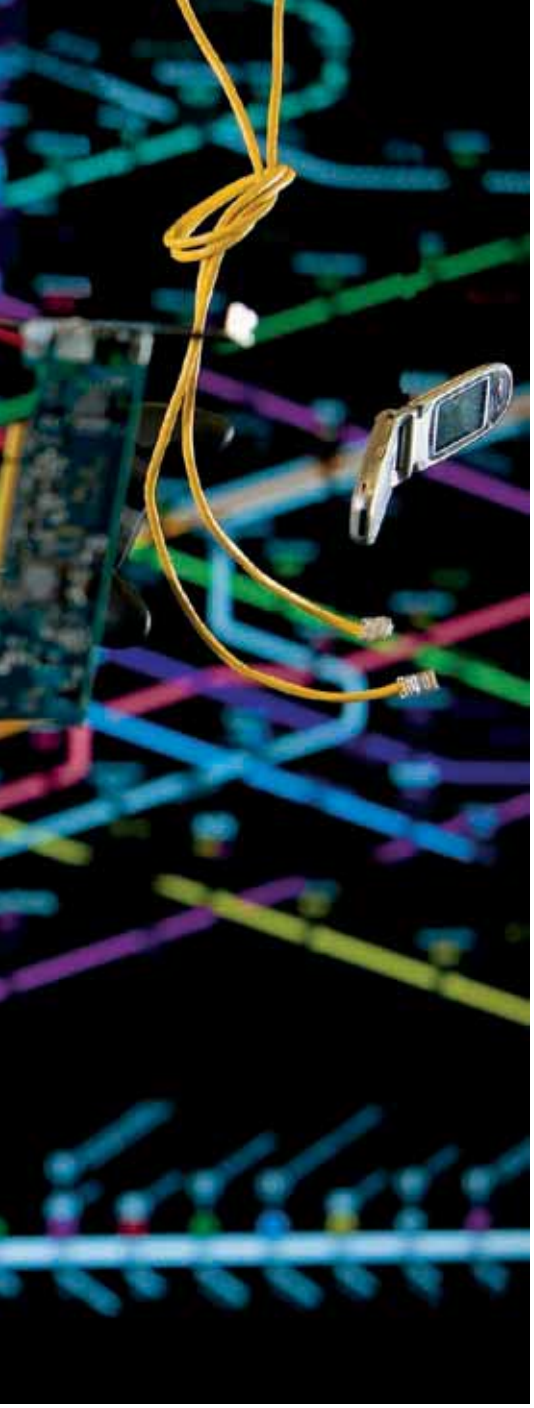
The idea of ubiquitous computing – computers of all types that seamlessly, invisibly weave themselves into our everyday lives – was first proposed in the late 1980s by Mark Weiser, a researcher at Xerox's Palo Alto Research Center (PARC).

Weiser called it computing's third wave, one that would follow the mainframe and desktop eras.

UCI informatics professor and ubiquitous computing expert Paul Dourish has a slightly different take on the concept of seamlessness. "I think the more we learn about some of these technologies and about the way they are deployed, the more we realize that this vision of ubiquity isn't necessarily something we really want," he says.

He references a small, seaside vacation retreat in the Pacific Northwest that intentionally has no cell phone access. "The town actively works against having any cell phone service; corporate executives like to buy holiday homes there because there is no service. They want to be able to disconnect."

On the other hand, cell phones, PDAs, digital still and video cameras,



laptop and desktop computers, DVRs, MP3 players, social networking sites, peer-to-peer file sharing, photo-storage sites and instant messaging have all become part and parcel of modern life. More than ever, reliable networking is essential for developing systems that consistently deliver content on demand.

"We can't think of Wi-Fi as this complete, uniform, ubiquitous Internet cloud," Dourish says. "We know it's made up of lots of different networks, so we can take advantage of that by recognizing that those networks are spatially bound."

He points to his Apple laptop.

"My Mac recognizes what Wi-Fi access point I'm connected to and associates which printer to use with that particular access point. When I go home, I don't have to tell it to print to my home printer; it recognizes automatically when I'm in a different place with a different network," he says.

Applications that incorporate elements of both ubiquity and separation will provide the most favorable approach, he says. "A Wi-Fi network means I can carry my computer around but at the same time it also creates this new kind of difference. There are different Wi-Fi providers, different access points and different kinds of security for different places."

And while he hesitates to predict the future of ubiquitous computing, he readily acknowledges the mounting pressure to design and maintain strong networks. "I do think we will increasingly see lots more automated devices, some of which we control and some of which we don't. I control my computer but I don't control what's in the walls or out in the network. There's going to have to be a negotiation among all those devices to create a coherent experience."

No Guarantees

The Internet is an interconnected network of millions of private and public, academic, business and government networks, linked by copper wires, fiber-optic cables, wireless connections and other technologies.

The labyrinth sprang from government-funded research sponsored by ARPA (the U.S. Advanced Research Projects Agency, predecessor of DARPA). When it debuted 40 years ago, the ARPANET consisted of two nodes – at UCLA and Stanford; the network's first message was transmitted on Oct. 29, 1969. Less than two months later, nodes at UC Santa Barbara and the University of Utah were added to the network.

By 1983, there were only 200 computers connected to the Internet, most of them used for sharing research efforts among academic institutions.

It wasn't until the Internet was released to the public in the mid-1980s

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that commercial advances in hardware and software led to an explosion of users that continues to mushroom exponentially.

In 1997, there were an estimated 50 million users online. Today, that number is 1.6 billion, and Vint Cerf, a Calit2 Advisory Board member who is often called the "father of the Internet," says he'll be disappointed if there are fewer than 5 billion users online by 2020.

But the Internet wasn't designed to handle billions of users. And dependability was never intended to be its strong suit, says Athina Markopoulou, assistant professor of electrical engineering and computer science.

Quality Control

In contrast to telephony, which incorporates reliable end-to-end circuits, computer networks use packet-switching technology. Before transmission, messages are divided into packets; if too many packets cross the network at once, some are dropped and resent later.

"The Internet was meant to be a cost-effective solution. It was not designed to be 100 percent reliable," Markopoulou says. "The term we use for quality of service is 'best effort.' It means there's no guarantee that packets will be delivered."

She aims to optimize network performance by determining the cause of bottlenecks and improving the ways in which information moves from point to point.

One approach is network coding, a model that refines packet-switching to enable more efficient use of network resources. Instead of simply forwarding data packets, network coding creates intermediate nodes that process and re-combine multiple incoming packets into one or more outgoing packets.

"Network coding says you can mix packets together to make them share resources. If several flows go through a link… we can make them share it better by combining the packets," she says.

She and her group are exploring ways to apply this relatively new approach to

Magda El Zarki "skypes" Scott Jordan: Quality of service and net neutrality go hand-in-hand.

practical applications like multimedia delivery and wireless networks.

Quality of service (QoS) also intrigues computer science professor Magda El Zarki, who is particularly interested in it as it applies to multimedia.

El Zarki advocates changes in public policy to alleviate logjams and other delays in service. Policies implemented when the Internet was simply a conduit for research data haven't kept pace with the rush of new applications now clogging the infrastructure.

"We've added multimedia to the whole slew of traffic types that go across the network and it was not designed for that," she says.

Embedding QoS in the network would allow traffic to be treated differently, with some data streams getting priority over others – a payment-for-priority paradigm.

Creating Net Neutrality

That's easier said than done, says computer science professor Scott Jordan, who specializes in public policy issues. While networking equipment already contains much of the hardware necessary to prioritize traffic, the issue is implementation.

"Who decides which traffic gets priority? How does that priority show up in terms of better performance? And how do you convince the various institutions – often, for-profit companies – that it's in their interest to offer this?" he asks.

The problem will continue to compound as consumers adopt ever more applications, according to Jordan.

In the U.S., five cable and telephone companies – Cox, Comcast, Time Warner, AT&T and Verizon – are the largest owners of the networks that comprise the Internet pipeline. They agree to connect with each other to send traffic across the Internet. They also rent space to other companies, which create their own private networks and monitor their own traffic.

Jordan currently is researching federal law to determine an optimum approach for guaranteeing parity to companies operating within this architecture. "Net neutrality" has been a contentious issue in Congress since 2006, he says.

Prioritization mechanisms should be incorporated into the networks, he believes, but in a way that guarantees a level playing field between those who run the networks and those who offer competing services on those networks. He predicts a debate in Congress this year or next but is reluctant to forecast the outcome. "There is a lot of money and lots of politicians on both sides of the issue."

Maximizing Flexibility

All packets may look alike but they are not created equal. Despite their uniform composition of binary code – combinations of 1s and 0s – their content requirements differ drastically. For some data packets, those associated with financial transactions, for instance, reliability and consistency are top priorities, while timeliness is more imperative for others, like streaming video or voice packets.

"The Internet was meant to be a cost-effective solution. It was not designed to be 100 percent reliable."

Additional complex problems also tax network architectures. Distributed computing, for example, requires synchronization. To address consistency and synchronization issues, Homayoun Yousefi'zadeh, associate adjunct professor of electrical engineering and computer science, developed and patented a database system that ensures an all-or-nothing approach to updates.

Simply put, when multiple users access and modify copies of the same data from different computers, changes made by one user should be consistently reflected in all copies. This requires that all input that occurs across the system by one user in a given timeframe simultaneously updates all of the other copies, preventing the problematic loss of synchronization that occurs with partial updates.

Large multimedia files, such as movies downloaded by consumers onto their television sets and home computers, present another challenge. Before transmission, algorithms break the files into pieces for downloading, but some of the packets get dropped or damaged, leading to delays in viewing and poor quality. "This is unacceptable," says Yousefi'zadeh. "A user expects to see a movie from beginning to end with relatively reasonable quality." To mitigate this problem, Yousefi'zadeh is designing optimal content delivery techniques.

El Zarki says transmission issues are compounded by the sheer volume of data as well as its augmented size. "We keep increasing the amount of data that's going through," she says.

Not only are more people than ever before using the Internet but new applications put unprecedented demands on the network. "At some point in the recent past, 2MB video was high quality," says El Zarki. "Now we're talking about 10-15 MB … high-definition and ultra-high definition, and that keeps increasing the need for extra capacity."

One solution is to enforce the packets with redundant information that can be decoded on the receiving end. Even if several packets get dropped along the way, extra data in the received packets can take its place. "If my data block is 1 MB in size, I will send 1.2 MB," Yousefi'zadeh says. "That is 200 KB of extra information that can be used to protect my original data block." Sophisticated coding mechanisms allow the original material to be recovered even if the extra packets do not contain exactly the same information as those that were dropped.

Data pre-processing and post-processing, El Zarki agrees, is the best approach. "I've been focusing on the end-to-end part of [multimedia

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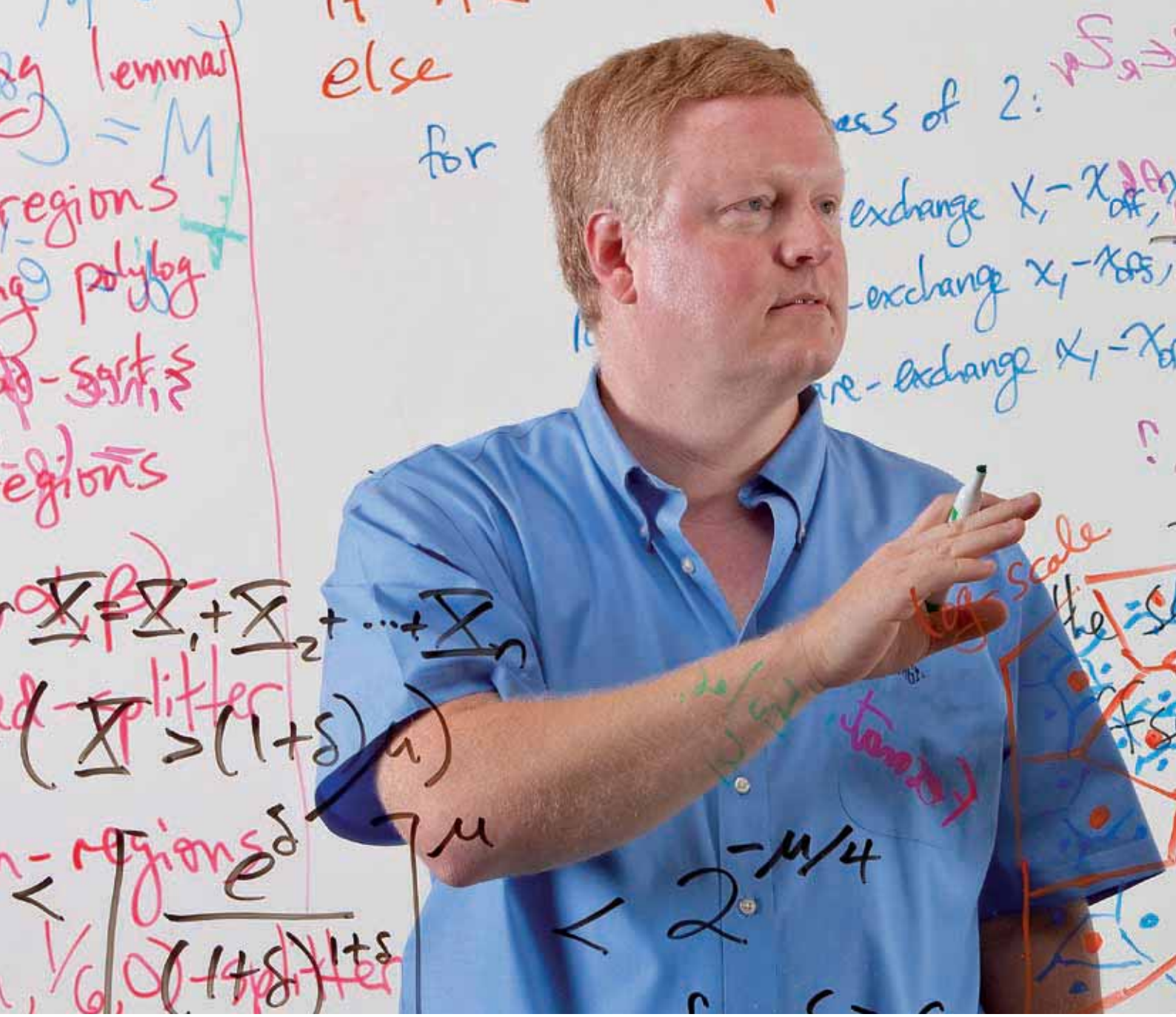


Michael Goodrich (left) and Gene Tsudik: Mounting security and privacy challenges require increasingly sophisticated solutions.

delivery]. If you create an application where you put enough information into it, you can survive certain losses and recover it at the other end."

New Network Models

Not long ago, wireless communication required a supporting infrastructure – a cell tower, a router connected to a wired network or an access point on a local area network.

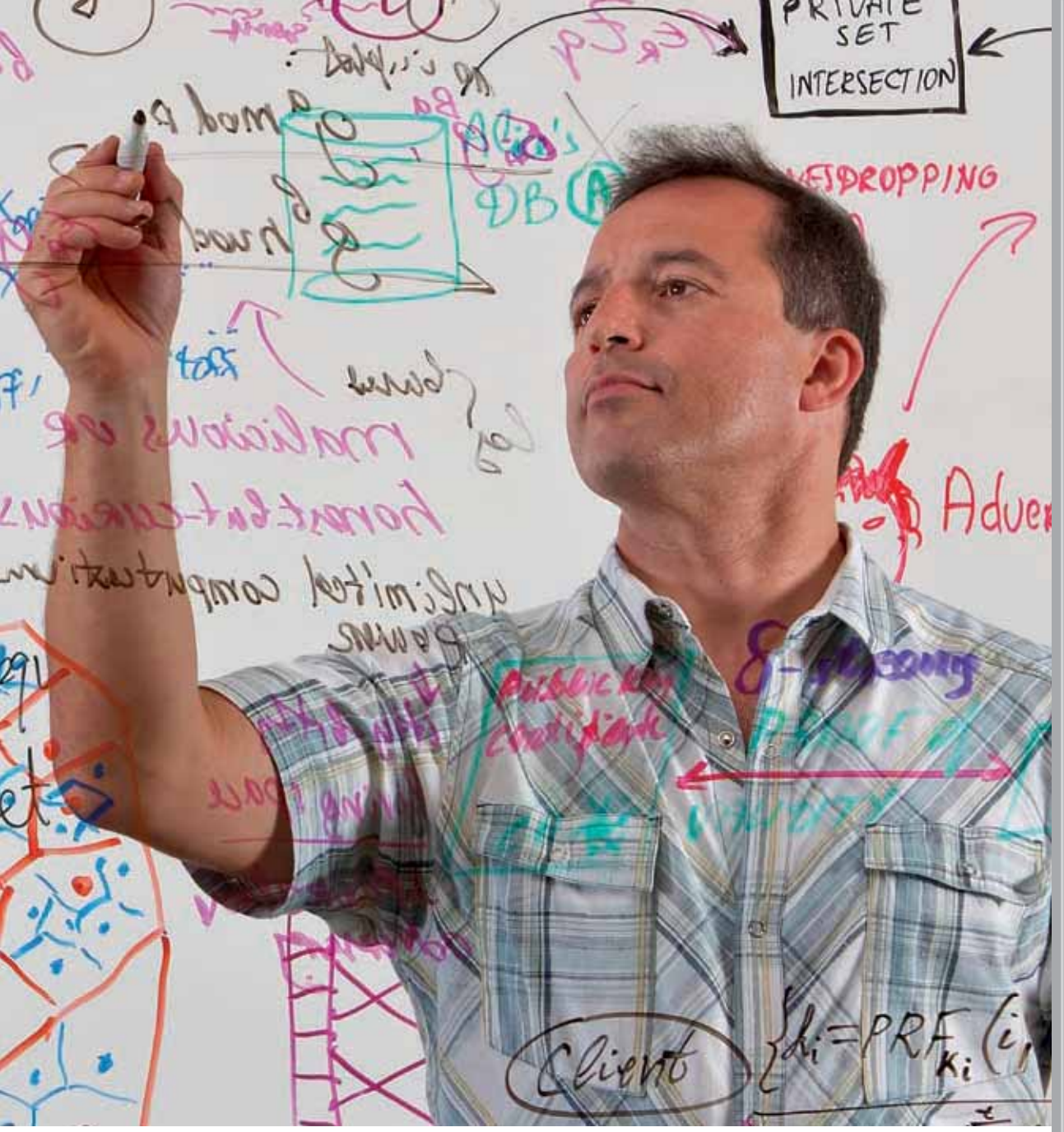
Today's advanced applications, including medical, military and emergency communications, often must send information outside the boundaries of those established infrastructures.

Mobile ad hoc networks, collections of autonomous mobile wireless nodes, eliminate infrastructure constraints. Known as MANETs, they transmit and receive a variety of data and rich media content in real time, via node-to-node relaying.

> **"There are all these problems popping up now that are a little more insidious."**

To increase flexibility, Yousefi'zadeh is designing and implementing adaptive protocols for MANETs formed by a collection of software-defined radios. This approach allows the networks to adapt to changing circumstances with simple software revisions instead of costly equipment updates.

Because such radios can transmit and display live audio and video content,



Yousefi'zadeh is working with UCI medical school faculty to utilize the MANET technology for medical care, such as live operating room monitoring and paramedic-physician communications.

Increased Threat

The last four months have been a busy time for cyber attackers. In July, a coordinated "denial of service" attack was launched on government computers – including the White House, Federal Trade Commission and the Departments of Treasury, Transportation and State – as well as the New York Stock Exchange and the Washington Post. The attack did little damage.

In August, social networking site Twitter suffered a similar attack that disabled it for hours. Perpetrators also targeted Facebook and Google in the same attack.

In both cases, experts blamed botnets, huge armies of machines, which, because they are infected with malicious software, can be remotely controlled to perpetrate network attacks.

UCI researchers, including Markopoulou and computer science professors Michael Goodrich and Gene Tsudik, all of whom are affiliated with UCI's Secure Computing and Networking Center (SCONCE), work to stay one step ahead of these and a host of other nefarious schemes and risky behaviors.

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Chancellor's Professor Goodrich says that while security has been a concern for more than two decades, the challenges are mounting. "Viruses existed in the '80s," he says. "They were even distributed on floppy disks and people were just physically handing them around. But the ways of networking have made security a bigger issue. There are all these problems popping up now that are a little more insidious."

"You know that you're communicating to people inside your network, but you don't know who they are and you cannot track them."

Most are the result of malware, malicious computer code hidden in email or on Web sites. Users who inadvertently open the emails or visit the sites unwittingly install annoying or downright dangerous programs that can inflict disaster in a number of ways (see page 12).

Malware can introduce unwanted spam and advertising pop-ups, or track and duplicate personal information, leading to identity theft and financial loss.

It can also hijack computers to produce the havoc-wreaking "botnets."

Predictive Blacklisting

Markopoulou and her group are designing innovative ways to prevent network attacks.

One approach is to examine firewalls and intrusion-detection systems that collect data from malicious activity. By processing and analyzing thousands of data logs compiled by DShield, a central repository, they hope to detect patterns of malicious behavior and develop methods to predict future attacks.

"By analyzing data from past attacks, we're trying to see which sources are the most likely to attack organizations in the future," she says. This information can be used to block specific IP addresses, groups of addresses or whole networks, or further investigate traffic originating from those malicious sources.

Homayoun Yousefi'zadeh: MANETs' software-designed radios and adaptive protocols allow the mobile ad hoc networks to be modified without updating costly equipment.

But even when attack sources can be identified, it's difficult to block only the perpetrators because innocent users often navigate the same networks. The challenge is to block the perpetrators without causing too much damage to legitimate traffic. "There's a tradeoff," Markopoulou says.

Her group's recent work on predictive blacklisting was inspired by the Netflix approach to customer movie recommendations. The multi-level model analyzes and combines information from several networks about past attacks. "This method can help enterprises and networks to collaborate in order to prevent attacks," she says.

Interestingly, while network security is a thoroughly modern phenomenon, the solutions used by computer scientists date back to ancient Greece. Mathematician Euclid, born approximately 325 B.C., developed the first algorithm – a series of sequential numerical steps – to compute the greatest common divisor of two numbers. It is still used today, forming the foundation for RSA, one of the best-known public key cryptography systems on the Internet. Says Goodrich: "This algorithm is absolutely essential for Internet security today."

Algorithms are at the heart of all modern network security. Public and private key encryption, digital signatures, reverse Turing tests, boundary checks: all implement algorithms in an effort to authenticate identity and prevent fraud.

In Confidence

In August, a former government informer was indicted, along with two co-conspirators, for masterminding the largest identify theft operation ever to be prosecuted. Albert Gonzales was accused of infiltrating the computer systems of a payment processing company and four large retailers, stealing more than 130 million credit and debit card numbers from late 2006 to early 2008.

Gene Tsudik tries to protect consumers from identity theft. He designs security systems and protocols using tools from applied cryptography.

The emerging field of RFID technology – radio frequency identification – also presents privacy and security issues. RFID tags are increasingly used in badges, credit cards, hotel guest keys and passports. The devices have no batteries of their own; rather, they receive power and transmit data through radio waves.

"When you swipe your ATM, credit card or passport through a mechanical device, it's very difficult to eavesdrop. In fact, it's close to impossible," says Tsudik. "But if you're using radio waves to communicate the same information, then eavesdropping becomes very easy.

"By analyzing data from past attacks, we're trying to see which sources are the most likely to attack organizations in the future."

Somebody could be sitting next door with a giant antenna and pick up every bit of information being exchanged."

Despite the risks, RFID systems are becoming widely used because they are convenient and inexpensive. "But we're paying a price," Tsudik says, "and that's privacy."

He and his colleagues have devised some solutions that allow a user to protect his/her privacy by interacting with an RFID tag. While he can't divulge details because a patent is pending, Tsudik says it requires "minimal" involvement by the user. "It cannot be onerous since the average user isn't technology-savvy," he adds.

Novel Challenges

Privacy issues multiply with each new application, especially those used in mobile networks. "The Internet of today and the future is going to consist of a lot more devices that are moving around, so their location is suddenly not stable," Goodrich says. "There will be information you want to share with some parties and keep from others. That brings in a whole new set of questions that we're wrestling with now. How do we maintain anonymity? What does privacy mean?"

Applications that allow users to connect with others in a specific area are already available, and Goodrich expects these to proliferate. "You might want to enable these applications but as soon as you do, you're reporting your location in a network where there are trusted and untrusted people. There could be risks and we're just now studying those issues."

Privacy issues are especially relevant to MANETs, the mobile ad hoc networks that rely on node-to-node communication. Because the location of nodes is transparent to those in the network, they provide temporary identities that can threaten security.

Tsudik is building privacy-preserving protocols for MANETS that allow nodes in the network to communicate without knowing the location of those with whom they're communicating. "You have security; you know that you're communicating to people inside your network, but you don't know who they are and you cannot track them," he says.

He and his team are trying to transition that approach from the MANETs to mobile geosocial networks like Google Latitude, an application that allows users to see their friends' locations on their mobile phones or browsers.

The proliferation of social networks has impacted tremendously the underlying computer networks. Facebook currently boasts more than 300 million users and founder Mark Zuckerberg, who said he expects social networking sites to become as important as Web browsers and operating systems, has a goal of one billion users. And according to Wikipedia, Facebook is just one of more than 150 active social networking sites, including MySpace, Twitter, Flickr and LinkedIn.

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Athina Markopoulou: Predictive blacklisting can prevent network attacks.

Markopoulou's group studies Facebook's online switching networks to determine how its traffic flows affect the network underneath. "Facebook is important because it has probably the largest population of users in an application that the Internet has ever seen," she says.

She believes Facebook will continue to add applications, ultimately becoming the platform for most types of communication. "As time goes on, more and more things will migrate there. People send emails through Facebook; they post their photos, their videos and they send gifts. It's possible that within a few years, all your communication will happen on Facebook."

The group is sampling the social graphs that define the applications and learning how those relationships impact the design of the infrastructure that supports the site.

For now, the network infrastructure is adequate. But as additional applications are developed and users flock to the network, will it hold up? "I'm interested in trying to understand how that could affect the underlying system. Could it be designed differently to improve its performance?"

Moving Ahead

Networking has evolved far beyond what researchers envisioned 40 years ago when they sent that first message over the Arpanet.

And today, more than ever, advances must stay ahead of the curve. Waiting in the wings are new devices and applications that will put additional stress on a network infrastructure already groaning under its own weight.

Researchers shy away from guessing what those new apps might look like. "Networking folks in academia have had a pretty good sense of long-term trends … like predicting that telephone networks, cable, the Internet and wireless would all merge together," says Scott Jordan. "But trying to foresee what the popular applications will be is where nobody does very well. That's incredibly hard to predict."

"It's interesting to look at the ways that the same technology has been imagined quite differently in other places."

El Zarki agrees. "Facebook, Twitter – keeping up with it is extremely hard. I'm an expert on the basic networks but the applications are mind-boggling," she admits.

She does think that wireless mobile devices will become the tool of choice for many current and future tasks. From texting and email to downloads and gaming, "everyone will be using them for just about everything and that will impact the wireless network," she says. "There will be a big crunch."

Internet developer Cerf says he too is surprised by some of the new applications. On the other hand, he notes that the Internet infrastructure was built to accommodate the unknown. "When we were doing the basic design, Bob Kahn and I believed we should not develop a 'purpose-built' infrastructure," he says. "Rather, we wanted something that was transport-technology agnostic and would allow expansion of the number and speed of the networks that were interconnected with the Internet architecture."

What they didn't envision was the crush of users that would require more Internet addresses than the system could provide.

The current IPv4 protocol, in use since the early days of the Internet, supports a theoretical limit of 4.3 billion addresses, a number that potentially could be increased 100-fold through a system called Network Address Translation. Even that won't be enough, Cerf says. Experts predict that the current system will run out of addresses by 2011.

A new protocol called IPv6 uses 128-bit addresses instead of the 32-bit version used by IPv4, supporting trillions more addresses. Worldwide deployment is underway.

The future is always first and foremost in researchers' efforts.

Cerf believes the future Internet will see faster language translation and the ability to search video, audio and imagery as effectively as text. He also says the Internet will control lots of sensor networks and devices.

Gene Tsudik is designing security protocols that can protect tomorrow's networks of autonomous drones or sensors.

"For me, true research is where you expect something 5-10 years from now and try to solve the expected problem," he says. "If only one out of 10 or one out of 100 of those problems actually pops up, then we'll have the solution by the time it does."

Adds Goodrich, "What we try to do as researchers is to focus on the features like authentication, integrity and authorization, things that are going to be a part of any solution. We're trying to learn to attack things we never even thought of."

Risks and Rewards

For Paul Dourish, the future is not as significant as understanding current trends in different cultures. Korea has the highest broadband penetration in the world. In Singapore it's almost impossible to summon a cab without a cell phone because "everything works by SMS." And in Indonesia, he says, mosques are the primary site of network deployment, not only because they are so plentiful but because technology development is closely integrated with spiritual practice. "It's interesting to look at the ways that the same technology has been imagined quite differently in other places," he says.

Modern life depends on a highly networked world, one that simplifies and enhances daily tasks while continually presenting a host of challenges.

"I think there are all kinds of dangers," Dourish says. "In a world where lots of things are talking to each other wirelessly, there are all sorts of opportunities for those things to be snooped and spoofed and for data to be disclosed."

He relays an anecdote. He was sitting at home one day recently when entries from a woman's diary began spewing from his printer. He figured out that a neighbor had been using his network, either accidentally or intentionally. While she was attempting to print her diary, her computer was automatically locating the nearest printer on the network, which happened to be Dourish's.

"Of course she had no idea that it was happening because she didn't know which network she was using," he laughs. To compound matters, she continued trying to print, ultimately sending six copies of the document to his house.

The experience reinforced Dourish's long-held contention: the more computing integrates itself into daily life, the more important it is to establish boundaries within that framework.

And while experts contend with a wide range of reliability, security, privacy and mobility issues, all agree that the gains outweigh the dangers. "There's a lot of really, really good stuff on the Internet," says Goodrich. "There are some risks, but I still think it is a net benefit."

Dourish convincingly sums up the situation. In his view, ubiquitous computing and networking boil down to two problems. "The first is how to get things to talk to each other," he quips. "The second is how to stop them."

MALICIOUS and Malignant

The malevolent equivalent of a gift that keeps on giving, malware constantly astounds computer and network professionals with its far-reaching capabilities. The hidden computer code, present in many emails and on an increasing number of Web sites, surreptitiously causes naive users to download dangerous programs that threaten personal, financial, computer and network security. Malware is spread by viruses, which require the user to open an email or click on a link; and worms, which can self-perpetuate, automatically infecting other computers.

Popular categories include:

Adware, which displays targeted marketing, including unwanted pop-up ads and spam, by tracking users' online activity and capturing email keywords;

Spyware, which captures users' passwords and other personal information in order to steal money, goods or personal identity;

Botnets, networks of computers hijacked by malicious code that can be controlled remotely to launch a variety of network attacks.

A particularly virulent malware program called Conficker, which first appeared about a year ago, has commandeered more than 5 million computers worldwide, confounding security experts' attempts to eliminate it.

Botnets attack legitimate Web sites with denial-of-service or flooding attacks similar to those that brought down government sites last summer. They can be sold to spammers, who use them to reach millions of people simultaneously. (Network security company McAfee Inc. recently estimated that spam accounts for 93 percent of the more than 2 billion emails sent across the Internet daily.) Or they can be used to extort legitimate sites by promising protection from large-scale attack in exchange for payment.

Botnets are particularly difficult to detect. "It's still a challenge figuring out which computers are in botnets and how they're being controlled," says computer security researcher Michael Goodrich. Malware schemes include:

Phishing, which starts with an email that leads unsuspecting users to a legitimate-looking Web site. The site prompts users for passwords or other identifying information, only to infiltrate bank accounts or charge purchases to victims' credit cards.

Pharming, which exploits computer caching systems, takes the scheme to the next level. Caches store, for a limited time, domain name service (DNS) information, which allows a user to find a Web site by typing in its domain name – google.com, for example – instead of its 32-bit IP address. But pharming poisons the cache system, causing it to connect established domain names to counterfeit Web sites instead of the legitimate site the user intended.

Fake 'Windows Security' pop-ups that are good copies of the original can cause users, thinking they're updating their computer security, to click on them. Instead, malware hijacks the computer, creating another 'bot' in the botnet. Many of these programs will not close and attempts to close them through the task manager cause them to respawn.

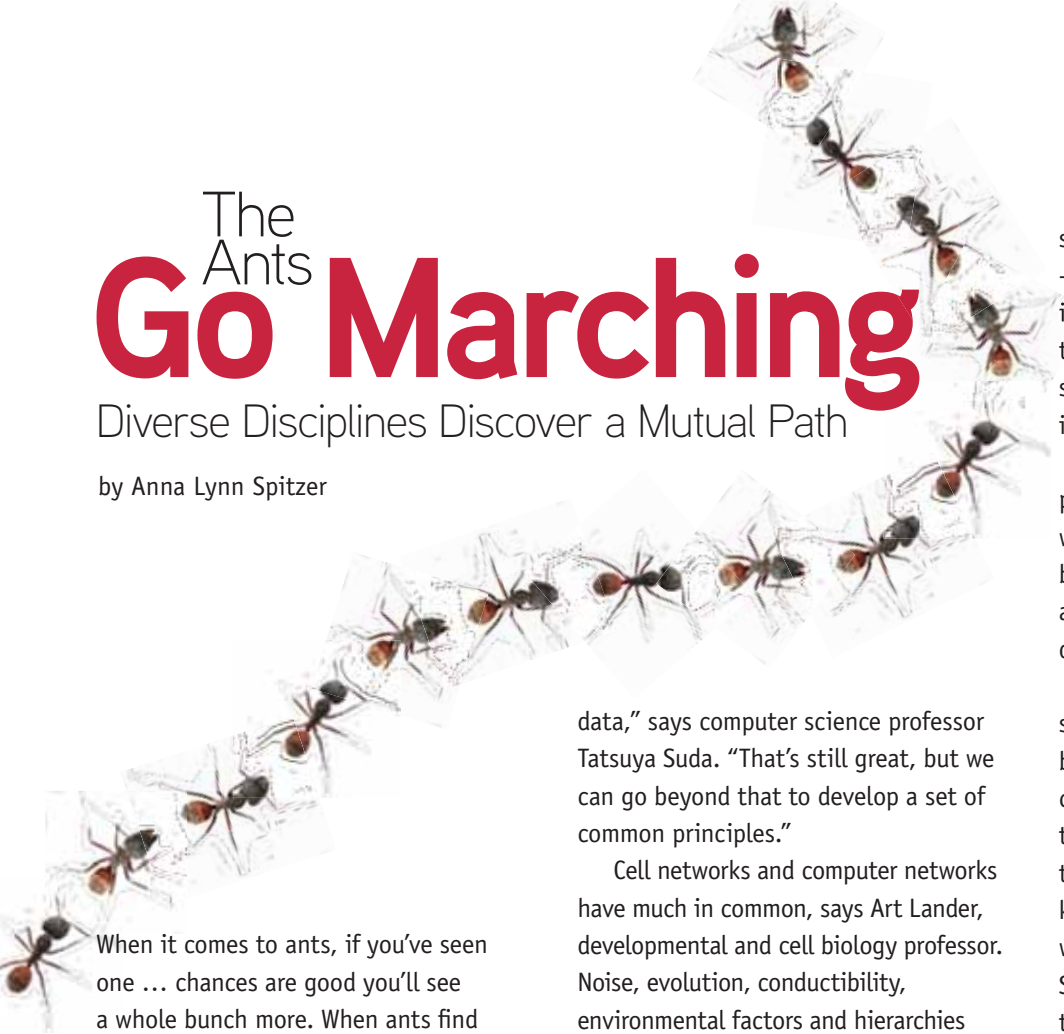
The widespread and growing use of social networks adds to the malware threat. A survey by anti-virus and security software company AVG and a marketing council shows that the use of social networks at home and work is creating a serious danger of Web-borne identity theft and infection.

Additional schemes are always debuting, according to Goodrich. "If the past is any indication, every five years there is a new risk that we hadn't even anticipated."

The Ants Go Marching

Diverse Disciplines Discover a Mutual Path

by Anna Lynn Spitzer



When it comes to ants, if you've seen one … chances are good you'll see a whole bunch more. When ants find food, they carry it back to their colony, leaving behind trails of pheromones that other ants use to locate the food source. Those ants find the food, carry some back and leave their own pheromone trails. And so the process goes.

The result is a messy situation for humans but an efficient delivery system for the ants.

Understanding biological processes like ant routing can help computer scientists create more secure and reliable computing systems. It turns out that ant-routing algorithms can be applied to network-routing problems to find the best path between a source and a destination node.

The concept of interdisciplinary scientific research is not new. But recent collaborations between biologists and technologists are providing both fields with a new understanding of principles they share as well as possible mutual benefits.

"Before, biologists would give inspiration to computer scientists so we could build better computer networks. And we'd provide database mining tools so biologists could look for biological data," says computer science professor Tatsuya Suda. "That's still great, but we can go beyond that to develop a set of common principles."

Cell networks and computer networks have much in common, says Art Lander, developmental and cell biology professor. Noise, evolution, conductibility, environmental factors and hierarchies impact both in similar ways.

"Biological systems naturally have to deal with exactly the same sort of problems [as computer systems]," Lander says. "Before, people thought of biology as just physiology, the functioning of organs and tissues. Many more biologists nowadays are comfortable thinking about biology as an information-processing problem."

This new approach may benefit next-generation computer networks.

For example, efficient computer systems must adjust to changes in traffic patterns. There will be more email traffic at the start of the business day than there will be during the lunch hour. "Traffic dynamically changes throughout the day and the system has to adapt to that," says Suda.

Helpful lessons could be gleaned from biological systems such as blood flow hydrodynamics, which adapts to changes in gravity. When a person stands up, muscles around the arteries readjust so that the blood flows in the right direction. "Down at every level, there's all this adaptability programmed into biological systems," Lander explains.

Another similarity: both systems share hierarchical organization schemes – identifiable levels of operation. Suda is hopeful that learning and applying the strategies used by biological systems to create hierarchies can improve computer systems.

Both professors, who have participated in Calit2-sponsored workshops aimed at reinforcing and building on this cross-disciplinary give-and-take, say that discovering system differences can be helpful as well.

Software engineers may use one strategy to improve a system while biology may rely on another. Take computer networks, for example. Suda thinks there might be a better approach than what is currently used. "We don't know whether it's the optimal product we can come up with," he says candidly. Studying communication systems in cells, though, might lead to a fresh model.

Cells contain proteins that communicate by passing signals through channels. According to Lander, by looking closely one can see all the channels cross-talking, creating a very different paradigm from that used in computer networks.

"It's so pervasive that you begin to think this is no accident," he says. "There must be some tremendous improvement; we're not sure what, but there must be something very beneficial that comes from using this architecture."

Both camps believe the collaboration will become more valuable as computer components get smaller and smaller.

"Biology, which operates at the nanoscale, has had to deal with issues of efficiency, energy utilization, noise and component reliability for a long time," says Lander. "That's going to help the development of nanocomputing."

Researchers have other innovative ideas. From creating biomedical devices to identifying computer viruses to developing online communication that extends beyond text and video to smell and feelings, the future seems limitless.

It's all in Z-DANCE

You put your right foot in,
you put your right foot out.
You put your right foot in
and you shake it all about.

by Shellie Nazarenus

The Hokey Pokey, with its whimsical cadence and simple movements, beckons even the most reluctant would-be dancers to join in the fun.

While the joys of participatory performance haven't changed, the medium has been transformed. Technology research in Calit2's eMedia Studio has given birth to an interactive exhibit at a children's museum.

By integrating tools such as processed video, computer-generated animation, motion capture and real-time motion tracking, the Z-Dance exhibit gives users a multi-dimensional experience that's light-years removed from other participation approaches.

First Step Forward

Zeum: San Francisco's Children's Museum commissioned John Crawford, UCI dance and media arts associate professor, to develop Z-Dance. Prototyping began last fall after Crawford's earlier Dance-IT work caught the eye of a Zeum board member. That project, developed with the San Francisco Ballet, featured a kiosk where people could step inside, select a pre-recorded dance style and learn from an instructor.

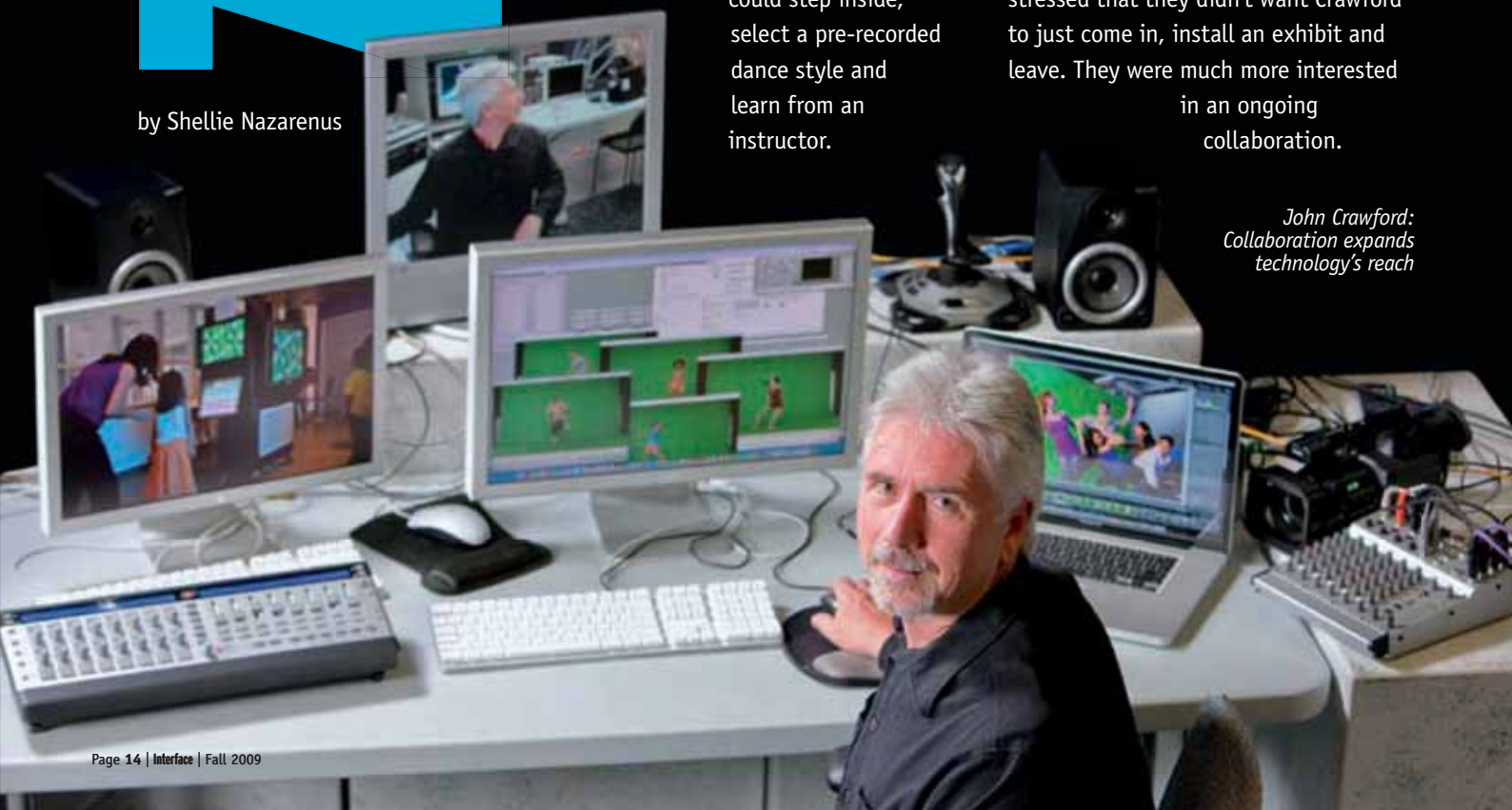
The goal for Z-Dance is far more experiential.

"It's really about bringing kids out of their shells and enabling them to explore movement," says Mike Lai, Zeum exhibits manager. "We really wanted to add a performance dance-type element to our exhibits that lowered the stage fright barrier."

Lai has been working closely with Crawford to develop and refine the Z-Dance experience based on feedback from Zeum guests. Since the museum opened in 1998, millions of visitors have come for the hands-on, multimedia arts and technology opportunities.

"We are not your typical children's museum," explains Audrey Yamamoto, Zeum's executive director. "We're focused on kids creating things that they never thought were possible, and technology is the tool we provide for them to be creative, collaborate and communicate."

The underlying technology for Z-Dance derives from the Active Space system Crawford created more than a decade ago. Zeum staff, however, stressed that they didn't want Crawford to just come in, install an exhibit and leave. They were much more interested in an ongoing collaboration.



John Crawford: Collaboration expands technology's reach

"It's a really great fit with what we are trying to do at Calit2, which is to find ways to expand the capabilities of our technology without replicating a proven concept," says Crawford. "After all, you might say that research is what we do when we don't know what we're doing."

Feeling the Effects

Z-Dance development blossomed in several phases.

First, Crawford helped the museum design and equip the dedicated space where the exhibit resides. Lighting and hardware were refined and an easy-to-use touchscreen interface was developed.

Initially, there were four music tracks and four special effects from which participants could choose. That selection doubled in the second prototype, offering more capability and a streamlined user experience. Icons on the touchscreen were developed to serve as visual cues that activate the system, allowing even the youngest participants to navigate easily.

"At first, my reservation was how intuitive the system was going to be. That's always the challenge in building exhibits for children, and this one is amazingly easy to use," says Lai.

Visitors entering the Z-Dance room are greeted by a continuous montage of video clips that the system has recorded of others' experimentations. The collective memory comes to life on a large display screen, drawing families into the space.

A green-screen wall is the exhibit's backdrop, while its technology backbone consists of a 3x4-ft. kiosk, where users pick music and visual effects that range from echo trails to a kaleidoscope-like pattern to an etch-a-sketch experience. As they begin to move in the space, the system responds.

"There really is a connection between the effects and what you're doing with your body," Crawford explains.

Positive Feedback

Joy Wong-Daniels, Zeum's marketing and public relations manager, is amazed by the multi-generational collaboration the exhibit is inspiring. "They don't have to figure out how to make the technology work, but rather how to be as creative [as possible] with their movements to make the most out of the sounds, effects and colors."

In the prototype's final version, the amount of movement changes the way the song sounds. For example, when there is little motion users may hear only the drum track. With more movement comes the rhythm guitar, and all-out enthusiastic participation is rewarded with the sounds of vocals and lead guitar.

"Yes, we are a children's museum, but when we see adults having fun that's when we know we've successfully created a collaborative, friendly experience," Lai contends.

Developers plan to grow the project in round two. Zeum and Calit2 hope to find funding opportunities to network multiple locations so that the experience spans time and space.

"The Zeum folks keep telling me that it's the hottest exhibit they have and how excited they are about the visitor response," says an enthusiastic Crawford. "We would love to find ways to expand it!"

The Z-Dance Experience

"All of the performances are unique and they don't take much thought. They're easy for a 7-year-old — even the design and creativity."
—Valerie, parent, age 44, Chicago, IL

"I feel good because it makes me feel jumpy and it makes me feel less shy."
—Dwijen, age 5-1/2, Sunnyvale, CA

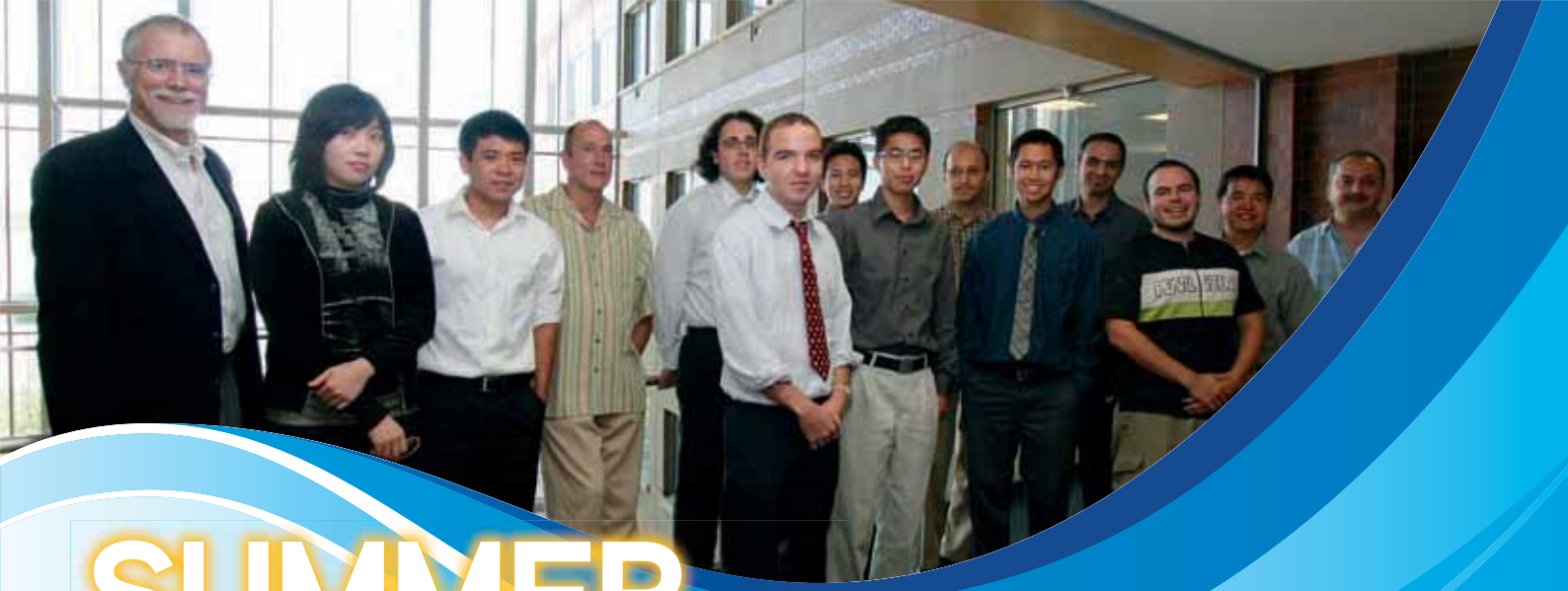
"Awesome! Amazing! Because you can see yourself while you do it and it's something you don't have at home."
—Bali, age 37, Great Neck, NY

"It looks cool because my brain thinks it looks cool!"
—Kevin, age 10, South Bay, CA

"It's a huge hit with my kid! I can't get him to leave. He has been here before and it was the first thing he wanted to do when he came in!"
—Parent of Ethan, age 3, Chicago, IL

"Z-Dance makes me feel energetic and graceful!"
—Stina, age 13, San Carlos, CA

"I have never seen this before. We really like it…nice to have so many controls. Loved mirror effect and music."
—Shari, age 65, Burlingame, CA



SUMMER EXPOSURE

This year marked the fifth anniversary of Calit2's Summer Undergraduate Research Fellowships in Information Technology (SURF-IT). The 10-week summer program provides an opportunity for UCI undergraduates to immerse themselves full-time in IT-related research and applications under the guidance of a faculty mentor and his/her graduate students and post-doctoral researchers. A series of seminars provides the Fellows more opportunities to learn about IT systems and applications, research conduct and potential career paths. This year, eight students were selected for the program, which is co-directed by UCI's Undergraduate Research Opportunities Program. Here, the students briefly share their efforts and impressions.

Sunhee Baik

Enhancing Social Skills Through Video Game Encounters

Mentor: Liane Brouillette, associate professor, education

I am an exchange student from Korea so I grew up in a very different education system and facilities. I was very impressed that everyone really cares and was eager about teaching children by using various technology and methods. In this project, my role is to understand what K-8 children need to learn social competency in the classroom, and make video games and illustrations. From basic storylines that my mentor provided, I set detailed stories for each game based on the theme being taught. For each theme, I usually made two or three images, selecting one that was most effective and made video games or seminar materials from them. During SURF-IT, I was able to experience how technology affects children's learning and makes it more rich and real. Now I have decided to be a researcher in human engineering, and have started to search graduate programs for that major as a first step in my future education plan.

Jakkree Janchoi

Web-enabled Home Health Monitoring

Mentor: Mark Bachman, associate professor, electrical engineering and computer science

I was part of an ongoing project known as Telios (Telepresence Interactive Operating System), a software infrastructure that transforms computing devices into user-friendly, real-time telemedicine tools. Since Telios was developed using Web 2.0 tools, it runs on any modern Web browser without additional software installation. I worked on three aspects of the project: the user experience, the device server and applications. We created a UI (User Interface) library called 'H2O,' which automatically scales based on

the current display area. Instead of stretching the size of the element and leaving it distorted, it figures out the size of its container and optimizes appearance based on screen resolution. It looks great on cell phones and large desktop displays without recoding anything. I also created the 'H2O.Chart,' a javascript element that utilizes html canvas tags for a customization graph that can display data in real time. Since we wanted data from different medical devices to be reliable and delivered in real time, we needed a way to make received data sets consistent. The 'Martinelli' device server dynamically adjusts the data set size to send to the client device based on how fast that client can request data. I also used the H2O library to create an activity monitor application for the Telios system. Web-based applications were always an interest to me and I will continue to work on more applications during the school year. This project helped me build the experience necessary to achieve my future career goals.

Bryce Kubo

Flow Characterization in a Microfluidic Compact Disc Platform for Clinical Diagnosis
Mentor: Marc Madou, professor, mechanical and aerospace engineering

I enjoyed learning about the uses of the microfluidic compact discs that I was making and all of the different projects being worked on. During lab meetings I found out some of the amazing uses for these discs, such as PCR and DNA splitting. I assembled and tested various compact discs consisting of differing microfluidic channel widths and lengths with multiple solutions. I plan to keep working on the project until the graduate student that I am working with has enough information to write an excellent paper. The interdisciplinary nature of the SURF-IT program with the weekly seminars allowed me to see up-and-coming research that wasn't biomedical-specific. For instance, I found it very interesting the many ways video games can be used to help students and the various ways computers are used to communicate. I am very glad I chose to apply for SURF-IT because it will be a strong stepping stone to get me into a graduate program.

Isaac Mahgrefteh

Feature Extraction from Multimedia Databases
Mentor: Sharad Mehrotra, professor, computer science

I am a programmer and my main objective in this project was to learn the theory behind image pre-processing. I developed software tools that can automatically recognize images. For the longest time, nothing I wrote worked. Once I was able to get a small program to work, I built another small program. I continued on like this until I had enough pieces of the puzzle. I then combined all my work into one program. I am now working on my own face-detection algorithm that is specially designed for Donald Bren Hall at UCI. Once completed, I will add my work to SATware (Situational Awareness Technologies) which is the main project that my mentor leads. In fact, I plan to continue working with Prof. Mehrotra on my current project until I graduate. I am also taking a deeper look at attending graduate school. During my SURF-IT experience, I have learned many new things, such as working with a team and how I should manage my time with deadlines looming. I taught myself C programming language and an advance library within C called OpenCV that did the image processing. I also enjoyed the weekly seminars, which featured information about what my peers were working on. I strongly feel that this is a perfect summer undergraduate experience.

Taylor Mar

Video Games and Learning
Mentor: Mark Warschauer, professor, education

I conducted observations in which I would set up and watch participants play approximately 40 minutes of video games. I also asked questions about their past experiences with video games and what they experienced while playing in our lab. Along with observations, I coded transcriptions according to James Paul Gee's 36 principles from the book "What Video Games Have to Teach Us About Learning and Literacy." What I gained most from my SURF-IT experience was how research is conducted and the process of how to come up with research ideas. So far we haven't discovered anything we were or were not expecting because most of my research was coding and observing participants. I think by the end of the study, when all the data is compiled, is when we'll see any profound discoveries. For that reason, I possibly might continue doing the research with my mentor. I'm curious where this study might lead in general and in my personal academics. I don't have any interest at the moment in pursuing any research-related career, but I do have a strong interest in where technology is going in the field of education.

James Milewski

Designing and Evaluating an Information System

Mentor: Yunan Chen, assistant professor, informatics

I studied the different ways patients manage their medical records, in order to make electronic record-keeping systems more useful. In the medical field, systems are usually designed from the care provider/organization perspective. My research is patient-centric. I recruited patients with diabetes from the UCI Medical Center and the Joslin Center, then administered a questionnaire and performed in-depth interviews in participants' homes. Finally, I transcribed, coded and analyzed the information from the 14 interviews I conducted during my 10-week fellowship. What I discovered was that individuals with Type-2 diabetes rely on technology to manage their personal health information at home. Upon diagnosis, the individual uses durable/paper-based media (e.g., log books, binders, calendars) to track their condition, coordinate care, obtain information about the disease and integrate their medication. Due to the nature of managing a chronic condition, the individual eventually shifts away from paper-based media to technology. These results indicate that individuals are eager to use and understand the benefits of technology at home in their personal health information-management process. My mentor and I are preparing a paper for the "MedInfo 2010" international health informatics event and hope to present at the American Medical Informatics Association 2010 conference. The SURF-IT experience has opened many possibilities. In addition to broadening my options for graduate school, the research will allow me to begin interfacing with private industry.

Alex Taubman,

Video Games and Learning

Mentor: Mark Warschauer, professor, education

I transcribed dozens of hours of video and then I took those transcriptions and coded them with 36 principles that researcher James Paul Gee outlines in his book "What Video Games Have to Teach Us About Learning and Literacy." Unfortunately, I did not feel challenged in my research. I thought I would be able to do something more technical than primarily transcription, such as actual programming to build a game modification. I understand fully that this happens in research; things change and one must adapt. As far as coding, it was indeed an exciting and interesting experience for the first two weeks. My partner, Taylor, and I discussed in detail what was classified as which code, and how to do it, and in what situations. However, after that, it became an exercise in monotony. Every day was basically the same thing. I don't regret having done the SURF-IT program, it will surely be a step up when applying for research positions in different areas, and I do know more about how this type of research works. In the future, I now know what specific questions to ask and what things to consider when applying for a program.

Jason Tran

A Software-defined Radio Implementation for Audio and Video Transmission over Wireless Ad Hoc Networks

Mentor: Hamid Jafarkhani, professor, electrical engineering & computer science

I wrote software to overcome some of the obstacles encountered by ad hoc networks – those that do not have pre-built infrastructures. My project is one component of a larger project including multimedia content delivery over the same ad hoc networks of software defined radios (SDRs). These radios communicate directly with one another, rather than through an established infrastructure, like all the computers at a home that connect to one router. Ad hoc networks provide ready mobility for many applications, such as military or medical use in fields without existing infrastructures. My specific role in this project was to optimize the transmission of live voice over the SDRs. Live voice transmission requires reliability and minimal delay. With the use of voice-specific compression and bit-error correction schemes, I was able to improve the robustness of the voice transmission in a congested network. Because of the SDR's programmable nature, the radio's protocols can be changed or designed on the fly using software instead of circuitry, allowing me to design the radio I wanted without the hassle of removing and changing parts. Working with my mentors and the graduate students in the lab has really sparked my interest in the field of computer networking. This academic year, I plan on taking on a new project and integrating it with my senior design project. Ultimately, I plan to apply to graduate school and the SURF-IT experience reinforced my interest to achieve a Ph.D.

Ask the TIPSter

TIPS (Taking IP to Startup) is a service offered by Calit2 to help guide faculty and students through the process of moving their research to the business market. Vasquez has open office hours 2 – 5 p.m. every Tuesday in the Calit2 Building, suite 4100.

Linking... Tweeting... Facebooking... The Networked Startup

by Luis Vasquez, OCTANe LaunchPad

When I was starting my first company (a few too many years ago), I spent hundreds of dollars to print and copy my business plan and executive summary. I was eager to get these printed documents into the hands of as many prospective investors as possible so I gave copies to my corporate attorney and my advisors, hoping to get them passed along. Today, I strongly advise startup entrepreneurs not to print anything unless absolutely necessary. Instead, founders should focus on using virtual networks to connect with prospective investors, customers, strategic partners and influential industry experts; use social media tools to create buzz around their ideas; and use electronic copies – whenever possible – to share information.

Why is a virtual network important to a startup?

One of the most common things I hear from venture capitalists and startup company investors is that the best way for an entrepreneur to get his executive summary read is to have it sent electronically by a "trusted" connection. That means the venture capitalist (VC) is much more likely to review a business plan executive summary or investment slide presentation when it is sent by someone that the VC already knows. So a startup entrepreneur needs to somehow meet the people who already know the VCs.

A virtual network offers incredible efficiencies over face-to-face networking as a way of meeting people who will be able to help fund and grow your business. By using virtual networks, it only takes minutes to make the connections. This same process could take days of phone calls or weeks of emails and replies to get the important introduction to the person you are trying to meet.

What tools are available for building this virtual network?

By far, the most common tool for building virtual business networks is LinkedIn *(www.linkedin.com)*. This Web site allows you to make professional connections and then search your virtual network for people who may be two or more degrees separated from you. Some people also choose to use Facebook for professional networking. The concept is the same but the process may not be as efficient, since you may have to wade through friends and family members to find the business contact you want.

What other tools and tips can an entrepreneur use to connect with difficult-to-reach investors?

While most startup investors can't always read all the unsolicited business plans they receive via email, there are a number of ways to electronically communicate with potential investors. A small but growing number of VCs and professional angel investors are using blogs and podcasts to share their thoughts about their profession and provide advice to entrepreneurs. So while a blog can seem like a one-sided conversation, I suspect that VCs probably read the comments section on their blogs more closely than unsolicited email. An insightful comment to a blog post may make a good impression that will get your email read the next time. You can also follow many VCs who have created Twitter accounts. Using the @username + message, your message may also be read by the VC. Some VCs have even joked about soliciting business ideas via Twitter using the service's 140-character limit. (Talk about a short pitch!)

How can a startup build buzz?

Blogs, Web sites, and Twitter accounts are not just for the investors. Networked startups can also use these tools to create interest and excitement about their company or their new products. Feedback on Web sites and blogs can also be a great way to hear what people are saying about your products or ideas. Entrepreneurs can try all these ideas for very little money. If you want professional help, all successful public relations firms now have advisors who are adept at using social media strategies to ensure the right message gets the maximum exposure.

What about old fashioned, face-to-face networking?

Even in the age of LinkedIn and Twitter, face-to-face networking is still important. However, many of the things you learn using social media can apply to your face-to-face networking: keep your pitch short, ask for feedback and ask for additional introductions.

These tips should help entrepreneurs create, use and leverage their social networks to help grow their businesses. If you want to discuss these in more detail, please drop me an email or stop by my office in Calit2. Better yet, you can follow me on Twitter (user name Luis_Vasquez) or look me up on LinkedIn.

Good luck!

Protective Impact

New study finds patent system may hinder innovation

by Lori Brandt

"The patent system added the fuel of interest to the fire of genius," said Abraham Lincoln in 1859, expressing the day's convention that patents fostered innovation.

Bill Tomlinson: Is the patent system effective?

Today, more than two centuries after the U.S. patent system was established and millions of patents later, many people still assume patent protection spurs new technology and economic growth.

"It's unorthodox to question the fundamentals of a system that has been in practice for hundreds of years and is even written into our Constitution," says Bill Tomlinson, a Calit2 affiliate and UCI informatics associate professor.

But that's exactly what Tomlinson's old friend Andrew Torrance of the University of Kansas School of Law wanted to do. He wasn't sure how to go about it though, so he turned to Tomlinson for help. Together, the interdisciplinary duo devised a way to test the assumption.

Playing with Patents

Tomlinson and Torrance, assisted by UCI undergraduate Bryant Jones, created an online simulation multiplayer game called PatentSim, which mimics the

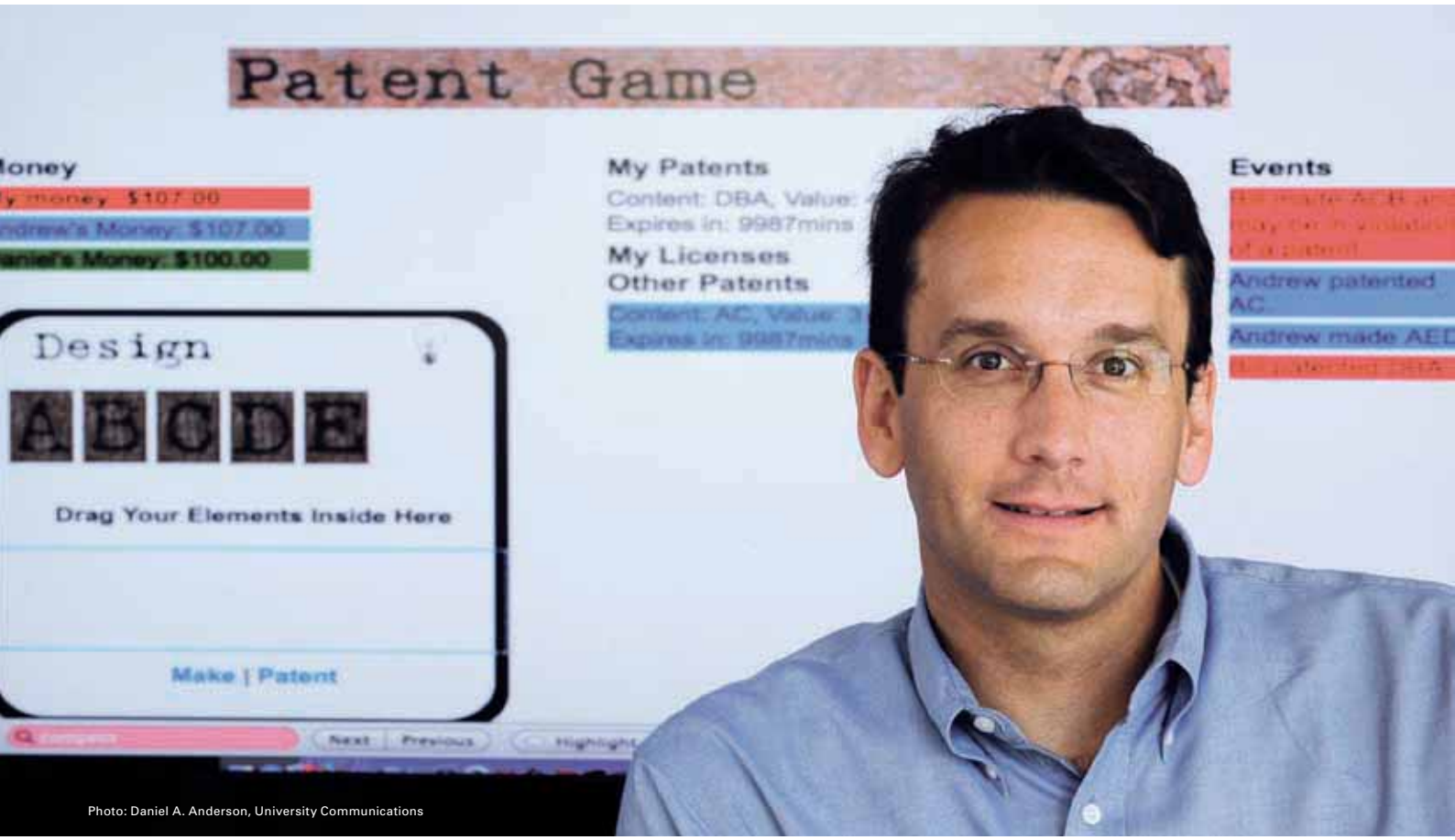


Photo: Daniel A. Anderson, University Communications

patent system. After groups of first-year law students played it online, results indicated that the patent system may actually stifle innovation.

The game features an abstract model of the innovation process, a database of potential innovations and a network through which players can interact with one another to license, assign, buy, infringe and enforce patents. The inventions on PatentSim are various combinations of five letters. The goal is to make money. The researchers conducted trials under three different modes of play and compared them. In one model, players created innovations under a traditional patent system; in another, players used a "commons" system with no patent protection; and in the third, both patents and open-source protection were available.

"In PatentSim, we found that participants were more likely to innovate when there was no intellectual property protection at all, or when they could open-source their innovations and share them with other people," says Tomlinson. "The study showed innovation, productivity and wealth all increased under a commons system."

The findings surprised Torrance, a patent attorney as well as an academic. He believes the debate about the effectiveness of the patent system should be intensified.

Real-Life Practice

Intellectual property law expert Dan Burk of the UCI School of Law says the success of the patent system is mixed. In his book "The Patent Crisis and How the Courts Can Solve It," Burk reviews a growing body of data showing that patent protection works differently in different industries. Of the PatentSim study, he says: "Simulations offer an important indicator as to where we should begin research on actual practices. It's important to remember that the study does not directly tell us anything about the patent system, but instead offers some interesting results from a simulation with incentives modeled on the patent system. This could have significant implications for further real-world research."

> **"Simulations offer an important indicator as to where we should begin research on actual practices."**

Michael Guiliana, a partner with Knobbe Martens, one of the largest intellectual property law firms in the nation, played a round of PatentSim, but was not convinced it could predict the system's effect on innovation. "In the game, there were no costs for research and development with a new product or for bringing it to market. Patent systems are designed to provide … a reasonable expectation that investors can achieve a substantial return on investment. My general sense is that the patent system is effective at spurring innovation."

An important component of Calit2's mission is to encourage technology transfer and speed commercialization of research discoveries. Universities are the source of many of today's innovations. The University of California has received the most U.S. Patents of any university in the world. UCI alone filed for 202 patents in the last three academic years.

Open source innovation advocate Eric Von Hippel of MIT thinks the patent system should be eliminated entirely. "PatentSim is a new, creative and interesting approach," says Von Hippel. "Multiple approaches to an important question like this one are always a good idea."

Fundamental Debate

Disagreement over the patent system's effectiveness is not new. Thomas Jefferson, one of the founding fathers of the system who served as the first patent examiner, was originally philosophically opposed to patents. He felt that all should have total access to new technology, which is why he never took out patents on his own inventions.

Tomlinson, who plans further variations of the game, notes that this type of research is only possible due to recent advances in Internet technology, mainly an open-source Web application framework called Ruby on Rails. "It opens up all kinds of possibilities to evaluate real-world practices," he says.

"This is one of the great advantages of working at Calit2. Not only is interdisciplinary research fostered, but we are able to incorporate the newest information technology in our research with the goal of developing innovative services to benefit society.

"As academic researchers, we have the freedom to pursue questions like this one, regardless of the outcome," says Tomlinson. "This study suggests that the patent system may not be working the way it was intended."

FUNDING NOTES

by Stuart Ross

We've Got it Covered

Networks have parts and connections; they also have applications and resulting social effects. In every case, Calit2's grant-getters have secured funding for their research.

Antennas are important parts, for example. Of course a cell phone needs an antenna to join the network, but you hardly see the antennas anymore – in most new cell phones and radio devices, the antenna is incorporated inside the phone as part of the circuit board or similar structure. An internal antenna confers great advantages for convenience, durability, manufacturing and appearance, but communication problems can result. For example, when the antenna is so close to the other components, absorption into the materials of the circuit board and interference with the circuitry occur. The **Semiconductor Research Corporation** recently awarded **$100,000 a year, for two years**, to a team of two Calit2 researchers to support their new approach to the problem. **Filippo Capolino** and **Payam Heydari** are studying new designs for layers of material that would decrease absorption losses, thereby substantially increasing antenna efficiency. Because the SRC is a joint venture of several major manufacturers, SRC awards go to projects that are a high priority for industry, and the results are very likely to see commercial applications.

Managing all the traffic in a network is a complex task for which scholars are still trying to find better rules and algorithms. **Athina Markopoulou** received an award this summer to study the real-time management of computer networks. Her **$360,000** project is a subcontract under an **Air Force** award to Princeton University that will investigate several kinds of network

management problems. Markopoulou's expertise will be applied to developing some of the tools. Network management usually occurs in the absence of full information, often without prior knowledge of schedules and structures, by sampling information flows and devising management protocols. As an expert on 'network coding,' an emerging approach that uses intermediate nodes in a network to aggregate and trace packets of information, Markopoulou will be able to develop more effective ways to sample the flows and to infer the current topology of the network.

Most wireless networks are designed around fixed points for transmission and reception, like radio towers and cell phone towers, through which all the devices communicate. On a battlefield, or at the scene of a major disaster, though, such structures may be damaged or non-existent, so the computers and radios brought to the scene have to organize themselves into an 'ad hoc' wireless network. Such networks usually also have more unpredictable patterns of interference than fixed networks. Yet the devices used for ad hoc networks typically have less power for transmission or signal processing and they need to adjust to different communication protocols. The **Boeing Company** awarded **$1.5 million** over three years to **Homayoun Yousefi'zadeh** and **Hamid Jafarkhani** to improve software design that can address these issues for mobile ad hoc networks (MANETs).

Networks also can be used to control energy usage in a community. **Southern California Edison** has awarded **$2 million** to UCI to network the campus community as a living laboratory for studying the use of renewable energy and energy efficiency. UCI is like a small city, with offices, residences, businesses, traffic lights and its own power plant, so it provides a realistic case study. Some university labs, office buildings and residences will be equipped with sensors and connected to a smart grid network that will measure and control energy consumption; solar and other renewable energy sources will be applied to the grid. UCI's **Advanced Power and Energy Program,** headed by **Scott Samuelsen**, has expertise and good energy-technology industry relations; it will serve as the campus's lead organization. Calit2 will provide experience with monitoring and networking multiple buildings as a result of its work on the use of IT in emergency management.

Discussions of future workspaces often include the idea of multiple devices networked into one environment. **Aditi Majumder** recently earned a grant of **$632,000** from the **National Science Foundation** for her plans to network visual displays in a workspace with data sets, objects and human participants. She has already made notable progress toward this goal in the Calit2 Visualization Lab, using several ordinary projectors working together to project huge images on a variety of different surfaces. Now, with the five-year "CAREER" grant, Majumder will explore a broader approach, in which visual displays are active members of the workspace, capable of interacting with data, human users, the environment and other displays. She will develop software that networks projectors, cameras and computers into a collaborative workspace. This project, which will include gesture-based interaction systems for mobilizing data for scanning, storing and interacting with life-size image-like representations, offers the prospect of higher resolution and more capability, at a lower cost than is currently available.

Everyone knows e-mail networks and the Internet contribute to maintaining personal connections, but clarifying and defining that effect has been difficult. For example, how do cultural attitudes affect the use of electronic media to maintain long-distance personal relationships in countries where Internet use is not yet ubiquitous? **Paul Dourish** and **Irina Shklovski** were awarded **$500,000** from the **National Science Foundation** to conduct three-year longitudinal ethnographic studies of people in Kazakhstan and Russia. Shklovski, a native Russian speaker, has first-hand knowledge of those cultures, and she designed most of the field work. Both scholars have long-held interests in the interactions of mobility, technology and social relations. Shklovski was a postdoctoral researcher at Calit2 until August, when she was chosen for a position as assistant professor at the IT University of Copenhagen.

[Bits and Bytes]

by Shellie Nazarenus

Engineers Explore and Enjoy

Indian and American engineers found common ground at Calit2 as they familiarized themselves with each others' research and explored potential collaborations. The third **INDO-U.S. Workshop on Fabrionics** took place in June, featuring speakers from advanced manufacturing and funding agencies. Fabrionics, also known as microfabrication, includes futuristic manufacturing techniques for micro- and nano-components. The workshop also included a student-organized poster session and round-table discussions. At the end of the first day, participants were treated during a networking reception to a performance orchestrated and directed by Calit2-affiliated professor Lisa Naugle, whose research melds technology with dance. "A Celebration of Styles" featured a range of genres, including Indian classical, modern, ballet and break dancing.

Robotic Jacket Inspection

Rehabilitation after a physical setback can be a long and tedious process but lately, the medical community has turned to technology to assist in the recovery. A team of six Calit2-affiliated researchers has been awarded funds from a division of Panasonic – **Panasonic Shikoku Electronics Co., LTD** – to evaluate the company's power jacket, a robotic prototype designed to give power assistance to those with disabilities. The six researchers are studying the possibility of helping partially paralyzed patients regain their sense of motion. The multidisciplinary team, which includes expertise from the schools of medicine, social sciences, engineering and computer sciences, is assessing various aspects of the device, which is being housed in Calit2's Robotics Lab for a three-month study period.

A Legislative Lesson

Calit2 continues to be an important stop for state and congressional leaders who want to learn more about the educational and economic impact of the institute's research projects. In June, **Diane Harkey, state assemblywoman** from Dana Point, visited the campus to learn more about graduate education and research. Harkey and her chief of staff, Jeffrey Corless, visited the Wireless Sensor Lab, where doctoral candidate Mark Merlo demonstrated bionic and assisted technologies that he is helping to develop. UCI alumna Harkey gave her enthusiastic support, saying, "It's always great to be back on the campus. The young energy is contagious and I look forward to working together as we expand Orange County's and Southern California's reach in the biotech industry." Harkey's visit was followed in August by **Congresswoman Loretta Sanchez's education analyst, Jessica Fernandez**, who viewed several projects in the building, including the HIPerWall.

The State of Calit2 in 2009

The **Calit2 Advisory Board** welcomed new members when the group met in late July. The 16-person board comprises representatives from across the nation in industry, venture capital, policy and academia. This year's meeting, held at UCI, focused on the state of Calit2 and its future challenges and goals. Utilizing a new zooming presentation tool, institute Director Larry Smarr creatively displayed Calit2's past research activities in a forward-thinking format. Four theme areas were discussed: health, energy, environment and culture. Board members were apprised of the activities underway in each area, ranging from academic and industry participation to technology developments and research success stories. "I've really learned a lot in two days about Calit2," said new board member David Schramm, CEO of Maxwell Technologies. "I found this to be a very productive meeting and encourage the institute to consider its value proposition…who can you jump in front of and get them to say, 'I need what you are doing.'"

Anteaters Dig Technology

With the Calit2 building as their setting, **UCI alumni** got down to business, including the installation of new officers, during their annual board meeting in June. After work, came play. Director G.P. Li welcomed association members by giving them a brief overview of the institute and encouraging them to spend the rest of their evening touring the many labs and research projects. "Consider us your vacation spot," he quipped. The 50-plus attendees explored the building's first and second floors, finding plenty of opportunities to experience the technology. Whether dancing in the eMedia studio's Active Space or viewing extraordinary images on the HIPerWall in the Visualization Lab, the Anteater alums were energized. "Calit2 technology definitely blew away our attendees," noted Alumni Association Associate Executive Director Michelle Williams. "Not only did they learn about some of the very cool projects underway, but they had so much fun getting to 'play' in some of the labs."

Semiconductor Leader Makes a Stop

Representatives from **Broadcom**, interested in learning more about Calit2's projects in e-health and wireless sensor technologies, paid a visit to the institute in May. Headquartered in Irvine, Broadcom is a global leader in semiconductor technology for wired and wireless communications. The group spent an afternoon learning about the breadth and depth of the institute's research, including viewing demonstrations of technologies that are being field-tested. Professor Maria Feng's research team demonstrated its wireless sensor devices that can monitor the health of buildings, bridges and civil infrastructures. Delegation members expressed their delight in seeing innovation going from lab to deployment, and are investigating a number of collaborations.

High Marks from Education

Information technology solutions to complement the elementary and middle school learning experience brought not one but two visits from representatives of the **Orange County Department of Education.** A team of instructors came early in the year to learn more about Calit2 gaming projects targeted at a young audience. During the visit, the group was also introduced to low-cost interactive technologies that could be easily deployed in schools to connect distant classrooms. That prompted a second delegation of education technologists led by **OC School Superintendant Bill Habermehl.** Facing deep budget cuts, the public school leaders were keenly interested in projects such as Telios, which offers a user-friendly, real-time teleconferencing platform that can be inexpensively connected to any computing device.

International Intrigue: Technology Connects a Global Village

The summer months were filled with visitors from several continents, including those with established Calit2 project collaborations and those who are exploring the possibilities.

A team from **Universidad Europea de Madrid** learned more about the institute's research in healthcare technologies and assisted living devices in hopes of finding common ground for a partnership. The team also asked to see the HIPerWall, led by lab manager Steve Jenks, which is gaining world-wide recognition and implementation.

A group from Australia with established ties with Calit2 San Diego came to Irvine in August to better understand the Irvine division's research activities and building infrastructure. With a $175 million initiative, the **Monash University** delegation will be opening a research and development facility in 2012 that will integrate faculty researchers with experts from CISRO, Australia's national science agency, and industry. Group members documented their visit, taking pictures and notes of research spaces that may be similar to ones in their new building, such as the Wireless Sensor Technology Lab, where engineering professor Pai Chou has one of several projects.

Two Korean delegations with formal agreements with UCI also made stops at Calit2. A delegation from the **Center for Digital Industry Promotion** in Daegu City, Korea got an update on the status of the three-year, $1.3 million grant the agency has with researchers in the Game Culture and Technology Lab. Various game projects were demonstrated, including Pixel TV led by researcher Garnet Hertz. This project reuses 64 discarded televisions, converting them into a giant video game, with each television used as a single pixel in the style of a low-resolution 1970s-style LED-based game system.

UCI Vice Chancellor Susan Bryant hosted a visit in late July from Dr. Mooyoung Jung, vice president and provost for academic affairs at **Ulsan National Institute of Science and Technology (UNIST)**. The Korean institute, which opened last March, is establishing partnership programs with world-leading science and technology centers. After exchanging information about UNIST and UCI, the respective campus leaders signed a memorandum of understanding in a Calit2 ceremony to further explore education and research activities.

Power Hungry Solution

One hundred fifty researchers, faculty and students from industry, government and academia convened at Calit2 for the **Smart Grid Research Symposium**, sponsored by a consortium that included Southern California Edison, UCI, USC, Caltech and UCLA. Participants brainstormed about how to create the next-generation grid that uses the power of information technology to track consumer use of electricity, raise and lower rates during peak and non-peak times and incorporate distributed power generation into its system. The symposium was covered by KOCE-TV, which interviewed several of the participants and session leaders, including Scott Samuelsen, director of UCI's Advanced Power and Energy Program, and National Fuel Cell Research Center.

Growing Corporate Ties

Canon, already familiar with one research project in the Calit2 building, returned in mid-August to view other activities. A year ago, the company donated equipment to the multi-projector display project in the Visualization Lab. The visit this summer included senior engineers and product developers as well as Yoshinori Ikeda, the president of **Canon Development Americas, Inc.** The group made many stops, including one in the Wireless Sensor Technology Lab, where professor Pai Chou demonstrated the tiny, MEMs-based sensors his team is developing for a variety of applications.

Healthcare Collaboration a Heartbeat Away

With UCI developing a telemedicine training facility and opening a new hospital, collaboration between Calit2 and health sciences has been percolating. Late last spring, Ralph Clayman, School of Medicine acting dean, hosted a **brainstorming-and-dinner session** at the medical center in Orange. A group of Calit2 researchers shared with physicians what healthcare-related technologies they were working on, and in turn, the physicians explained their needs and the types of IT-solutions they wished for. That led to round two, when the doctors made **a house call to Calit2** to experience the prototypes first-hand. Among the projects demonstrated was the new Telios platform for user-friendly, real-time telemedicine applications. "I was amazed by the sophistication of the technology available, and by the innovative ideas for its use," said Anne Tournay, associate clinical professor in pediatrics. "The home telemedicine system was of particular interest, as it was exactly what I've been looking for to use in a research proposal."

A Clean Energy Challenge

Energy independence has been a dominant theme for the Obama administration, which is promoting clean and renewable alternative energy sources, including solar and wind power, biofuels and fuel cells. Calit2-affiliated researchers are on pace, developing novel technologies to advance sustainable systems. A record crowd gathered last May to learn more about these advances as part of the ongoing **Igniting Technology** presentation series. Five panelists from the research and investment sectors presented clean energy challenges and market opportunities. Michael Guiliana, a partner at intellectual property law firm and event co-sponsor Knobbe, Martens, Olson & Bear, moderated the presentation, singling out Calit2 for its success in launching new technologies into the marketplace. "Calit2 is fast becoming one of the finest university-backed incubators in the country," he said.

Picturing the Possibilities

A team from **Disney Imagineering** spent a day last summer visiting Calit2's Visualization Lab. The group is particularly interested in the multi-projector display project led by professor Aditi Majumder. Her research team is developing camera-based calibration techniques and custom software to produce realistic, high-resolution, seamless displays at much lower cost than what is commercially available now. The researchers use inexpensive projectors to produce realistic images, and that is something the Disney team is interested in exploring further for various applications. "What we are working towards is a completely self-sufficient unit that you can purchase at low cost from a Best Buy-type store and create an amazing do-it-yourself display system," said Majumder. The initial visit by Disney has led to further collaborations with the research team.

Photo: Goran Matijasevic

Li Honored for Leadership

The Asian Business Association of Orange County (ABAOC) named Calit2 Director G.P. Li an outstanding Asian American and Pacific Islander Community Leader and Role Model. He was among 14 honorees singled out in May for their dedication to diverse communities. "I'm proud to be included among such a distinguished group of business and community leaders," he said. Li received his award in conjunction with the **Asian Pacific American Heritage Month** celebration. ABAOC was founded in 1992 as a non-profit organization serving and assisting the needs of growing Asian American businesses in Orange County.

The California Institute for Telecommunications and Information Technology is a two-campus multidisciplinary research institute. In collaboration with its sister institute at UC San Diego, Calit2@UCI develops innovative projects that integrate university expertise with industry experience. The result: IT-based solutions that benefit society and ignite economic development.

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WoW

ART ECHOES CULTURE

Avid video gamers can develop complicated connections with their avatars. A 2x12-ft. lightjet digital depiction of this relationship by Calit2 affiliate Antoinette LaFarge was displayed last summer at the Laguna Art Museum in Laguna Beach, Calif. The exhibit paid tribute to an international game sensation. "WoW: Emergent Media Phenomenon" explored cultural production spawned by World of Warcraft® and emerging artistic practices influenced by game culture.

LaFarge's "World of World: The Adventures of Malbec and Player" examines the player/avatar relationship from the avatar's point of view, while also portraying the male gamer and his female avatar as a split personality.

LaFarge, and fellow Calit2 affiliates Robert Nideffer and Alex Szeto, were among 14 international artists selected to participate in the event.

"I think the show was significant because it brought together work made for the commercial game industry, which is a very restrictive world, with work made by artists with widely differing points of view about the game itself," LaFarge said.