New Faces at CUCS

The impact of huge data sets is hard to underestimate, responsible for advancing almost every scientific and technological field, from machine learning and personalized medicine, to speech recognition and translation.

The flip side of the data revolution is that massive data has rendered many standard algorithms computationally expensive, necessitating a wholesale rethinking of even the most basic computational methods. To take one example: Nearest neighbors search, the classic method since the 70s for finding similarity among objects, is straightforward for small data sets: compare every object to every other one and compute their similarity for each pair. But as the number of objects increases into the billions, computing time grows quadratically, making the task prohibitively expensive, at least in terms of traditional expectations.

Alexandr Andoni, a theoretical computer scientist focused on developing algorithmic foundations for massive data, sees the need to reframe the issue: “The question today is not ‘what can we solve in polynomial time?’ but ‘what is possible in time proportional to data size, or even less?’ With all this data, what is the best we can do given the resources? Fortunately, vast improvements are possible in both theory and practice once we settle for approximate answers.”

Rather than searching an entire data set for the single most nearest neighbor, a search would go much faster if objects were pre-grouped according to some shared attribute, making it easy to zero in on just the small subset of objects most likely to contain the most similar neighbor. The new challenge then becomes: what attribute shall we use to make such a pre-grouping maximally efficient. The speed-up thus gained reverberates across a wide range of computational methods since nearest neighbors search is ubiquitous and serves as a primitive in higher-level algorithms, particularly in machine learning.

More generally, in the same spirit of relying on (approximate) attributes to speed operations, Andoni has developed a theory of sketching that represents complex objects by smaller,
Institute. His research is directly from across the university and Valley, which closed in 2014. One continually re-examining and time by using data-dependent, problem (in papers published in decades-old problems and solve objects yet use less (sublinear) and subversion, Jana wants to protect security and privacy. Especially in terms of privacy and security. A paper he co-authored, "Human Computer Interaction and Perception systems. "Wu wants to develop mod- els of human perception that are both human--computer and psychology, literature, and applied database research in visualization system performance. On the visualization side, less attention has been paid to the programming languages (like JavaScript) used to construct the visualizations. Consequently, the visualize and interact with the data; but the invention of SQL, a high- level, declarative language, made it easier for developers to express relationships in the database. Without having to worry about the underlying data representa- tions, payments can be processed today's ubiquitous use of data.

For Wu, the natural progression is to extend the declara- tive approach to interactive and automated analysis. As an example, a high-level approach to querying data at Berkeley and University of Washington, Wu is designing a declarative analysis tool that would free programmers from implementation details so they can focus on modeling the problem while letting the database figure out the best way to do it.

A declarative language for visualization would have ad- ditional positive benefits. "Once you have a high-level language capable of expressing analyses, all of these analysis tools such as the explainability and graphical user interface is in a sense baked into whatever you build; it comes for free. There will be less room for individuals to write their own ad hoc analysis programs." As interactions become portable and accessible to everyone, past and passed from one interac- tive visualization to another for collecting and analyzing data becomes easier to build and瑜, Wu's focus is on making database access and understanding to all users. "When a diverse group of people has access to data, the questions you get are more interesting than if just one or two computer science or business people are asking questions." A major improvement in coming to Columbia is the chance to work within the Data Science Institute and collaborate with researchers from across the university, all sharing ideas and working with the same data. "Columbia has a huge range of leaders in nearly every data science field, from computer science to Bioinformatics to Government studies. Our use of data isulti- mately driven by the applications built on top, and I'm excited about working on research that can help improve and benefit from the depth and breadth of research at the university."
Cover Story (continued)

Paul Blaer
Lecturer in Discipline

Columbia this fall promoted Paul Blaer from adjunct professor to Lecturer in Discipline, a full-time faculty position that makes teaching Blaer’s primary focus, something he’s wanted for a long time. Hiring Blaer full-time is not exactly a stab in the dark for Columbia where Blaer is a well-known quantity. Since he was 3, he has been floating around campus. His father is physics professor Allan Blaer, who did both undergraduate and graduate work at Columbia and who—after teaching stints at Princeton and Swarthmore—returned to Columbia where his son would likewise attend as both undergraduate and graduate student.

Paul Blaer did his PhD research in the area of mobile telecommunications and 3D vision, working in Peter Allen’s lab. It was there, while a grad student leading lectures, that he got his first taste of teaching. He knew immediately that teaching was what he wanted to do. “For him, it was the fun stuff, a chance to engage with students, to think interactively, my own way and to keep the material fresh and interesting,” says Salleb-Aouissi.

With teaching in mind, Blaer originally planned to seek a position at a small four-year college, but the combined draw of Columbia and New York City proved strong, and Blaer, knowing Columbia as well as he did, figured someday a teaching opportunity would open up. Until it did, there were other ways on campus for him to contribute. In Allen’s lab Blaer had been doing systems work: his skills for controlling his own computing environments scaled up for a large number of users—what led to a full-time position at Computing Research Facilities (CFR), processing large part-time advising. For seven years now, Blaer has been teaching introductory computer science classes part-time while working at CFR full-time to help faculty design and build backend systems for all types of research projects. With his new position, the mix gets recalibrated: teaching becomes full-time and CFR part-time.

“I’m thrilled to be working full time with students here at Columbia. It’s the best of both worlds: a large university environment with highly motivated students, yet like a college where I have the direct interaction with the students, which is the favorite part of my job,” says Blaer.

Blaer knows the classes, the students and faculty, the projects, and how the computer systems are set up; in a department that relies so heavily on systems, that’s better than knowing where the bodies are buried. He’s involved also in the administrative aspects that touch on teaching: he is Director of Undergraduate Studies for BS Programs and is active in the Science Honors Program for area high-school science and math students.

Deep institutional and systems knowledge is well and good, but a lecturer first and foremost has to be able to teach. Blaer has that angle covered especially well as someone who has been teaching about teaching, he pays attention to what resonates with students and what doesn’t, and strives to keep his lectures engaging, using humor and real-life stories from his own research to keep students interested. That he succeeds is clear from student comments on the Columbia Undergraduate Listing on Teacher Abilities (CULTA) site, where Blaer has earned a silver nugget for his teaching and approachability.

“We’re thrilled to have Paul join the faculty full-time as a lecturer. The department has been looking for someone with both the skills and expertise to lead and build courses, and we are very pleased to have him,” says Vincent Salleb-Aouissi, chair of the Computer Science department.

The increasingly data-centric approach in all aspects of science and technology means students need to learn what algorithms and methods can stand up to the immense scale of today’s data sets. Teaching computer science from the perspective of large data sets is the job of Ansaf Salleb-Aouissi. A data scientist from before the term predictive in nature, forecasting when power-grid failures are likely to occur in one case, and in another predicting which expectant mothers are most, or least, likely to deliver preterm. In this last example, Salleb-Aouissi, with support from the National Science Foundation Smart and Connected Health program, used advanced machine-learning methods to vastly expand the number of risk factors to be considered, including socio-economic, psychological and behavioral factors.

Precision is also at the heart of her most recent (and current favorite) project: a web browser optimized for self-learning. “We want to create a personalized self-learning experience by sifting through huge numbers of search results to identify and return those customized for student’s learning preferences—whether they be videos, books, blogs—and that also fit within the student’s short or long time constraints. The challenge here, as it was with the preterm study, is making all these different and heterogeneous resources work together in a system. It’s an ambitious project and I am very excited to work on it. More so because it is a link between my research and my teaching.”

Though research forms the bulk of her recent work, teaching has also been a component. As a PhD, she worked as an adjunct professor at the University of Orleans and discovered how much she enjoyed interacting with students. She would have gladly accepted the position of assistant professor except for her plans to eventually move to the US. Instead she took the offer of a Postdoctoral Fellowship at the prestigious research lab at INRIA (French National Institute of Computer Science and Control) at Rennes, France. There she did more fundamental investigation of new algorithms, particularly new methods for quadratic association rules, but also for frequent patterns matching, ranking, ranging and action recommendation.

While still at INRIA, she ap- plied to the CCLS for an open position. Though that position filled quickly, David Waltz, then director of the CCLS, took note of her INRIA fellowship and her growing publications list and contacted her. She left her current position came up. She and Waltz later collaborated on a number of papers and projects. “Dave smoothied my transition to the CCLS and helped make it an enriching experience where I could grow and learn, I will always be grateful to him.”

Once settled in at the CCLS, she was able to get back into teach- ing, adjuncting in the Computer Science department, teaching courses in data science, discrete math, and artificial intelligence. As a lecturer, teaching will now be her primary focus, but she will continue doing research, which will now serve a double purpose. “I like to deliver my lectures in an engaging and interactive way, my way and to keep the material fresh and alive so students actively absorb it rather than just be passive recipients. My own research may serve to give students a peek into what you can do with computer science, and I hope that can motivate the spark their interest so they learn now so they can do later.”

Allison Bishop
Assistant Professor
Columbia Computer Science Department

Allison Bishop has been awarded a five-year $500,000 National Science Foundation (NSF) CAREER award to develop tools for designing and proving the security of new cryptographic systems.

Allison Bishop, an assistant professor within Columbia’s Computer Science Department and a member of the Data Sciences and Engineering faculty, has been awarded a five-year, $500,000 National Science Foundation (NSF) CAREER award to develop tools for designing and proving the security of new cryptographic systems. The CAREER award is the NSF’s most prestigious honor designed to support junior faculty who exemplify the role of teacher-scholars through their outstanding research, excellent teaching.

With the award, Bishop will build on her current research into provably secure cryptographic systems that can accommodate various levels of access to data, thus allowing different people to access different data within the same data source. The need for fine-grained control over data access has never been greater as vast amounts of sensitive data have to be simultaneously shared and protected, such as when a hospital needs to see almost all of a patient’s data but an insurance company needs to see only what procedures have been done. Achieving more nuanced cryptographic capabilities means also enhancing the mathematical foundations that support such capabilities so that security at each level can be achieved in a provable way.

For this, Bishop is looking to inte- grate recent advances in lattice cryptography with her previous work in designing security reductions.

Bishop will also use the award to provide an entry point and learning material for emerging young scientists of all ages, giving advanced graduate classes a more integrated view of cryptographic system design principles, while spanning valuable research opportu- nities to students at both the undergraduate and graduate levels.

Allison Bishop Wins NSF CAREER Award

Allison Bishop’s work focuses on provably secure cryptographic systems that can accommodate various levels of access to data, allowing different people to access different data within the same data source. The need for fine-grained control over data access has never been greater as vast amounts of sensitive data have to be simultaneously shared and protected, such as when a hospital needs to see almost all of a patient’s data but an insurance company needs to see only what procedures have been done. Achieving more nuanced cryptographic capabilities means also enhancing the mathematical foundations that support such capabilities so that security at each level can be achieved in a provable way.

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The educational outreach aspect extends to students of elementary-school age, for whom Bishop is producing a book that uses a fairy-tale set- ting to introduce mathematical reasoning. Motivating others will help ensure faster progress towards a flexible and more unified theory of cryptography to defeat the mounting chal- lenges of huge data sets, cloud computing, and other emerging data systems.

Linda Crane

NSF CAREER Award

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Linda Crane

NSF CAREER Award
Steve Bellovin Named First Technology Scholar by the Privacy and Civil liberties Oversight Board

Computation Science Professor Steven Bellovin has been appointed the first Technology Scholar by the Privacy and Civil Liberties Oversight Board (PCLOB). A nationally recognized expert in technology and network security, Bellovin has examined technology and its privacy implications throughout his career. “I’m delighted to be joining PCLOB,” says Bellovin. “Modern intelligence agencies rely heavily on technology; many of their classifications are based on software. My role will be to help the Board members understand these mechanisms and their implications.”

Bellovin has taught computer science at Columbia since 2003. During more than 20 years at Bell Labs and AT&T Labs Research, he focused on network security, firewalls, protocol failures, routing security, and cryptographic protocols. He is a member of the National Academy of Engineering and the Computer Science and Telecommunications Board of the National Academies. He has served on the Science and Technology Advisory Committee of the U.S. Department of Homeland Security, the Technical Guidelines Development Committee of the U.S. Election Assistance Commission, and as Chief Technology Officer of the Inter-Trade Commission. He also has authored numerous publications and has received awards and national recognition for his work. He holds a B.A from Columbia University and an MS and PhD in Computer Science from the University of North Carolina at Chapel Hill.

In announcing the appointment, PCLOB Chairman David Medine said, “I am pleased that Professor Bellovin will be joining our team as our first Technology Scholar. His vast knowledge and significant expertise in both the private and public sectors will be of great benefit to our agency’s mission to ensure that the federal government’s efforts to prevent terrorism are balanced with the need to protect privacy and civil liberties.”

The PCLOB is an independent agency within the executive branch established by the Implementing Recommendations of the 9/11 Commission Act of 2007. The five-member Board is appointed by the President and confirmed by the Senate. The PCLOB’s mission is to ensure that the federal government’s efforts to prevent terrorism are balanced with the need to protect privacy and civil liberties.

Vishal Misra Named IEEE Fellow

For contributions to “network traffic modeling, congestion control and Internet economic laws.”

Vishal Misra has been named a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), the highest grade of membership. Misra has actively participated in the public debate, contributing articles and interviews to leading media outlets. Earlier this year, he appeared before the Indian Parliament to present his views on zero rating, a policy contrary to network neutrality.

Misra’s opinions and expertise are sought not only for his rich technical research, but also for his real-world experience building Internet-based businesses. While still a graduate student, he co-founded the sport website Crickinfo (acquired by ESPN in 2007); more recently he founded the data center storage startup Infinio.

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Three Columbia Engineering Professors Win Sloan Fellowships

Three Columbia Engineering professors—Matel Ciocarlie (Mechanical Engineering), Roxana Geambasu (Computer Science), and Daniel Hsu (Computer Science)—have won 2016 Sloan Research Fellowships. They are among 126 outstanding young scientists and scholars announced by the Alfred P. Sloan Foundation.

Awarded annually since 1955, the Sloan Fellowships honor early-career scientists and scholars whose research has potential to identify them as rising stars, the next generation of scientific leaders. The 2016 fellows, who receive $50,000 to further their research, have been drawn from 62 colleges and universities in the United States and Canada, and represent a wide range of research interests.

Matel Ciocarlie’s research is focused on developing versatile manipulation and mobility in robotics, in particular on building dexterity into robotic hands, and he sees robotic manipulation in unstructured environments as a critical research area. “We aim to discover how artificial mechanisms can interact with the world as skillfully as biological organisms,” he notes. So far, robotic applications that have had significant impact (especially in industrial domains) have been done by being fast, precise, and tireless. In order to advance to less constrained domains, robots need to become more versatile and learn to handle variability, or be more intelligent in the environment interaction. “True dexterity in interacting with the world will play a role in the more general problem of developing cognitively advanced computers and machines,” Ciocarlie adds. His Robotic Manipulation and Mobility Lab is working on a range of applications, from versatile automation in manufacturing and logistics to mobile manipulation in unstructured environments to assistive and rehabilitation robots in healthcare. He is a member of the Data Science Institute and has numerous prestigious honors, including the 2013 IEEE Robotics and Automation Society Early Career Award, a 2015 Young Investigator Program grant from the Office of Naval Research, a 2015 NASA Early Stage Innovations grant, and a 2016 CAREER Award from the National Science Foundation.

Computer Science Professor Roxana Geambasu is working to ensure data security and privacy in an era of cloud computing and ubiquitous mobile devices—technologies upon which billions of users rely to access and host sensitive data and which have become easy targets for theft, espionage, hacking, and legal attacks. Our mobile devices are packed with confidential information under operating systems that never securely erase data. And at the other end, cloud services do not automatically accumulate endless logs of user activity, such as searches, site visits, and locations, but also keep them for extended periods of time, mine them for business value, and at times share them with others—all without the user’s knowledge or control. Geambasu, a member of the Data Science Institute, is working to identify the security and privacy risks inherent in current mobile and web technology and designs, and constructing systems to address those problems. Her research spans broad areas of systems research, including cloud and mobile computing, operating systems, and networks, as well as areas with a focus on security and privacy. She integrates cryptography, distributed systems, database principles, and operating systems technology and works collaboratively in developing cross-field ideas in order to solve today’s data privacy issues.

A computer science professor at Columbia Engineering and a member of the Data Science Institute, Daniel Hsu develops machine learning algorithms that have been used in automated language translation, personalized medicine, and privacy transparency systems. His work making computers better at understanding natural language was recently recognized in IEEE’s Intelligent Systems magazine. Hsu specializes in a branch of machine learning called interactive learning, which turns an algorithm loose on a small set of hand-labeled data. When the algorithm encounters a term it doesn’t recognize, it requests a label, massively speeding up the training process. As a graduate student in the late 2000s, Hsu helped develop an active learning method that was later applied to electrocardiograms, reducing the amount of training data needed by 90 percent. His work on Hidden Markov Models has been applied in genomics to understand the role of gene regulation in disease, and how the choice of packaging a cell’s DNA may be implicated. More recently, he helped develop a tool to bring greater transparency to how personal data is used on the Web. The Sloan Fellowships are awarded in eight scientific and technological fields—chemistry, computer science, economics, mathematics, computational and evolutionary molecular biology, neuroscience, ocean sciences, and physics. Candidates are nominated by their fellow scientists and winning fellows are selected by an independent panel of senior scholars.

For contributions to “network traffic modeling, congestion control and Internet economic laws.”

Vishal Misra has been named a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), the highest grade of membership and limited every year to one-tenth of one percent of the total voting membership. Throughout my career I have attempted to solve real world problems via mathematical modeling and analysis,” says Misra. “While I am deeply honored by this recognition by the IEEE, the credit for it goes to all my great collaborators who have ensured that our work has had an impact.”

On the faculty of the Computer Science department at Columbia University, Misra in his research emphasizes the use of mathematical modeling to examine complex network systems, particularly the Internet. It’s an approach that has been highly productive from the beginning. His PhD thesis work on modeling Internet congestion, done in collaboration with colleagues, opened up entirely new directions in TCP design and led to better control mechanisms, helping achieve high throughput, low latency, and low packet loss on Internet links. Software that grew out of Misra’s PhD thesis is now being deployed in all modern websites.

In a 2008 paper, he and colleagues used mathematical modeling to examine pricing policies and profit motives of Internet service providers, in the process identifying at an early stage the economic incentives that would later give rise to paid peering. Misra was thus one of the first in academic circles to warn that network neutrality legislation is required to protect without first understanding Internet economics.

Recognized as network neutrality has become a political issue, particularly in the US and India, Misra has actively participated in the public debate, contributing articles and interviews to leading media outlets. Earlier this year, he appeared before the Indian Parliament to present views on zero rating, a policy contrary to network neutrality.

Misra’s opinions and expertise are sought not only for his rich technical research, but also for his real-world experience building Internet-based businesses. While still a graduate student, he co-founded the sport website Crickinfo (acquired by ESPN in 2007); more recently he founded the data center storage startup Infinio.

Misra’s elevation to IEEE fellow is an important achievement in a career that has previously earned him a National Science Foundation CAREER Award, a Department of Energy CAREER Award, and Google and IBM Faculty Awards.

Linda Crane
Two professors in the Computer Science department at Columbia University have been elected 2015 Association for Computing Machinery (ACM) Fellows: Julia Hirschberg for "contributions to spoken language processing," and David Blei, for "contributions to the theory and practice of probabilistic topic modeling and Bayesian machine learning." The ACM fellowship grade recognizes the top 1% of ACM members for their outstanding accomplishments in computing and information technology or outstanding service to ACM and the larger computing community. This year, 42 have been named ACM Fellows.

Julia Hirschberg is the Percy K. and Vida L. W. Hudson Professor of Computer Science and Chair of the Computer Science Department. She is also a member of the Data Science Institute. Her main area of research is computational linguistics, with a focus on the relationship between intonation and discourse. Her current projects include descriptive speech, spoken dialogue systems, entrainment in dialogue; speech and language research in low-resource languages; and hadding behaviors.

"I am deeply honored to be joining this wonderful group of computer scientists," says Hirschberg. "The ACM has done a wonderful job of supporting and promoting computer science for many years.

Upon receiving her PhD in Computer and Information Science from the University of Pennsylvania, Hirschberg went to work at AT&T Bell Laboratories. From 1990s she pioneered techniques in text analysis for prosody assignment in text-to-speech synthesis, developing corpus-based statistical models that incorporate syntactic and discourse information, models that are in general use today. She joined Columbia University faculty in 2002 as a Professor in the Department of Computer Science and has served as department chair since 2012. As of November 2015, her publications have been cited 14,161 times, and she has an h-index of 60.

Hirschberg serves on numerous technical boards and editorial committees, including the IEEE Speech and Language Processing Technical Committee and the board of CRA-W. Previously she served as editor-in-chief of Computational Linguistics and co-editor-in-chief of Speech Communication and was on the Executive Board of the Association for Computational Linguistics (ACL); on the Executive Board of the North American ACL; on the CRA Board of Directors; on the AAAI Council; on the Permanent Council of International Conference on Spoken Language Processing (ICSLP); and on the board of the International Speech Communication Association (ISCA). She is also noted for her leadership in promoting diversity, both at AT&T and Columbia, and broadening participation in computing.

Among many honors, she is a fellow of the Association for Computational Linguistics (2011), of the International Speech Communication Association (2008), of the Association for the Advancement of Artificial Intelligence (1994); and she is a recipient of the IEEE J. Flanagan Speech and Audio Processing Award (2011) and the ISCA Medal for Scientific Achievement (2011). In 2007, she received an Honorary Doctorate from the Royal Institute of Technology, Stockholm, and in 2014, was elected to the American Philosophical Society.

David Blei is a Professor of Computer Science and Statistics and a member of the Data Science Institute. He is a leading researcher in the field of probabilistic statistical machine learning and topic models, having co-authored (with Michael I. Jordan and Andrew Y. Ng) the seminal paper on latent Dirichlet allocation (LDA), the standard algorithm for discovering the "topics" or clusters of words in a collection of documents. LDA has become an important statistical tool and is used to capture interpretable patterns in a range of applications, including document summarization, indexing, genomics, and image database analysis.

In addition to continuing work on topic models, Blei develops models of social networks, music and audio, images and computer vision, and neuroscience and brain activity. Recent work with students has resulted in efficient algorithms for fitting a wide class of statistical models to massive data sets, enabling the scale of data that can be analyzed using sophisticated methods.

"I am deeply honored to have been elected an ACM fellow," says Blei. "The ACM is a wonderful organization—for many years it has nurtured the fantastical intellectual and community spirit of computer science.

Blei's research has earned him a Sloan Fellowship (2010), an Office of Naval Research Young Investigator award (2006), the NSF Presidential Early Career Award for Scientists and Engineers (2001), the Blavatnik Faculty Award (2013), and the ACM Infosys Foundation Award (2013). He is the author and co-author of over 80 research papers.

Before coming to Columbia in 2004, Blei was an Associate Professor of Computer Science at Princeton University. He received his PhD in Computer Science from UC Berkeley and his BS in Computer Science and Mathematics from Brown University.

David Blei

Julia Hirschberg

David Blei

Elected 2015 ACM Fellows

Henning Schulzrinne Named Recipient of 2016 IEEE Internet Award

Henning Schulzrinne, the Julian Clarence Levi Professor of Mathematical Methods and Computer Science at The Fu Foundation School of Engineering at Columbia University, has been named the recipient of the 2016 IEEE Internet Award for exceptional contributions to the advancement of Internet technology.

Schulzrinne was recognized "for formative contributions to the design and standardization of Internet multimedia protocols and applications." Schulzrinne is particularly known for his contributions in developing the Session Initiation Protocol (SIP) and Real-Time Transport Protocol (RTP), the key protocols that enable Voice-over-IP (VoIP) and other multimedia applications. Each is now an important standard and together they have had an immense impact on telecommunications, both by greatly reducing consumer costs and by providing a flexible alternative to the traditional and expensive public-switched telephone network.

"This award also recognizes the work of my students and visitors in the Columbia IRIT lab as well as all the other colleagues who contributed to making Internet-based multimedia possible," says Schulzrinne, in referring to the Internet Real-Time (IRT) Lab, which he directs and which conducts research in the areas of Internet and multimedia services.

The Internet Award follows on the heel of two other honors recently accorded Schulzrinne. In 2014, he was named an ACM Fellow, and in December 2014 he received an Outstanding Service Award by the Internet Technical Committee (ITC), of which he was the founding chair. In 2013, Schulzrinne was inducted into the Internet Hall of Fame. Other notable awards include the New York City Mayor’s Award for Excellence in Science and Technology and the VON Pioneer Award.

Schulzrinne whose research interests include applied network engineering, wireless networks, security, quality of service, and performance evaluation, continues to work on VoIP and other multimedia applications and is currently investigating an overall architecture for the Internet of Things and making it easier to diagnose network problems. He is also active in designing technology solutions to limit phone spam ("robocalls") and recently testified on this topic before the Senate Special Committee on Aging.

In addition to his research, Schulzrinne is active in public policy and in serving the broader technology community. From 2012 until 2014, he was the Chief Technology Officer for the Federal Communications Commission where he directed the FCC’s work on technology and engineering issues and played a major role in the FCC’s decision to require mobile carriers to support customers’ abilities to contact 911 using text messages. He continues to serve as a technical advisor for the FCC.

Schulzrinne is a past member of the Board of Governors of the IEEE Communications Society and a current vice chair of ACM SIGCOMM. He has served on the editorial board of several key publications, chaired important conferences, and published more than 250 journal and conference papers and more than 90 journal papers.

Linda Crane

Jonathan Gross Retires After 47 Years of Teaching and Research at Columbia

Jonathan Gross retired last semester following a highly active career that allowed him to indulge his lifelong love of mathematics while doing pioneering work in graph theory, three-dimensional topology, shape modeling, and sociological modeling.

Professor Gross’s main specialty is topological graph theory, a math subdiscipline involving combinatorics and geometry marked by a strong visual component. In several of his books and in over 100 papers and journal articles, Gross expanded topological graph theory by initiating new programs of investigation and by developing new methods for them, often collaborating with Thomas W. Tucker. Together Gross and Tucker authored the influential and comprehensive Graph Theory, which is in its second edition. This work in 1988 represented the state-of-the-art in graph theory.

Their objective in writing that book was to create a single source that would provide someone new to topological graph theory with sufficient breadth to move as quickly as possible into frontier research. It remains a standard reference.

Gross invented the voltage graph construction in 1973, which is the basis for a concise and simple construction specific of infinite families of large graphs and also of placements of such graphs on increasingly complicated surfaces. Gross’s joint work with Tucker on his generalization, published in 1977, includes some of the most frequently cited publications in topological graph theory. The name voltage graph plays on the fact that one of the key properties that sometimes
“Not only did we have no cell-phones or personal computers when I was young, most families did not have a television before 1950. We would start being nice to the rich kid around Thursday, in the hope that he would invite us to watch television at his house over the weekend.”

For his excellent teaching, Gross received two SEAS awards; in 1994 he received as well the career Great Teacher Award from the Society of Columbia Graduates.

In later career and retirement, Gross continues his research work with his co-authors around the world. Each year he produces new studies in topology graph theory, and he continues to travel to national and international mathematics meeting to give talks about his research and to chair sessions in his specialty. One math friend has joked, “Jonathan, you are in danger of flunking retirement.”

His career shows that Gross orchestrated for the large lecture room in Have–Van Vleck Hall, “where”—as the department fundamental; as the department grew over the years—it now numbers 44 professors and 5 lecturers—Gross was the organizer of department-wide efforts to make mathematical curriculum at the educational forefront. Over the years, he became the keeper of institutional memory.

Mathematician, researcher, author, and computer scientist, Gross was also an instructor to thousands of Columbia students. He taught his students to understand the grammar and combinatorial properties of the graph theory and, combinatorial theory, lecturing with humor and with what he called “enhancement,” short historic anecdotes from science and mathematics as well as from his own mathematical career and personal history. “Enhancements” were short, amusing, and meticulously put-together notes, often giving students insight into a different time and place.

He proved popular with students, who variously described him as devoted to his work, brilliant, idiosyncratic, and highly quotable.

“My when a baby-level proof, that’s just how mathematicians talk. I don’t actually know any babies who can do algebraic topology.”

“Negative plusomniplusominus
thethesquareofofour
minusfourisovertwelve. You have to say it quadratically, or you’ll get it wrong.”

“I have no idea what liquid soap will make your dishes sparkle, but I recommend liquid joy for making high-quality knotted soap bubbles with interesting mathematical properties.”

- From a collection of quotes compiled by students

Jonathan Weisz, a computer science PhD candidate at Columbia Engineering, has been named the recipient of the inaugural Morton B. Friedman Memorial Prize for Excellence.

Named after the beloved professor and senior vice dean who passed away in 2009, the award honors undergraduates and graduate students who exemplify “Mort’s” legacy of academic excellence, visionary leadership, and outstanding promise for the future.

Weisz’s work at the Columbia University Robotics Group, led by Computer Science Professor Peter K. Allen, advances real-world applications in brain-computer interfaces.

He has developed code for a range of robotics platforms spanning research and industry and published several papers at peer-reviewed conferences. His research with Allen has included measures of grasp stability under uncertainty, “human-in-the-loop” grasping, and data-driven hand design optimization. He also helped manage integrating the various components of the Robotics lab’s grasping platform, arm trajectory planning, and tactile sensing.

“The work our lab is doing with brain-computer interfaces and assistive robotics is exploring how far we can push practical, affordable technologies to help people with motor impairments regain some autonomy,” said Weisz.

Weisz participated in Phase 1 of DARPA’s Autonomous Robotic Manipulation (ARM) Challenge to create a manipulable object of high-level tasks and adapting to real-world environments with little supervision, as well as the DARPA Robotics Challenge to develop innovative ground robots for use in disaster response operations. Previously, as a student and researcher at Johns Hopkins and the University of Southern California, he contributed to augmented reality projects to combat phantom limb pain and small devices to measure motor impairment of cerebral palsy and osteoarthritis patients.

Professor Friedman, who founded the Division of Mathematical Methods, the precursor to the applied mathematics component of the Department of Applied Mathematics, chained the Department of Civil Engineering and Engineering Mechanics for 14 years. In his role as associate dean, vice dean, and senior vice dean, he was in the vanguard of engineering education and helped shaped the School for many decades. He died last year at age 86.

“I am very humbled by the link to someone who contributed so much,” Weisz said. “I hope that the community of researchers that Dr. Friedman created will continue to have an impact.”

Jesse Adams

Riley Spahn, a computer science (CS) PhD student working with CS professors Rosanna Geambasu and Gail Kaiser, was recently awarded a North American Google PhD Fellowship for his work on privacy issues. He is one of 15 students chosen from a highly competitive pool of applicants to represent the next generation of researchers working to solve some of the most interesting challenges in computer science.

“I’m very happy that Google will be supporting my research,” says Spahn, who will pursue research on operating and distributed systems with a focus on security, privacy, and data management. "I am hopeful that the community of students will continue to have an impact.”

Google created the PhD Fellowship program in 2009 to recognize and support exceptional graduate students doing exceptional work in computer science and related disciplines.
Columbia Engineering’s Computer Vision Laboratory Develops Cambits, a Modular Imaging System That Can Transform Into Many Different Cameras

Computer Science Professor Shree Nayar and Makoto Odamaki, a visiting scientist from Ricoh Corporation, have developed Cambits, a modular imaging system that enables the user to create a wide range of computational cameras. Cambits comprises a set of colorful plastic blocks of five different types—sensors, light sources, actuators, lenses, and optical attachments. The blocks can easily be assembled to make a variety of cameras with different functionalities such as high dynamic range imaging, panoramic imaging, refocusing, light field imaging, and even microscopy.

“We wanted to redefine what we mean by a camera,” says Nayar, who is the T.C. Chang Professor of Computer Science at Columbia Engineering and a pioneer in the field of computational imaging. “Traditional cameras are really like black boxes that take one type of image. We wanted to rethink the instrument, to come up with a hardware and software system that is modular, reconfigurable, and able to capture all kinds of images. We see Cambits as a wonderful way to unleash the creativity in all of us.”

Cambit blocks, whose exteriors were 3D-printed, are easy and quick to configure. They are attached through magnets: no screws, no cables. When two blocks are attached, they are electrically connected by spring-loaded pins. The pins carry the power (from a host computer, tablet, or smartphone), data, and control signals.

Each block has an ID and when a set of blocks are put together, the host computer recognizes the current configuration and provides a menu of options for what the user might want to do. Cambits is scalable: new blocks can be added to the existing set.

A key aspect of the Cambits design is a circuit board designed by Odamaki that sits inside each block. The board includes a microcontroller, an upstream interface, and a downstream interface. Through the circuit, each block can provide power downstream and receive data upstream. Control signals are conveyed both up and downstream.

“Using our novel architecture, we were able to configure a wide range of cameras,” adds Odamaki, who spent two years working with Nayar on the proof-of-concept project. The suite of computational photography algorithms used by Cambits was implemented by a group of MS project students at Columbia Engineering. Odamaki and Nayar are hoping to partner with a manufacturer to bring their concept to the public.

“Silicon is incredibly exciting in computational photography these days,” Nayar adds. “We hope this reconfigurable system will open the door to new avenues of creativity, bringing new dimensions to an art form we all enjoy.”

Holly Evans

Halfway through their Ubiquitous Dynamics class, 20 students were handed a MinION device, a mobile DNA sequencer that can read the matches laid end to end. This $1000 device, now fully available after being introduced in an early access program, is expected to play an important role in advancing the goal of real-time, on-site DNA sequencing, vastly increasing the applications for DNA sequencing and, as far as reaching, expanding the number of people who can do DNA sequencing. For their professor, Yaniv Erlich, the device has a more immediate purpose: a teaching tool that gives students direct experience with handing and sequencing DNA samples for themselves. Plus he was curious. What happens when you give smart, ambitious students a new device not yet fully explored?

The class teaches the basics of DNA sequencing with an eye on future sequencing technologies that promise to make DNA identification possible in real time at almost any location. Touched in conjunction with Sophie Zaatari, a postdoc in Erlich’s New York Genome Center lab, the class combines aspects of computer science, biology, electrical engineering, algorithms, and data science, particularly the special challenges of acquiring, storing, and analyzing huge amounts of genomic data. (The first reading assignment was Big Data: Astronomical or Genomic? by ZD Stephens and others.)

The class, however, has a major DIY twist. Rather than sending out DNA samples to a lab equipped with $1M sequencing machines, Erlich would have students learn DNA sequencing by actually doing it themselves. What makes this scenario even more imaginative is a new, portable DNA sequencing device called a MinION. Inexpensive (approximately $1000), portable, and capable of sequencing DNA in almost real time, the MinION will vastly broaden the applications of DNA sequencing and who can accomplish it. The MinION uses a sequencing method different from traditional (or sequential) DNA sequencing, which works by first breaking up the DNA into tiny snippets before painstakingly reassembling them, mapping them against a template DNA—a process that can take days and requires a high level of expertise. Instead, MinION relies on nanopore sequencing, where a single-stranded DNA molecule passes through a small biological pore, or nanopore, embedded in an elec-
trical field. As the DNA molecule transmits through the nanopore, the individual nucleotides (A, T, G, C) that construct a string of DNA disrupt the ion current in characteristic ways, creating a profile (called a `signature`) that can be analyzed by software to `decode` the nucleotide sequence, almost in real time.

Erlich was able for procuring for his class five MinIONs because the device’s manufacturer, Oxford Nanopore Technologies, is interested in exploring the potential applications of the MinION in education. (The class was generated interest among the community growing up around the MinION and was covered by a GenomeWeb article.)

Two hackathons count for half the grade
Half the grade would be determined by two hackathons. For the 29 graduate and undergraduate students, working in small groups, would be given the five MinIONs along with PCs running MinION software. The MinION has a `Sequencing Sequence`, requiring several tasks to identify that constitute the MinION itself. MinION starts detecting the DNA sequence of the current direction. This raw data (in HDF5 format) gets uploaded to the cloud where software analyzes the recorded events to identify the individual bases. MinIONs later, students begin seeing preliminary sequencing data on their screens. (All reads—a long with new code written—are posted to the class github site.)

Not all 512 channels contain a nanopore that produces reads, but those that do produce individual sequences for each individual, with a new read aligning to each data in a very short time, both the problem of the MinION and the beginning of the difficulty for the students is simple, but the difficulty level can ratchet up quickly depending on what two sequences are being compared. Discriminating between two species is one thing; differentiating between two humans who share many of the same traits is something else entirely.

Difficulty level increases in second hackathon
Of the two hackathons, CSI Columbia proved to be much more challenging. One group, for example, was to test whether MinION sequencing could be used to identify a single person. Normally short tandem repeats (STRs) are used to identify individuals (the FBI typically uses 13 different STRs for identification purposes), not the combination of bases by nanopore sequencing. As yet, no scientific framework exists on how to identify an individual using the reads generated from the MinION nanopore sequence. But there are repeat align-ment tools for comparing two or more human DNA sequences, almost all were developed for traditional sequencing methods. Choosing an alignment tool took time. With many different ones, it was a challenge to know where to begin. Even downloading the tools took time, a step that often happened when students discovered their first tool choice didn’t work well. File for files were another issue and consumed a significant amount of time for the teams. Different tools accept and output different file formats. Many were incompatible; only some were standard. For CSI Columbia, the difficulty level ratcheted up much more than even Erlich and Zaaijer had imagined. One group had actually been initiated to solve first, ahead of the shock hackathon. However, preparing the DNA libraries for CSI Columbia turned out to be more challenging, necessitating a switch in the order of hackathons.

Students were not originally given equal access to the identities of the individuals whose DNA was being sequenced; they were told only to search several online genetic databases for a close match. With students having to spend considerable time finding the right tool and overcoming file incompatibility issues, the assignment Erlich narrowed the scope, naming himself, Craig Venter, James Watson, or someone in the 100 Genomes Project as the possible suspects. This extra information changed the scope considerably: rather than finding a single individual in a sea of others, the task became to look closely at a few individu-als, and ultimately, it was the one of the groups made the correct identification.

The fundamental structure was sound; it was the data that was lacking. This was when the students demonstrated they were able to properly interpret the data they had. If they couldn’t identify the exact donor, they still were able to provide a list of traits that in the real world would help narrow the number of suspects.

Zaaijer points out also that the students were dealing with a technology that is not yet mature. ‘Mobile sequencing is just now getting off the ground, and the error rate in the reads is still relatively high compared to traditional DNA sequencing, though many scientific groups are working on solving this. It was good for the students to experience that not everything is www. In an iPhone, a virus could wipe the box and it works. Technology evolves by hard work of many people, and we need to estimate when mobile DNA se- quencing might replace passport checks and internal border controls. Answers were more conservative at the second asking, but not by much. One or two of the students averaged their answer. Students clearly see the potential for mobile DNA sequencing, even with first-hand knowledge of the technology and work dedicated still needed to optimize the technology.

Though there were hiccups, the problems had more to do with finding the right tools and overcoming incompatible file formats. Erlich and Zaaijer had been pushing from the beginning to see how far the students could go; that some original assumptions didn’t work out was only to be expected. However, the main goal was clearly achieved: students new to DNA sequenc-ing were able—with a little training—to successfully set up a MinION and move beyond new uses for the MinION. That a sophisticated process once relegated to specialized laboratories was played out relatively smoothly in the classroom points to the huge possibilities of mobile, onsite DNA sequencing.

Says Erlich, “The future is here: we can place DNA sequencers in the hands of our students. No more theoretical explanation of how sequencers work; no more just data wrangling. We can let them feel the internal, promote critical thinking, and determine ownership. DNA is everywhere. In your food, on your clothes, in the classroom points to the huge possibilities of mobile, onsite DNA sequencing.”

In a classroom at the New York Genome Center, students obtain MinION data during second hackathon. Screenshot shows a tassel on number and length of reads.

Linda Crane

Questionnaire
When do you think the real time sequencing will be used to do person identification at borders, instead of passport/drivers licenses?

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Before Hack</th>
<th>After Hack</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>80%</td>
<td>60%</td>
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<td>50%</td>
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<tr>
<td>2019</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>2020</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>Never</td>
<td>20%</td>
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CS/EEU 2016 15

SPRING 2016 15
Researchers Develop Algorithm to 3D Print Vibrational Sounds

In creating what looks to be a simple children’s musical instrument—a xylophone with keys in the shape of zoo animals—computer scientists at Columbia Engineering, Harvard, and MIT have demonstrated that sound can be controlled by 3D-printing shapes. They designed an optimization algorithm and used computational methods and digital fabrication to control acoustic properties—both sound and vibration. They can control the shape of 2D and 3D objects. Their work—“Computational Design of Metallophone Contact Sounds”—will be presented at SIGGRAPH Asia on November 4 in Kobe, Japan.

“Our discovery could lead to a wealth of possibilities that go beyond xylophone instruments,” says Changxi Zheng, assistant professor of computer science at Columbia Engineering, who led the research team. “Our algorithm could lead to ways to build less noisy computer fans, bridges that don’t resonate, and less noisy 3D-printed metallophones with unique forms.”

Zheng, who works in the area of computer science, has long been interested in the way objects vibrate, of an object. Simulating the vibration modes of an object involves solving the wave equation, which describes how the object vibrates under stress, and vibration–breathing modes of sound. The researchers modeled the object’s normal modes of motion using computational methods while the object itself, not through strings or reeds. Because the surface vibration and resulting sounds depend on the interaction of sound waves with surfaces, they can use this technique to design musical instruments and even non-musical objects.

“Our zoolophone’s keys are automatically tuned to play notes on a scale with overtones and frequency of a profession- ally produced xylophone,” says Zheng, whose team spent nearly two years on developing new computational methods while borrowing concepts from computer graphics, acoustic modeling, mechanical engineering, and computer vision. “By automatically optimizing the shape of 2D and 3D objects through deformation and perforation, we were able to produce such professional sounds that our technique will enable even novices to design metallophones with unique sound and appearance.”

Though a fun toy, the zoolophone represents fundamental research into understanding the complex relationships between an object’s geometry and its material properties, and the vibrations and sounds it produces when struck. While previous algorithms attempted to optimize either amplitude (loudness) or frequency, the zoolophone’s design simultaneously controls both, allowing it to realign acoustic properties. Creating realistic musical sounds required work to add in overtones, secondary frequencies higher than the main one that contributes to the timbre associated with notes played on a profession- ally produced instrument. Looking for the most optimal shape that produces the desired sound when struck proved to be the core computational difficulty: the researchers had to consider both amplitude and frequency is immense. To increase the chanc- es of finding the most optimal shape, Zheng and his colleagues developed a new, fast stochas- tic optimization method, which they called Latin Complement Sampling. They then implemented algorithms to improve the shape of the objects through de- formation and perforation to pro- duce the wanted sounds. LCS outperformed all other alternative optimizations and can be used in a variety of other problems.

“Acoustic design of objects today remains slow and expensive,” Zheng notes. “We would like to explore computational design algorithms to improve the process for better controlling an object’s vibrational properties, whether to achieve desired sound properties or to reduce unwanted vibrations. Geometric optimization of a zoolophone is a new way.”

Zheng, whose previous work in computer graphics includes synthesizing realistic sounds that are automatically synchronized to simulated motions, has already been contacted by re- searchers interested in applying his approach to micro-electro-mechanical systems (MEMS), in which vibrations filter RF signals.

The work at Columbia Engineering was supported in part by the National Science Foundation (NSF) and Intel, at Harvard and MIT by an NSF Focused Research Laboratory, and DARPA.

In U.S. Senate Testimony, Henning Schulzrinne Offers Technology Solutions to Unwanted Calls

Researchers Develop Algorithm to 3D Print Vibrational Sounds

To demonstrate their optimization algorithm, the researchers built a “zoolophone,” a metallophone with plushy animal shapes.

Robocalls are proliferating and becoming increasingly sophisticated and untraceable. They can be used to dupe banks or government agencies to trick senior citizens into divulging personal information or transfer- ing money. Recent advances in robocalling have reduced the cost of calling to nothing and made it easier to “spoof,” or misrepresent, the originating number or caller ID. The famous Do Not Call list, while effective against unwanted calls from legitimate businesses, is no longer a barrier against robocalls.

The ability of robocallers to associate their numbers with any other number or caller ID name gives rise to a whole slew of semi-plausible scams: the IRS demanding payment for overdue taxes, the Social Security Administration requesting an account number to make a deposit, or a mortgage demand from local police if a debt is not immediately paid. There are many others, like the one that promises a “free” medical alert system. Most people today know enough to be wary of such calls, but the robocaller’s simple model—-fake phone numbers with millions of cheap auto-dialers and deceptions, making it possible for scammers to inundate the Do Not Call list and make a sale. Against those who are not sufficiently discouraged robocalls, making them a small business owner who lost 62 robocalls within a month, an FTC representative who testified about her agency’s difficulty in dealing with the problem, and a Missouri Deputy Director whose office last year fielded 5,000 complaints, 52,000 of which concerned unwanted calls.

Testifying about the technol- ogy aspects was Henning Schulzrinne, who developed the key protocols that enable VoIP and who continues to work on VoIP protocols as a professor of computer science at Columbia University. He is also knowledgeable about the policy issues, having served as the Chief Technologist at the FCC from 2012 to 2014. While currently consulting for the Senate, he was, in his private role as a technology expert that he addressed the Senate. After summarizing eight categories of scams, Schulz- rinne described the technology solutions, which fall into roughly three categories: filtering, caller ID and name authentication, and gateway blocking. Each, he noted below, has its strong points and limitations.

Filtering

Filtering, either through a third- party service or a downloaded app, works by checking each incoming call against a white list of trustworthy phone numbers or...
both to make filtering effective. Preparing spoofing is necessary to ensure that phone numbers can be verified to identify the individual or company—for the express purpose of capturing the phone numbers of the local police department or the IRS. Built-in safeguards can ensure emergency alert calls get through as do calls placed from medical facilities; unknown phone numbers can be verified by making callers prove that they are human rather than robotic.

Filtering today has several drawbacks. First, it's a phone-to-phone process; almost anyone can use VoIP to reach phone numbers that have not been assigned to a carrier. Because it is usually available only through large cable companies like Time Warner or Comcast, the do-not-originate approach protects the relatively small number of government agencies and banks not other legitimate-sounding numbers. And filtering is usually available only through such gateways to enter the traditional circuit-switched phone lines used by most US companies and large carriers. Companies generally contract with a carrier that operates a VoIP gateway on their behalf to handle the transition for all incoming and outgoing calls. VoIP gateways do not check whether the originating number is valid or not. It would be easy to program a VoIP gateway to reject origination numbers that are not valid or to be out of service. Any calls from numbers on a list to not originate—a so-called "Do Not Engage Call"—can be rejected by the gateway and thus blocked from entering the phone network. Alternatively, the gateway could replace the fake caller ID information with a fraud indicator, such as the (made-up) area code 666. VoIP users can choose dialing technologies that can reject those calls if the carrier prefers not to. While companies generally contract with only a limited number of service providers, SIPS allow for changing the mechanics how caller ID information is given. This approach, and thus filtering, could make it hard to do spoofing in the first place.

Current ID information is collected from many different databases and is often not validated, making it easy for those who create VoIP gateways to insert any information they like, especially for numbers that have not been assigned to a carrier. But because SIP allows the calling party to provide address information directly into the call signaling request, it’s possible to avoid looking up the information in databases and making it easier to track who generated the call. Long-term carriers may occasionally indicate that they have validated the information by cross-checking them against address service records or credit card billing information, for example.

Breaking the business model

Each of the three methods—filtering, authentication, VoIP-gateway blocking—does one part to add to the difficulty and expense of spoofing robocalls, but each addresses only a subset of the problem. The do-not-originate addresses spoofing of high-profile entities, such as government agencies and banks but not other legitimate-sounding numbers robocallers invent ("Card Sucks," "Medicare"). Authentication stops robocallers from impersonating legitimate businesses and government agencies and makes fraudulent calls less likely to be accepted. It can also be used to prevent robocallers themselves. Filtering can stop robocallers but currently protects the relatively few individuals who use it and is easily circumvented by spoofing. But used in combination with one another, the three methods complement one another to understand economics of spoofing robocalls. Once authentication is in place to prevent spoofing and filtering is in place on many landline phone numbers, legitimate, white lists of acceptable numbers—bankers or Comcast technicians, for example—can be compiled and safely distributed to the phone network for protection. And without spoofing to disguise their identity, robocallers quickly get identified and blacklisted (and in the best case, shut down). It’s the combination of methods, working in conjunction with the VoIP technology and the support of government, that seems the best chance of approaching the 100% suppression rate needed to make a big dent in robocalls. Since it was technology that allowed robo calling in the first place, perhaps the technology that stops it makes the most sense.

Why did you write Thinking Security?

Thinking Security is written for network and security administrators, but ensuring their systems are secure is complex.

If you don’t answer those questions, you’re doing security just to do security, forgetting that the purpose of security is not to increase security, but to prevent fraud.

Defenses have been matched to the likely attacks. If you’re using a firewall to stop email viruses, a firewall will probably suffice. However, if it’s 17 databases all tied together and made to function as a single resource while also needing to be accessible by those inside and outside the company, a firewall is not going to work.

Or will a firewall protect you from an attack launched from inside. Even employees might work against a firewall if it prevents them from getting their work done.

People might be surprised to see you can see your himself such as credit card transactions.

The underlying vulnerability here is the reuse that occurs when you’re sending something to one site that can be stolen from that site and reused against you. In RSA SecurID—generally considered very secure—a cryptographic secret is embedded in the token but a server somewhere has a copy of that secret. Anyone hacking into that server can impersonate the victim of the token. Some will say: Lock down the server. If you can look down the ladder, you can take down your password file? Why is that server more secure than a password file? It’s not. A one-time password if done right is secure, not because it is hard to guess, but because it can’t be reused. Your most valuable password is your email account password, because that’s used for all the other passwords. Anyone hav- ing your email password can potentially learn any password emailed to you, no matter how strong the password.

Passwords are ubiquitous. Can they be used safely?

I use and recommend passwords because there are some bad designs out there. The book discusses the characteristics that make for a good password manager.
having a firewall creates vulner-
abilities that can be exploited.

Which is what happened in the
breach at Target. Attackers obtained
the network credentials used by Target’s HVAC vendor,
which had external access to Target’s network. Once inside,
hackers were able to move freely
over Target’s network, which from
all accounts was relatively
loosely structured with little
tight segmentation. Internal firewalls
should have been used to cordon
off sensitive parts of the net-
work, like the payment systems
which is how the attackers were
ultimately able to steal credit card
information.

Legacy systems are a problem;
an internal network might have
taken. Upstart launched its big
open beta last year and has a
time to develop. If things do not
work, turn them off. There are a lot of
things one can do if I’m not able

Many things come down to
ethics, and security is one
of them.

That is one of the main
themes in the book.

Yes, security costs money.
Companies have to spend
resources, understand the need,
and have a strategy. There are
a lot of things I will do if I’m not liable.

The Target breach was one
of many big ones in the last
couple of years. Fed-
eral agencies were attacked
multiple times, for example, Anthem Health, even Chase.

Attacking seems to be a
one step ahead…

…mostly, but not completely.
We don’t hear about the attacks
that get repulsed.

With all the risks, would you
recommend people not use
online banking?

No. And I’ll tell you why. As
a matter of practice, banks
don’t hide customers liable for
money hacked from their bank
accounts because the next
down the street won’t.

It’s not competitive. The

Merchants and businesses,
however, are generally liable.
A store can lose a lot because
there are a lot of things I will do if I’m not liable.

The result is that location
data sets collected from apps
comparing an accurate
and time stamps. (Data was
utilized by one nearby
store.)

Including two real-world data sets,
the To prove the concept, the
researchers trained the model
using two real-world data sets,
a sparse one collected from a
mobile ad exchange, and a dense
data set from a cellular carrier.
In both cases, only inputs were
user IDs, latitudes, and
and time stamps. (Data was
anonymized by removing all
personal information.)

With data aggregated across all
users, a strong, global temporal
pattern emerged fairly quickly.
It is likely that contained within it sever-

The strong, well-defined patterns on the left results from combining global weekly patterns with
spatial-temporal data of an individual user arbitrarily chosen from the dense dataset. The right
distribution for the same user is a more noisy baseline model that did not infer global
patterns and so as not to correctly identify important places.

The right information delivered at the
right time can make apps and
ads more appealing and relevant
to customers: a traffic alert, app-updates for the
work or home commute as appropriate, a
restaurant that offers lunch coupons for people
who work in the area but dinner
coupons for people who live nearby.

This level of customization requires
a traffic app that
coordinates with
time of day and day of week.

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patterns and so as not to correctly identify important places.

The strong, well-defined patterns on the left results from combining global weekly patterns with
spatial-temporal data of an individual user arbitrarily chosen from the dense dataset. The right
distribution for the same user is a more noisy baseline model that did not infer global
patterns and so as not to correctly identify important places.
In a paper presented at the ACM Conference on Computer and Communications Security, four computer scientists from Columbia University—Yossi Oren, Vasileios P. Kemerlis, Simha Sethumadhavan, and Angelos D. Keromytis—demonstrate that it’s possible to spy on activities of a computer user from a web browser, even in some cases determining what website a user is visiting. This type of attack, dubbed spy-in-the-sandbox, works by observing activity in the CPU cache on Intel microprocessors. It affects close to 80% of PCs, and it represents an escalation and scaling up of what’s possible with side-channel attacks, requiring no special software or tricks up to the victim. Fortunately the fix is easy and web browser vendors, alerted to the problem, are updating their code bases to prevent such attacks. One other update: the spy-in-the-sandbox attack may serve as a primitive for secure communications.

In a side-channel attack, an attacker is able to glean crucial information by analyzing physical emissions (power, radiation, heat, vibrations) produced during an otherwise secure computation. Side-channel attacks are not new; Cold-War spies, for instance, used a special implementation of a typewriter to identify letters inside, or installing microphones during an otherwise secure communication channel. Side-channel-attacks often work in typewriters to infer the information of interest to the attacker, and leaves open the possibility of a functional spying more than 60 years of assembly and virtualization. The unifying feature is that it indicates a variable constantly being accessed during measurements, and (probably) leaking to the measurement code or to the underlying JavaScript runtime.

Feature Articles (continued)

Side-channel Attacks in Web Browsers: Practical, Low-cost, and Highly Scalable

Side channel attacks can be particularly insidious because they circumvent security mechanisms. Traditionally they are directed against targeted individuals and assume proximity and special software installed on the victim’s computer. However, those assumptions may have to be rethought after four computer scientists from Columbia University (Yossi Oren, Vasileios P. Kemerlis, Simha Sethumadhavan, and Angelos D. Keromytis) demonstrated the first time that it is possible to launch a side channel attack from within a web browser. The method is detailed in their paper titled “The Spy in the Sandbox—Practical Cache Attacks in JavaScript and Their Implications,” which was presented October 12, 2015 at the ACM Conference on Computer and Communications Security.

The attack, dubbed spy-in-the-sandbox by the researchers, does not steal passwords or extract encryption keys. Instead, it shows that the privacy of computer users can be compromised from code running inside the highly restricted (sandboxed) virtual machine associated with a web browser. The researchers were able to tell, for instance whether a user was sitting at the computer and hitting keys or moving the mouse; more worrisome from a privacy perspective, the researchers could determine with 80% accuracy whether the victim was visiting certain websites. More may be possible. As Yossi Oren, a postdoctoral researcher who worked on the project (now an Assistant Professor at the Department of Information Systems Engineering in Ben-Gurion University) puts it, “Attacks always become worse.”

In one sense at least, spy-in-the-sandbox attacks are more dangerous than other side-channel attacks because they can scale up to attack 1,000, 10,000, or even a million users at once. Nor are only a few users vulnerable; the attack works against users running HTML5-enabled capable browser on a PC with an Intel CPU based on the Sandy Bridge, Ivy Bridge, Haswell, or Broadwell micro-architectures, which account for approximately 80% of PCs sold after 2011.

How it was done

Neither proximity or special software is required; the only assumption is that the victim can be lured to a website controlled by the attacker and leaves open the browser window.

What’s running in that open browser window is JavaScript code capable of viewing and recording the flow of data in and out of the computer cache, specifically the L3, or lower-level caches as well. To check whether data residing at a certain physical address is present in the L3 cache as well, the CPU calculates which part of the cache the data resides. From there one can check where within the cache that the data resides, and can build a classifier that could, with 80% accuracy, determine if a website open on a victim’s machine matched one of the pre-selected sites. (The same website viewed on different browsers will exhibit slight differences; it’s this noise that prevents 100% accuracy when matching memorygrams.)

Future work

As pernicious as the side-channel attack, especially considered how practical, cost-effective, and low-cost it is, avoiding it is surprisingly easy: run only a single web browser window at a time. An across-the-board fix, however, presents a threat to security as well. In March 2015, the researchers demonstrated that it is possible to launch a new data element to the cache, the CPU will need to evict data elements to make room. The data element is evicted not only from the L3 cache but from lower-level caches as well. To check whether data residing at a certain physical address is present in the L3 cache as well, the CPU calculates which part of the cache this data resides. From there one can check where within the cache that the data resides, and can build a classifier that could, with 80% accuracy, determine if a website open on a victim’s machine matched one of the pre-selected sites. (The same website viewed on different browsers will exhibit slight differences; it’s this noise that prevents 100% accuracy when matching memorygrams.)

The researchers visited 10 sites and recorded multiple memorygrams in each case to build a classifier that, could, with 80% accuracy, determine if a website open on a victim’s machine matched one of the pre-selected sites. (The same website viewed on different browsers will exhibit slight differences; it’s this noise that prevents 100% accuracy when matching memorygrams.)

Future work

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And in this story of data privacy at least there is a happy ending. In March 2015, the researchers shared their findings with all major browser vendors; by September 2015, Apple, Google, and Mozilla had released updated versions of their browsers to close the identified security hole.

The researchers are not yet done examining the potential of web-based side-channel attacks. They will continue looking at the problem (on old versions of browsers to test the attack) at larger scale. They also are considering a more interesting question: can memorygrams be used for good purposes? A pre-set memorygrams might be placed in memory to be viewed by a trusted party to convey information. One memo- rymgram might represent a 1 bit, another a 0 bit. The capability of communicating in this fashion would be slow, but it would be extremely difficult for an attacker to even figure out that explicit communication is occurring between two parties. Memo- rymgrams might thus serve as a primitive in secure communications, and what was once a threat to security may serve to enhance it.

Linda Crane

A memorygram of L3 cache activity. Vertical line segments indicate a cache access. Data elements are active during the same time span. Since consecutive cache sets (in the same page frame) correspond to consecutive addresses in physical memory, it is assumed that a functional spying more than 60 years of assembly and virtualization. The time-base line indicates a variable constantly being accessed during measurements, and (probably) leaking to the measurement code or to the underlying JavaScript runtime.
“Let me tell you how I got hooked on computing. For my thesis I worked for six months starting from a mathematical model of the helium atom and writing a program to compute the energy and wave functions of the helium atom. I was using a variational principle which means I was converging down to the ground state of the helium atom. I started in late 1959 and loaded them on the printer. The printer started spewing out approximations to the ground state energy of helium. I needed at least 200 digits per second but the IBM 650 was not fast enough, so I needed to use a much faster computer. The next day, I had a new printer and it was about four times faster. A few days later, I had a new printer and it was about eight times faster. By the end of the month, we had the ground state energy of helium. We called it the Robust approach to computing, and we published it in the Journal of the Association for Computing Machinery (JACM). Since then I have published over 200 papers on algorithms for solving equations, and I have received over 10 awards for my contributions to computational mathematics. I am still working on algorithms, and I believe that the field of computational mathematics will continue to grow and evolve.”

Joseph F. Traub, a pioneering computer scientist and founder of the Computer Science department at Columbia University, died Monday, August 24, 2015 in Santa Fe, N.M. He was 83. Most recently the Edwin Howard Armstrong Professor of Computer Science, Traub was an early pioneer in computer science years before such a discipline existed, and he would do a lot to shape the field.

Traub was most known for his work on algorithms and computational complexity, and he was a key figure in establishing the strong frontier leadership in this field, “I’m almost moved to tears but who could have predicted the impact that Joe had on computer science?” said Julia Hirschberg, chair of the Computer Science department at CMU. He is survived by his wife Pamela and two daughters, Claudia Traub-Cooper and Althea Traub-Marchetti.

The field of computational mathematics, in which Traub set about to better understand the behavior of algorithms, was emerging in the 1950s. Traub, who was using a variational principle which means converging down to the ground state energy of the helium atom, had a major role in building and leading organizations that promoted computer science. In 1971, at the age of 38, he was appointed chair of the computer science department at Carnegie Mellon University (CMU), overseeing its expansion from fewer than 10 professors to 50, and making it one of the strongest computer science departments in the country.

Based on his achievements at CMU, Columbia University in 1979 extended an offer to Traub to found the University’s Computer Science department. He accepted the offer and chose to locate Computer Science within the Engineering School, which at the time offered a single computer, only three tenure faculty members teaching computer science, and a huge demand for computer classes.

After securing a $600,000 gift from IBM (which later provided another $4 million), he was able to add faculty and attract top students. Within a year the department was awarding bachelor’s and master’s degrees as well as PhDs. He would chair the department until 1989.

In 1982 he oversaw the development of the Computer Science Building, working closely with architects to come up with a final design that would later win awards. Traub liked building things from scratch. In 1985 while still chair of the Computer Science department, he became the founding editor-in-chief of the Journal of Complexity (a position he held at the time of his death). In 1986, he founded the Computer Science and Technology Board (CSTB) of the National Research Council, serving as its chair from 1986 until 1992 and again in 2005 and 2009.

His awards and honors are many and include election to the National Academy of Engineering in 1985, the 1986 Knuth Prize, the IEEE Poineer Gold Medal from IEEE, and the 1992 Distinguished Service Award from the Computer Research Association (CRA). He is a fellow of the Association for Computing Machinery (ACM), the American Association for the Advancement of Science (AAAS), the Society for Industrial and Applied Mathematics (SIAM), and the New York Academy of Sciences (NYAS). He was selected by the Academia Nazionale dei Lincei in 1993 to present the 1993 Lecce Lincee, a cycle of six lectures. Traub received the 1999 Mayor’s Award for Excellence in Science and Technology, an award presented by Mayor Michael Nutter.

That he returned to New York City to found Columbia’s computer science department is entirely appropriate. He attended both Bronx High School of Science and City College of New York (earning degrees in math and physics) before entering the U.S. military in 1954. He attended the University of Pennsylvania and earned a PhD in theoretical physics. That plan changed when he met and married his wife Pamela, who was working at Columbia—where he had no computers—but at the IBM.

Watson lab then located in Casa Hispanica, just off campus at 612 W. 116th Street. He hired three researchers in 1959, a year before the world’s first semi-conductor (solid-state) transistors were demonstrated by IBM and loaded them on the printer. The printer started spewing out approximations to the ground state energy of helium. Traub’s “contributions to Columbia’s Computer Science Department have been instrumental in establishing the strong foundation of excellence of our Computer Science department today, enabling our ongoing frontier leadership in this field,” said Dean Mary C. Boyce. “Joe will be sorely missed by all of us at Columbia and by the computer science community across the globe.”

A life of science and discovery

Traub always described himself as lucky. Lucky in his early life that his parents were able to flee Nazi Germany in 1939 and settle in New York City. He was a knock on math and problem-solving just when the decade of fast computers was beginning. Today, computers—and such a wonderful career. "We miss David very much. He was a wonderful colleague and mentor for many students," said Julia Hirschberg, chair of the Computer Science department at CMU. He is survived by his wife Pamela and two daughters, Claudia Traub-Cooper and Althea Traub-Marchetti.

In Memoriam

Joseph Traub was an important and valued member of the Computer Science department he founded. He will be missed by faculty, staff, and students.

In Memoriam

David S. Johnson

David S. Johnson, a leading expert in the area of computational complexity and the design and analysis of algorithms, died Tuesday, March 8, 2016. Since 2014, Johnson was a visiting professor at Columbia University. Johnson was an active member of the computer science community. He was a leading expert in the area of computational complexity and the design and analysis of algorithms, and was just this year elected to the National Academy of Engineering (NAE). It was the start of his career as an undergraduate studying computer science, and he is best known. He was one of the first to investigate NP-completeness, a concept that deals with problems that are believed to be unsolvable within a reasonable amount of time in the worst case. His book, Computers and Intractability: A Guide to the Theory of NP-Completeness, co-authored with Michael Garey and David Johnson, has been called a classic for its rigorous treatment of NP-completeness and its clear, concise exposition. The book is one of the most cited works in all of computer science, with over 50,000 citations.

Johnson continued to write on NP-completeness throughout his career, and was the subject from 1982 until 1992. During this time, he was awarded the ACM’s Kanellakis Prize for lifetime achievement in computer science, which he shared with Michael Garey. Johnson was a visiting professor at Columbia University. Johnson was a leading expert in the area of computational complexity and the design and analysis of algorithms, and was just this year elected to the National Academy of Engineering (NAE). It was the start of his career as an undergraduate studying computer science, and he is best known. He was one of the first to investigate NP-completeness, a concept that deals with problems that are believed to be unsolvable within a reasonable amount of time in the worst case. His book, Computers and Intractability: A Guide to the Theory of NP-Completeness, co-authored with Michael Garey and David Johnson, has been called a classic for its rigorous treatment of NP-completeness and its clear, concise exposition. The book is one of the most cited works in all of computer science, with over 50,000 citations.

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Li Yang Tan (NSF) grant for their proposal to project for up to two years. Among all the competition, only six were chosen to receive funding for each competition, including the ACM SIGDA Best Student Paper Award at the ACM SIGDA 2015 International Conference. Tan’s paper, titled “3D Printing Your Circuits,” was awarded an Honorable Mention. The award will allow Servedio to pursue his research and gain recognition in the field of computer science.

Kathryn Angelle, a former student of Prof. Tony Jebara, has been awarded the inaugural American College Personnel Association (ACPA) CASHE Fellowship. The award, which is intended to support students in the field of computer science, was presented to Angelle in recognition of her contributions to the field.

Three undergraduate computer science majors have been recognized by the Computing Research Association (CRA) for showing outstanding research potential in an area of computing research. The three students are: Yunsung Kim, Aaron Bernstein, and Jessica OuYang. Their research areas include wireless coverage, machine learning, and computer vision.

A paper co-authored by Prof. Shree Nayar and Columbia Engineering student Daniel Simis won Best Student Paper Award at the 2015 workshop on Web 2.0 Security and Privacy. The paper is titled “Tracking Protection in Firefox: For Privacy and Performance.”

In the field of computer science, the world is constantly evolving. In order to stay ahead of the curve, researchers and students must continue to push the boundaries of what is possible. The awards and recognitions mentioned above are a testament to the hard work and dedication of these individuals. As we look to the future, it is clear that the field of computer science will continue to be at the forefront of innovation and discovery.