Technologies and Foundations for Robust and Secure Networked Systems

Fall 2011 Newsletter

Center for Networked Systems

Cybersecurity Public Policy Class Brings Together Political and Computer Scientists

Recent technological advancements have made networked computing devices nearly ubiquitous and have increased exponentially the amount of information that can be gathered, stored, and analyzed about nearly every aspect of our lives. And since this mass of data is also easily and quickly transmitted, the security and privacy of personal and proprietary data have become key issues in research and innovation. But these issues have greater valence than being simple technological conundrums- they also have significant public policy dimensions.

Legal and societal standards must be set so that purveyors, aggregators, and holders of information know what their rights and responsibilities are regarding information and security. But oftentimes those who write public policy and law are not as well-informed about technology as they need to be for their policies to be effective. Conversely, those who design software, hardware, and systems architectures need guidance as to how to manage security issues so that their technology better promotes the values and needs of society. However, these designers often work in complete ignorance of how their technology fits into the larger picture of the economy, national security, personal privacy, or the political process.

Robust and effective laws are grounded in well-formulated public policy that not only takes into account the nuts and bolts of how to achieve something technically, but that has a clear philosophy about best practices that balances the needs of all constituents, be they corporations, non-profits, governments, or individuals. To achieve this, experts in both public policy and technological innovation must carry on an open dialogue that facilitates an understanding of relevant issues so that both profit from the conversation.

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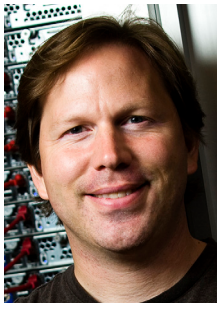
CNS Director Kicks Off Google Cybersecurity Seminar Series



CNS Director Stefan Savage was invited to kick off the Fall 2011 Google Cybersecurity Seminar Series on Thursday, September 1 on the University of Maryland, College Park campus. In his talk, “Looking Before You Leap: The Argument for Data-Driven Security,” Dr. Savage explained how computer security is a field that is fundamentally co-dependent. Innovation is driven largely by the need to respond to the actions of adversaries; when it comes to cybersecurity, it definitely takes two to tango. This combative dance has created both a vibrant research community and a multi-billion-dollar computer security industry.

However, to date, most security efforts have focused on the technical components of this battle: identifying new vulnerabilities, exploits, and attacks, building and deploying new defenses, and so on. In this talk, Dr. Savage argued for a complementary research agenda based on an understanding of the economic forces that drive today’s Internet attacks. He delineated a deconstruction of the underlying value chain for attackers and explained how the use of this information can bring a tighter and more effective focus to security interventions. He provided a rough sketch of the modern cyber-criminal ecosystem, described its dependencies, and highlighted some of the key open questions that motivate current research direction. Using a range of activities, including his own completed studies, work in progress, and work in development, he illustrated how many of these questions can be tackled empirically. Finally, he discussed the real and significant challenges involved with conducting this sort of research and suggested how to bring these issues to the attention of appropriate stakeholders.

CNS Members

In This Issue

CSE Student Wins First CNS Grace Hopper Travel Grant

CSE Ph.D. student Neha Chachra has won the first annual CNS Grace Hopper Travel Grant. Chachra (pictured) will attend the 2011 Grace Hopper Celebration of Women in Computing, which will take place in early November in Portland, OR. According to Chachra, the conference is "a great venue for showcasing my research work, finding potential collaborators, [and] being exposed to and inspired by new ideas."

Oracle Supports Research in Power Efficiency

Oracle awarded Professor Tajana Simunic Rosing (below) with a gift to support a project in energy efficiency in networked systems. The target of the collaboration will be to identify novel methods for maximizing performance as a function of power with an eye towards making specific recommendations that enhance component, subsystem, system, solution and/or data center energy efficiency of Oracle Solaris and related products. Rosing will also investigate methods to size workloads accurately so that resource management can be maximized.

NetApp Faculty Fellowship Award to CNS Researcher

CNS Research Scientist George Porter (at right) recently was awarded a prestigious NetApp Faculty Fellowship. This fellowship program was established by NetApp to fund innovative research on data storage and related topics that help to foster relationships between academic researchers and engineers and researchers at NetApp. Only eight to ten fellowships are given each year, with only one previous recipient, CNS faculty member YY Zhou, being at UC San Diego. Dr. Porter will use the funds to research new ways to incorporate networked storage within highly efficient, data-intensive computing environments.

Graduating Ph.D. Students

Raid Ayoub, advised by CSE professor Tajana Rosing, received his Ph.D. After defending his dissertation on "Temperature and Cooling Management in Computing Systems", Ayoub became a Research Scientist at Intel Corp.

Moitrayee Gupta, a CSE MS student of professor Geoffrey M. Voelker, joined NetApp as a Software Engineer. His thesis was on "Understanding the Role of Malicious PDFs in the Malware Ecosystem."

Dionysius Logothetis became a Research Scientist at Telefonic after completing his doctorate on "Architectures for Stateful Data-Intensive Analytics." His advisor was CSE's Kenneth Yocum

Marti Motoyama, CSE Ph.D. student, will be joining start-up company Fitbit as a Software Engineer. His dissertation, "Understanding the Role of Outsourced Labor in Web Service Abuse" was submitted in September, and his advisors were professors Stefan Savage and Geoffrey M Voelker.

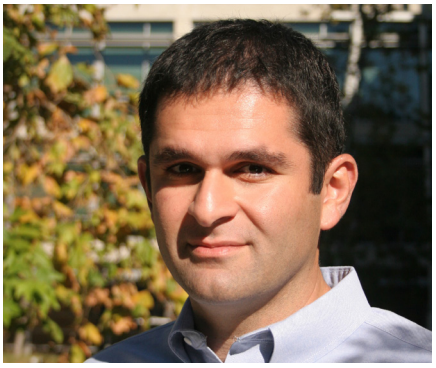
Shervin Sharifi received his Ph.D. with a dissertation on "Accurate Temperature Sensing and Efficient Dynamic Thermal Management in MPSoCs". His advisor: CSE professor Tajana Rosing. Dr. Sharifi is now a Staff Engineering at Qualcomm, Inc.

Frank Uyeda, a CSE Ph.D. student of professor George Varghese, graduated in August after completing his dissertation on "Algorithms for Measuring and Enhancing Distributed Systems." Dr. Uyeda is now a Software Engineer at Google.

Data-Intensive Scalable Computing Research

In August, CNS Research Scientist George Porter and CSE Professor Amin Vahdat (below) were awarded a three- year NSF grant for their proposal to study highly efficient, pipeline-oriented data-intensive scalable computing (DISC).

An increasing number of commonplace applications such as search engines, social networking sites, and biological and scientific programs are making use of DISC to solve computing problems. However, explains Dr. Porter, "The potential benefits of deploying applications at this scale will only be possible if they can be deployed in a sustainable, efficient manner." The data centers that operate these applications are significant consumers of energy, affecting both the environment and the bottom line of the entity that manages them. Finding a solution to the problem of inefficiencies inherent to the architecture of data centers has become a high priority in the field.



This project proposes to find a way to increase per-node efficiency of DISC computing. These reductions would result in the need for fewer machines and less energy usage, thereby reducing the total capital and operational costs of large installations. The possible benefit to commercial, academic, and non-profit enterprises would be considerable. In addition to these already remarkable advantages, the work would also make computing more resilient to common disk failures at significantly less cost and complexity when compared to current solutions.

Graduate Student Summer Internships

Every summer CNS faculty coordinate with the center's corporate partners and affiliates to place CNS graduate students in internships. The CNS Internship Program matches talented Ph.D. and M.S. students from the departments of Computer Science and Engineering and Electrical and Computer Engineering with mentors in industry who supervise their work on research projects of common interest. Over the years these collaborations have resulted in conference papers, journal publications, and dissertation topics. Participants in the CNS 2011 Summer Internship Program:

Amazon.com
- Hamid Bazzazz interned with Matthew Green and studied problems related to opportunity cost
- Ben Ellis
- Filippo Seraccini

Apple
- Jon Weiner

Arista Networks
- Utpal Kumar was supervised by Adam Sweeney and Sriram Sellappa

Boeing
- Thirith Hout

Broadcom
- Yen-Kuan Wu

DARPA
- Rajib Nath worked at Intel Labs with Douglas Carmean on DARPA's UHPC project.

Google
- Michael Conley was supervised by Marián Dvorský and worked on MapReduce
- Matthew Der studied data access anomaly detection
- Keaton Mowery was mentored by Harish Rajamani and focused on search quality
- Andreas Pitsillidis worked with Alon Altman and Úlfar Erlingsson on analyzing the hijacking of Gmail accounts
- Sivasankar Radhakrishnan studied TCP improvements for data centers with Glen Anderson
- Malveeka Tewari collaborated with Dr. Leon Poutrievski on fine grain time measurement in data centers
- Jagannathan Venkatesh
- Liuyi Eric Zhang

HP Labs
- Kevin Webb worked on Opennet tenant segregation with Jean Tourrilhes and Sujata Banerjee

Huawei
- Hao Wang

Livermore National Laboratories
- Baris Aksanli worked with Inder Monga on the energy efficiency of networks.

Microsoft
- Radhika Niranajan Mysore
- Daniel Turner interned with David Maltz on data center fault modeling

Nokia Research Center
- Nima Nikzad interned with David Racz on personalized relevancy, ranking, and recommendation (PR3)

Oracle
- Yanqin Jin
- Bryan Kim

Cybersecurity Public Policy Class Brings Together Political and Computer Scientists

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In an effort to bring this kind of intellectual collaboration to the graduate level, this past spring quarter, Professor Peter Cowhey, the Dean of the School of International Relations and Pacific Studies (IR/PS), and Professor Stefan Savage of Computer Science and Engineering (CSE), co-taught a new class focused on the intersection of cybersecurity and foreign and domestic policy. The purpose of the course was to give students an understanding of the technical challenges involving cyber security and the options for improving it.

In particular, they studied the range of cyber threats that exist, from attacks that are made to gain military or political advantage to the many forms of cyber crime. Having explored these issues, the students then learned about the fundamental problems involved with designing national policies that are politically feasible. They also gained an understanding of the possibilities and limitations of creating cooperative international arrangements that involve the input and participation of governments and civil society and that can effectively reduce risks to cyber security. In the last portion of the class, students evaluated a number of illustrative remedies proposed for cyber security risks.

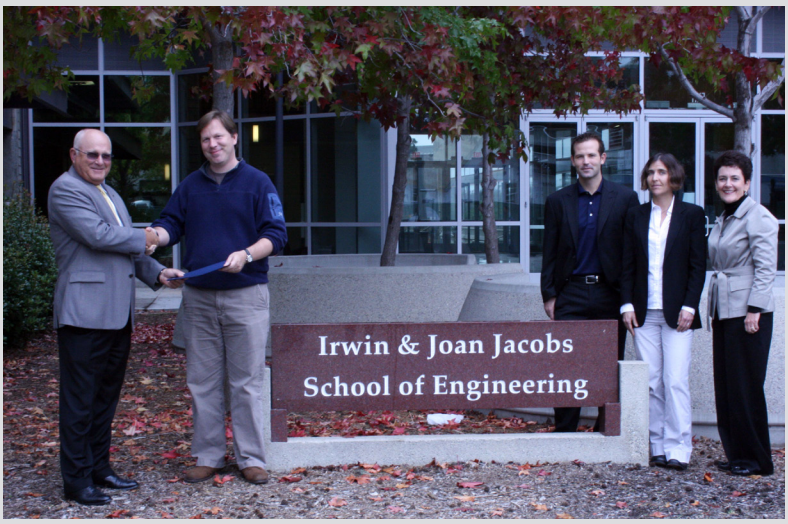
The class was open to graduate students in CSE, IR/PS, and Economics, with the majority coming from CSE and IR/PS. In general, the response was enthusiastic, with students on both sides finding value in exploring a common problem with input from an outside perspective.

CSE Ph.D. student John McCullough said that he took the class because he was curious. "Most computer scientists probably have a limited understanding of policy in general and I wanted to find out more."

McCullough found the exposure to a different kind of approach to solving a technical problem to be enlightening. "Computer scientists tend to expect there to be some answer that is correct and precise, likely with some number of steps to follow or to be derived. Government and people in general don't work the same way as computers- a precise goal gets lost or reinterpreted, and you have to get a lot of people to agree… and there are a wide variety of interests in play."

Likewise, IR/PS Ph.D. student Shawn Li said that the class "taught me effective ways of… exploring different angles on a policy, and examining the incentives of different stakeholders."
Much of the learning came from the students observing each other through class discussions and collaboration on their final team projects. For his project, McCullough's team analyzed the "National Strategy for Trusted Identities in Cyberspace" (NSTIC) document. This is a directive issued by the White House that proposes a way to address the issue of creating online identities. The intent of NSTIC is to reduce the impact of identity theft and fraud by establishing trusted identities, while avoiding the creation of a national ID (a controversial and politically divisive issue).

IR/PS Dean Peter Cowhey co-taught the public policy class with CNS's director.



In October CNS and the Jacobs School of Engineering Corporate Affiliates Program participated in a signing ceremony on the UC San Diego campus, when Northrop Grumman awarded funds in support of the CNS Winter 2012 CNS Research Review. "The CNS Research Review is a key venue for collaborations among graduate students, faculty, researchers, and industry representatives, and CNS appreciates the support that we are receiving for our center's most important event," said center business officer Kathryn Krane. "We look forward to deepening our relationship with Northrop Grumman in the near future."

Pictured (l-r): John Pettitt, Corporate Executive Lead, Northrop Grumman; CNS Director Stefan Savage; Cody Noghera, Deputy Director, CAP; Kathryn Krane, Business Officer, CNS; and Anne O'Donnell, Director, CAP.

To do so, the document proposes to federate the authentication and authorization across many systems and provide for minimal attribute disclosure. For his part in the project, McCullough considered whether technical solutions might align with the goals of the proposal while his IR/PS teammates weighted proposals on fiscal feasibility, incentives alignment, and what steps, if any, needed to be taken to ensure that privacy goals were respected.

Said McCullough, "It was interesting to see how students from IR/PS consider the problems when coming from a less technical background… I think there were often differences in assumptions, but I don't think I would have learned as well in the class if they hadn't been there."

After the course was over, students found that they had not only gained knowledge, but had expanded their perspective about other dimensions to the problems they grapple with in their respective fields. McCullough concluded, "Accomplishing a policy goal… is much more about aligning the pieces of the governmental system… [and] the experience of the class has made me appreciate the challenges of making change in our society."

When asked about the value of working with students outside of the department to study an issue, Li commented, "There should be more cross-discipline learning. Diversity opens up new territories of knowledge. People from different academic fields sometimes find themselves solving the same kinds of problems. [Additionally], working on projects in a diverse group of specialists and generalists prepares students well for the real world."

Student's Bright Idea Wins an IDEA

CSE student Baris Aksanli recently was granted a 2011 Internet2 Driving Exemplary Applications (IDEA) award for his development of a proof of concept for an application that he believes can help reduce the energy consumption of networked systems. Internet2, a networking consortium led by U.S. research and educational institutions, began its IDEA Awards program "to recognize and encourage innovative advanced network applications that have the most positive impact and potential for adoption within the research and education community." Internet2 chose Aksanli's application, MAVEN (Monitoring and Visualization of Energy consumed by Networks), as a winner in its first year of accepting student submissions.

Aksanli's design is a response to the pressing need of enterprise level organizations of all kinds to reduce their energy demands. While analyzing the problem, Aksanli realized that despite the fact that computer networks and communications have become interwoven into the fabric of our daily lives, the amount of energy consumed by these networks remains largely unknown- estimates of consumption historically have been only approximate calculations.

For example, in the U.S., it was estimated that in 2008 networks comprised 1% of building electricity usage and are projected to grow to 6% of usage by 2012. As network traffic and capacities continue to grow, the concern is that power consumption by networked systems will see even more significant growth than what is currently projected. This growth promises to escalate the demand on dwindling and increasingly expensive energy resources. The general ignorance of the scope of consumption presents a serious stumbling block for engineers who wish to study and address the problem.

CSE student Baris Aksanli

MAVEN was built to allow network engineers, energy efficiency researchers, and network equipment vendors to have a real time view of live network energy consumption. And to make the application widely usable, the back-end software and database design allows customizable visualization of a broad range of information, such as network-wide views of power consumption, location-specific data, or per-node information.

In addition to power monitoring, MAVEN also displays live environmental conditions, like temperature and humidity, for the equipment being monitored. MAVEN can also be used to monitor the power consumption of servers, terminal servers, network hubs, and other support equipment required to operate a network efficiently.

In future, Aksanli plans to enhance MAVEN's capabilities so that it can co-relate traffic, environmental conditions, and power as well as provide an improved user interface that showcases historical trends. In addition, there is a potential to enhance MAVEN so that it will include power planning tools, end-user views, and research analysis.

"Bug" Analysis Paper Chosen for SIGSOFT Distinguished Paper Award

CNS Professor Yuanyuan (YY) Zhou (pictured below) recently was notified that a paper which she co-wrote with a team of students from UC San Diego and the University of Illinois at Urbana-Champaign (UIUC), and two researchers from NetApp, was selected by the European Software Engineering Conference/Foundations of Software Engineering (ESEC/FSE) 2011 program committee to receive an ACM Special Interest Group on Software Engineering (SIGSOFT) Distinguished Paper Award at the upcoming ESEC/FSE 2011 conference in Szeged, Hungary. The joint meeting of ESEC and ACM SIGSOFT FSE is one of the most prestigious international forums for researchers in academia and industry to present their work on software engineering.

The winning paper, "How Do Fixes Become Bugs?" is a "comprehensive characteristic study on incorrect fixes in commercial and open source operating systems," and is in line with much of Zhou's work, which focuses on the broad issue of software and system reliability with an eye towards a finding the most cost and time-efficient methods to increase reliability and manage human programming errors. The specific concerns of this paper centered on how to analyze the phenomenon of how programming fixes to deployed software and applications sometimes generate a new round of errors.

Because software is a designed and manufactured by people, it can be expected to contain errors and vulnerabilities of various types. Even after undergoing a rigorous testing phase before being released to customers, it is a given that more bugs will be discovered after deployment in a live environment. Further problems arise when the programmers deployed to "fix" the existing bugs unintentionally introduce new errors with their patches. This results not only in wasted time and resources for the software provider, but causes more damage to the operations, good will, and brand loyalty of end users.

In order to examine this problem, Zhou's team looked at a twelve year history of bug-fixes and mistakes in several large operating system code bases. This study revealed that 14.8% to 24.4% of post-release fixes result in further damage that affects the experience of end users. Furthermore, the group demonstrated that a pattern of "fix" scenarios exists that are more likely to generate mistakes than others. For example, Zhou's team identified that concurrency bug fixes are the most likely to result in further errors. Additionally, developers who have never touched the source code files associated with the fix are far more likely to write a buggy patch than those with previous source code experience.

These results can guide future developers on how to design new tools for software development and can help response teams to assign resources efficiently when providing solutions to reported post-release errors. Based on this information, a commercial software vendor is already incorporating a tool into their bug assignment process that can be used to categorize the types of failure and so route them to the most appropriate developer to fix them.

To read the award-winning paper:
http://opera.ucsd.edu/~zyin2/fse11.pdf

CNS Computer Scientists Claim World Data Sorting Record for Second Year

Not content to rest upon their laurels, a team of CNS data center researchers broke two of their own world records set in 2010, and then succeeded in setting three more, when their system, Tritonsort-MR, sorted a terabyte (1 trillion bytes) of data in 106 minutes. The competition that they entered, the Sort Benchmark, is the large-scale data processing world's Formula One World Championship and Daytona 500 rolled into one, and it attracts competitors from academic and industrial labs all over the world who vie to implement ever faster data center designs.

The CNS group consists of Dr. Amin Vahdat, Dr. George Porter, and Ph.D. students Alex Rasmussen and Michael Conley. Last year, they won in the "Indy" category for the "Gray" and "Minutesort" categories, racing to sort 1 TB of data as quickly as possible and as much data as possible in a single minute, respectively. The "Indy" category represents a parameter that exists only for the purpose of the competition, so that designing a system to compete here is comparable to constructing a racing vehicle that could only ever be driven on a track. But building on their successful foray in 2010, the team decided to take their game to a new level by adjusting their system to compete in the "Daytona," or general purpose, category.

The key to the Tritonsort-MR design, says Porter, is seeking an efficient use of resources: "The whole aim of this project is to

build balanced systems." To do this, "we made some improvements on the data structures and algorithms- basically, to make it a lot more efficient in terms of sending records across the network." The results from their new modifications in the "Daytona" general system not only were successful, but they also proved transferable to the original specialized system built to compete in the "Indy" category. Showing impressive improvements in performance, the team submitted for and won both categories in the "Gray" and "Minutesort" competitions. But beyond the achievement of speed, the efficiency of Tritonsort-MR's design is remarkable: while the second place team used thirty-five hundred nodes to achieve their result, the Tritonsort-MR team used only fifty-two. If implemented in a real world data center, that would mean that Tritonsort-MR could allow a company to sort data more quickly while only making one-seventh of the investment in equipment, space, and energy costs for cooling and operation.

While winning in these four categories exceeded the team's original goals from 2010, they found themselves intrigued by a new category on offer in 2011: the 100 Terabyte Joulesort competition in which teams vie to build a system that can sort the greatest number of data records while only consuming one joule of energy (for some idea of how much a joule is, it takes about a million Joules to watch TV for an hour). The introduction of this new category reflects the recognition of an increasingly dire challenge facing industry in trying to solve data intensive computing problems: energy usage. A primary reason that data centers are expensive to operate is because of the staggering scale of their energy consumption. Any design that could increase energy efficiency would have a positive and much needed impact on both the environment and on a company's bottom line.

Medals recognizing their accomplishments were awarded by the Sort Benchmark committee at the 2011 ACM SIGMOD conference. The Tritonsort-MR team's web site: http://tritonsort.eng.ucsd.edu/.

The Tritonsort-MR team acknowledged the support of CNS member company Cisco Systems, Inc. and the National Science Foundation..

Success at the Summer 2011 Research Review

On August 3 and 4, CNS held its 15th semi-annual Research Review in the Jacobs School of Engineering on the UC San Diego campus. The agenda included summaries of ongoing or recently concluded CNS Research grants, talks by industry leaders from Intel, Microsoft, and Technicolor, and a poster session of recent work by graduate students. The highlight of the event was a slate of research proposals from CSE and ECE professors on such topics as managing data in digital cinema, redundancy in distributed systems, energy management in smart phones and batch workloads, and security in cloud-backed file services. Though research proposals were formerly only made at the Summer Research Review, it was announced that proposals will also occur at the Winter Reviews going forward.

CNS Announces New Membership Structure

In a response to the changing needs of our industrial members and affiliates, CNS announced at the CNS Summer Research Review a revision of its membership structure and grant funding model. Interim Director Stefan Savage explained to attendees how the old model of collecting membership fees to fund a number of proposals that members chose jointly was being retired. Going forward, members will be invited to participate either as affiliates or as direct sponsors of research. Affiliate members join by paying annual dues that give them access to CNS events, brainstorming meetings with our faculty and research scientists, and recruitment opportunities with our graduate students. Companies who wish to support specific research projects will have a seat of on the CNS Advisory Board, an annual visit to the company from our Director, and further access to networking opportunities with our faculty and graduate students.

For more information about our new membership structure and benefits, see: http://cns.ucsd.edu/memberbenefits.shtml. If you have any questions, please email CNS Director Stefan Savage at cns@ucsd.edu.

Get Connected

Stay up-to-date about upcoming CNS events, including lectures and Research Reviews, by signing up for the CNS Events RSS feed. To do so, visit the CNS website at

http://cns.ucsd.edu

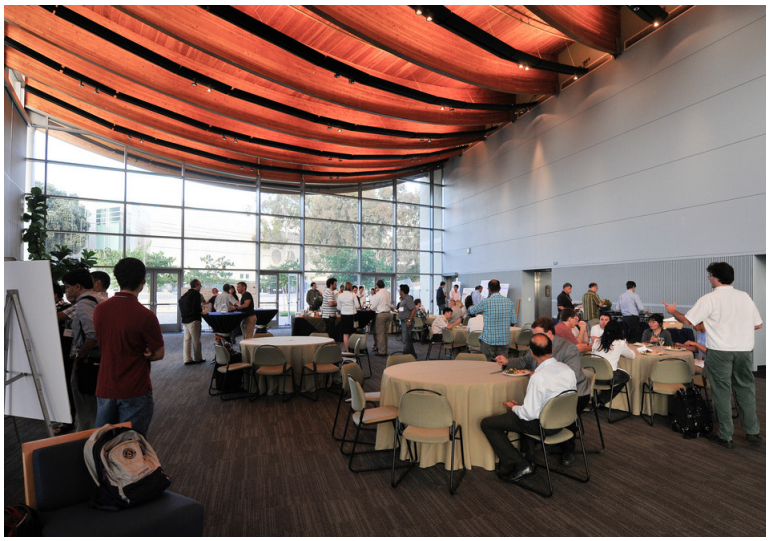
and click on the link "CNS Events RSS Feed."

Upcoming Events

CNS Winter 2012 Research Review
UC San Diego Campus in La Jolla, Calif.

The Research Review will take place on February 8 and 9, 2012 on the UC San Diego campus. The agenda will include research proposals, talks given by industry guests, updates on ongoing CNS research projects, a graduate student poster session, and numerous opportunities for networking and interaction with academic and industry members of the research community. Attendance is by invitation only to CNS sponsors and affiliates.

If interested, please contact Director Stefan Savage at cns@ucsd.edu. For more information, please contact Kathy Krane at kkrane@ucsd.edu or call 858-822-5964.



Mission and Objectives of CNS

The mission of CNS is to develop key technologies and frameworks for networked systems. By combining our research talents and strengths in partnership with industrial leaders, CNS achieves critical mass and relevant focus, accelerating research progress and creating key technologies, frameworks and systems understanding for robust, secure networked systems and innovative new applications. CNS also works to educate the next generation of top students with a perspective on industry-relevant research and to train students on how to continue their leadership throughout their careers. This is accomplished by bringing together leading faculty, students, and companies to investigate the most challenging, interesting and important problems in computer networks.

If you are interested in joining the Center, please contact Director Amin Vahdat at vahdat@cs.ucsd.edu.