ISR Connector

INSTITUTE FOR SOFTWARE RESEARCH / UNIVERSITY OF CALIFORNIA, IRVINE

HOT RESEARCH

Automated Means of Vetting Mobile Apps

Mobile app markets are creating a fundamental paradigm shift in the way software is delivered to end users. By providing a medium for reaching a large consumer market at a nominal cost, app markets have leveled the software industry, allowing entrepreneurs and hobbyist programmers to compete with prominent software development companies. The result of this has been an explosive growth in the number of new apps for platforms that have embraced this method of provisioning software, such as Android. This paradigm shift, however, has given rise to a new set of security challenges.

Professor Sam Malek

Over the past few years, Professor **Sam Malek** has received substantial funding from various government agencies (e.g., DHS, DARPA, FBI, NSA, NSF) to develop new technologies for mitigating the security risks posed by mobile apps. According to Malek, "We are witnessing a steep increase in the security threats targeted at mobile platforms. This is nowhere more evident than in the Google Play market, where we have seen many cases of apps infected with malwares and spywares collecting all sorts of private user data for nefarious purposes." A key obstacle to safeguarding the app markets is the fact that assessing the security properties of apps is largely a cumbersome manual process. The market operators, developers, and users alike are in desperate need of automated tools for vetting the trustworthiness of apps. The development of such tools has been the focus of Malek's research.

Malek explains, "Broadly, our research in this area can be categorized under two thrusts: (1) How to ensure an app does not harbor a malicious capability. For instance, ensuring an app does not have the ability to eavesdrop on the user. (2) How to ensure an app does not have security vulnerabilities that could be exploited by an attacker. For example, ensuring an app cannot be tricked into leaking private user information."

The first thrust of research in Malek's group has resulted in RevealDroid, a machine-learning based approach for malware detection and family identification. RevealDroid uses novel program analysis techniques to extract security-relevant properties, referred to as features, from simply an app's installation files, and without requiring access to its source code. One of the key challenges of detecting malicious behavior is that attackers often obfuscate their code, i.e., change the implementation logic of the malicious behavior to avoid detection via conventional signature-based anti-virus products. To mitigate this challenge, RevealDroid focuses the analysis on features that are difficult to obfuscate. Specifically, RevealDroid extracts features

RESEARCH BRIEFS

Prof. **Sam Malek** and Assistant Project Scientist **Hamid Bagheri** have been awarded $499,170 by the National Science Foundation for their research on "Efficient Formal Analysis of Evolving Software Systems."

Prof. **Paul Dourish** has been awarded $193,899 by the National Science Foundation in the Science, Technology, and Society program for his research on "Representational Materialities of Internet Protocols."

Prof. **Gloria Mark** was a featured speaker at the Aspen Ideas Festival in June. She was one of three speakers in the Connecting With Purpose breakout in the Power of Connectivity track. She spoke on the power of connectivity in our day-to-day lives.

Prof. **Crista Lopes** gave a keynote talk titled "Simulating Cities: A Systems Design Perspective" at the 15th International Conference on Modularity held in Spain in March.

Prof. **Walt Scacchi** has been awarded $117,658 from the Naval Postgraduate School, Acquisition Research Program for his project "Achieving Better Buying Power for Mobile Open Architecture Software Systems Through Diverse Acquisition Strategies." ISR Research Associate **Thomas Alspaugh** is assisting in the project.

Prof. **Alfred Kobsa** gave an invited talk titled "TIPPERS: A Test Bed to Explore IoT Privacy by Design" at the iConference 2016 Information Privacy Workshop held in Philadelphia, PA in March.

More Research Briefs on pages 9.

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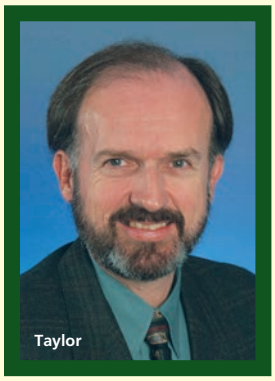
MESSAGE FROM THE DIRECTOR

Which Industry are we talking about? And does Academia have anything to say?

The ISR Research Forum held at UCI in late May of this year was highlighted by two keynote addresses, one by Dr. Eric Dashofy from The Aerospace Corporation and the other by Dr. Marija Mikic from Google, Inc. Though titled differently and addressing somewhat different concerns the two talks both fundamentally addressed how software can be, and is being, built in industry today. Software architecture was a common theme, but with two very different takes: Dashofy highlighted the limits imposed on principle-driven design by the ever-encroaching maw of frameworks; Mikic highlighted how up-front, clear, documented design coupled with an admirably comprehensive development process rules the day within Google. The ensuing discussion centered around what corporate and/or financial characteristics need to be in place before a "doing it right" approach is both feasible and cost-effective. One answer posited was that it takes an organization with the resources of Google to "do it right." But other experience belies this. I am familiar, for example, with a small software shop overseas that indeed "does it right" and does so without access to a lot of financial or personnel resources. The issue, rather, seems to be the constraints an organization labors under. When constrained by particular kinds of interoperability demands, procurement policies, or lock-in to some vendor's products, life becomes much more difficult, and doing it right becomes less of an achievable goal—even though there would be many benefits. This statement is too facile, of course, and could be used to exonerate plain-old poor engineering practice. Teasing out the issues and understanding the core underlying matters is what makes research in this area so interesting. The Forum just scratched the surface, but I think it gave our audience a lot to contemplate.


Taylor

The degree to which academic research can contribute to practical software development practices is a matter of much debate. Arguably, system design that proceeds methodically from the application of solid reasoning based on analyzed, codified experience is ultimately the fruit of good academic work. I recently attended a UCI-ICS/Engineering alumni event in New York City during which several attendees related stories validating the utility of what they had learned during their time at UCI. While that is always gratifying to hear, my view is that the research field today is, in large measure, moving most unfortunately towards the useless kind of academic work that makes for cynical comments. More than a few recently published papers in prestigious conferences, for instance, give well-packaged experimental answers to questions that no one is the least bit interested in, nor will ever be interested in. A slavish devotion to statistically valid experiments has seemingly pushed system development and technology innovation to the sidelines. Even formal pressures within academia influence this, where shrinking limitations on the time one has to finish all degree requirements is slowly squeezing out room for substantive system building and meaningful partnerships with industry. Schools in the U.K. are probably in the worst shape for this, as there is a 4-year (post Bachelor's degree) normative time to degree in many schools. Required post-docs anyone?

The difficult matter is determining what to do about this drift and, to the extent it is part of the problem, determining how to "fix" the conferences. The plague of inconsequential results is not confined to software engineering, and in that observation there is hope, for many fields are wrestling with this issue and some potential solutions are emerging. In the database community, for example, the VLDB conference accepts papers continuously throughout the year. Published versions appear in the PVLDB journal, and oral presentations corresponding to only those papers are given at the annual VLDB conference. Arguably this addresses some issues, such as quality and scalability of reviewing, but does not necessarily address the lack of wrestling with consequential issues. For that there must be a mechanism to encourage and reward system building and evaluation that may span several years. Let me know if you have any suggestions.

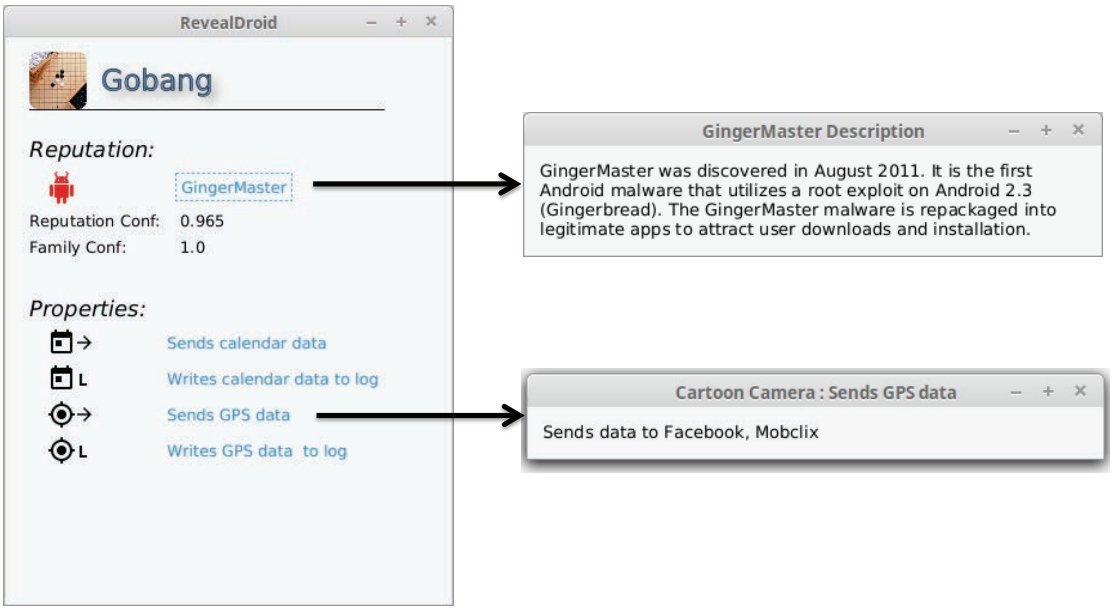
New Associate Director

Lastly, and on a decidedly happy note, I am very pleased to announce the appointment of Professor **Crista Lopes** as Associate Director for ISR. I look forward to her contributions and leadership as we work together to determine strategic emphases for ISR.

ISR Director **Richard N. Taylor** can be reached at taylor@uci.edu.

such as Android-API usage and system call invocations that are outside the control of the attacker, and thus much more difficult to obfuscate. In extensive experiments on a dataset of 51,496 malicious and benign apps, RevealDroid was able to detect malicious apps with an accuracy of 91%, and identify the malware family of the app with 87% accuracy. Most notably, RevealDroid was able to achieve this accuracy on heavily obfuscated apps that were shown to evade all major commercial antivirus products.

According to Malek, "The most rewarding

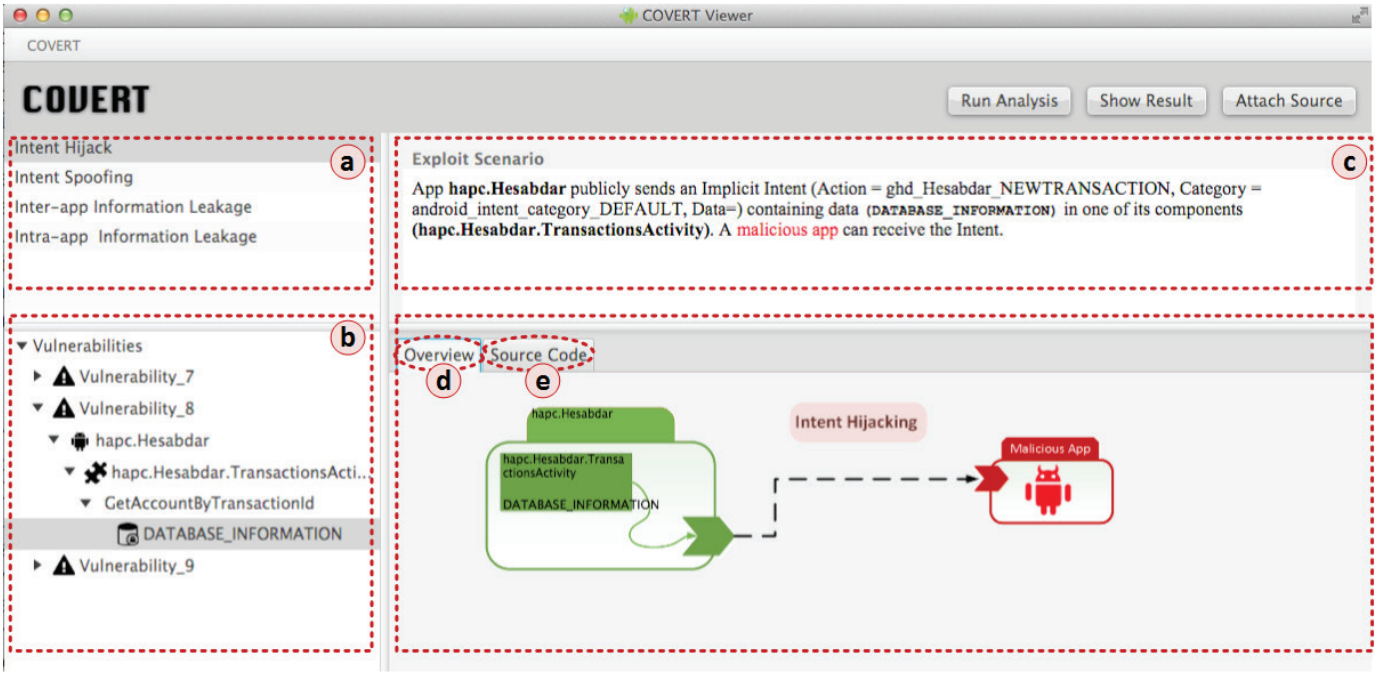


Output of RevealDroid after analysis of an app. For each app, it determines the reputation of the app as benign or malicious, its family if it is malicious, as well as the properties that make it malicious.

part of this work has been the adoption of RevealDroid by the security analysts within the Department of Homeland Security (DHS) and Federal Bureau of Investigation (FBI) for vetting mobile apps." RevealDroid is now one of the tools available on the Software Assurance Marketplace (SWAMP), a DHS-sponsored cloud-based environment for vetting software products used in the government.

The second thrust of research in Malek's group has resulted in the development of COVERT, an approach for detection of security issues that arise due to the interaction of multiple apps. This is an increasingly important problem for Android due to its flexible Inter-Component Communication (ICC) that may cross app boundaries. As an example, it has been shown that a malicious app may simultaneously exploit vulnerabilities in two benign, yet vulnerable apps, to achieve its objectives. Similarly, given that Android's permissions are enforced at the level of individual apps, it is quite easy for two malicious apps to collude and leak the user's private information.

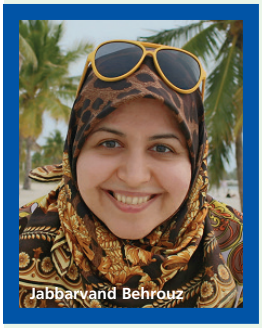
Since a given device may have a large number of installed apps, evaluating security issues that arise due to their interaction is a very challenging problem. To solve this problem, Malek and his team developed a hybrid static analysis and formal verification technique that decomposes the problem as follows. Each individual app is first statically analyzed to extract security-relevant properties about its behavior. These properties are then specified in a formal declarative language, called Alloy, the models of which can be composed and analyzed together with the help of an off-the-shelf SAT Solver. This novel approach allowsCOVERT to decouple the static extraction of apps' security-sensitive behaviors from the verification of their interactions through the ICC



A snapshot of COVERT's user interface after analysis of a set of apps: (a) vulnerability categories; (b) detailed elements of vulnerabilities; (c) a potential exploit scenario; (d) graphical overview of the exploit scenario; and (e) decompiled source code of vulnerable component.

ISR STUDENT NEWS

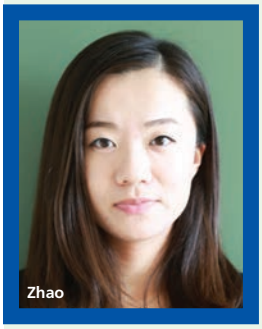
Reyhaneh Jabbarvand Behrouz's (S. Malek, advisor) paper "Energy-Aware Test-Suite Minimization for Android" was accepted to ISSTA'16: The International Symposium on Software Testing and Analysis, held in Saarbrücken, Germany in July. The paper is co-authored by fellow Ph.D. student **Alireza Sadeghi**, assistant project scientist **Hamid Bagheri**, and her advisor, Prof. **Sam Malek**.


Jabbarvand Behrouz

Alireza Sadeghi (S. Malek, advisor) is interning this summer at Google in Mountain View, CA where he is working on Android app security with the Gmail/App Security team. His mentor is Nicolas Lidzborski. This is the second year that Sadeghi has interned at Google.

Sadeghi

Mengyao Zhao (D. Redmiles, advisor) is spending her summer as an intern at Google in Mountain View, CA as part of the Analytics team as a User Experience (UX) researcher. Zhao also served as Social Media Chair for the 11th IEEE International Conference on Global Software Engineering (ICGSE) held in August at UC Irvine.


Zhao

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Affiliate—Visiting	$40,000	Visitor at UCI.
Affiliate—Grad Student	$60,000	Graduate student research.
Partner	$100,000 or more	Large-scale research project.

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capabilities of Android. It also eliminates the need to perform the analysis again from scratch every time apps are updated and new ones are installed. In a set of experiments over 4,000 real-world apps, COVERT was able to identify 385 types of vulnerabilities, most of which were previously unknown.

Malek believes there is a lot more future work in this space. He explains, "In spite of the promising results we have gotten so far, our tools suffer from the well-known limitations of static program analysis. Most notably, the static approximation of a program's behavior can result in false positives, meaning, for instance, identification of vulnerabilities that are not really exploitable." To mitigate this limitation and make the technology more useful for practitioners, Malek and his group are now working on dynamic analyses to complement the properties that can be inferred statically. His group is also developing a self-protection autonomic framework that allows a mobile device to intelligently neutralize security attacks at runtime. Finally, in addition to their work on mobile security, his group is developing novel automated testing tools to help developers assess other quality attributes (e.g., energy) of their apps.

For more information on these projects visit Malek's Software Engineering and Analysis Lab (SEAL) website:

https://seal.ics.uci.edu/

Contact Prof. Sam Malek at: malek@uci.edu.

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Rubbing elbows with ISR faculty, staff and students gives you a valuable window into the technology landscape of the future. But a relationship with ISR can be much more: Think of us as an extension of your company—a think tank, an R&D department, a research library, a consulting firm, a training department, and an employment agency, all rolled into one. More importantly, when you sponsor ISR you become part of a friendly group of folks who speak the same language and are eager to work with you to solve your current technical problems in the most cost-effective way possible.

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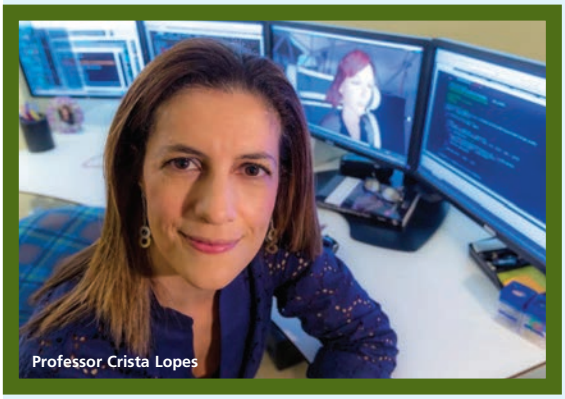
Crista Lopes is Recipient of the Pizzigati Prize

The Tides Foundation, a social justice and sustainability-focused organization, has awarded ISR Associate Director Prof. **Crista Lopes** the Antonio Pizzigati Prize for Software in the Public Interest. The prize, which includes a $10,000 cash grant, is given annually to one individual who has created or led an effort to create an open source software product of significant value to the nonprofit sector and movements for social change. Lopes is the first woman to receive the honor.


Professor Crista Lopes

The Tide Foundation blog notes that "Lopes has been the moving force behind OpenSimulator, the noncommercial software that's opening the 3D virtual world to nonprofits all across the globe. The decade-long effort behind OpenSimulator has involved hundreds of programmers, but no developer has been more central to that effort than Lopes. She has personally designed much of OpenSimulator's core architecture. As coach, mentor, and host of the first ever virtual OpenSimulator conference, Lopes has also nurtured the vibrant open source community that has evolved around the software."

"I strongly believe in the benefits of a public software infrastructure, something that has been emerging over the past 20 years or so, but that needs a lot more investment by everyone," Lopes says. "Modern society runs on it, and the developers who contribute to it are unsung heroes. So I am honored to be given this award by the Tides Foundation, who seems to have a similar attitude."

For more information:

http://www.tides.org/impact/awards-prizes/pizzigati-prize/winners/#lopes

Software Analytics at Scale

The DARPA Mining and Understanding Software Enclaves (MUSE) program seeks to make significant advances in the way software is built, debugged, verified, maintained, and understood. Central to its approach is the creation of a community infrastructure built around a large, diverse, and evolving corpus of software drawn from the hundreds of billions of lines of open source code available today.

An integral part of the envisioned infrastructure is a continuously operational specification mining engine. This engine will leverage deep program analyses and foundational ideas underlying big data analytics to populate and refine a database containing inferences about useful properties, behaviors and vulnerabilities of the program components in the corpus. The collective knowledge gleaned from this effort would facilitate new mechanisms for dramatically improving software reliability, and help develop radically different approaches for automatically constructing and repairing complex software.

Central to this vision is the very important step of understanding the nature of these very large bodies of source code. In machine learning, the results are only as good as the data that is fed into the system. So, what do these repositories consist of? Are all projects "good data"? This is where Associate Director Prof. **Crista Lopes** comes in. Her team is performing software analytics at scale in order to better understand how these very large repositories of open source code can best be used.

For example, in analyzing the existing MUSE corpus, which includes 150,000+ Java projects and 70,000+ C/C++ projects from various origins, Lopes and her team have discovered a large amount of code

ISR STUDENT NEWS

Eugenia Gabrielova (C. Lopes, advisor) is interning for the second summer in a row at SPAWAR Systems Center Pacific in San Diego in the Cybersecurity Science & Technology division. She hopes to investigate how her research on distributed system testing might be used on systems already in development at SPAWAR and to gain some insights into testing and performance challenges in cybersecurity. Her SPAWAR mentor is ISR alumnus **Jose Romero-Mariona.**

Gabrielova

Wen Shen (C. Lopes, advisor) presented his paper "An Online Mechanism for Ridesharing in Autonomous Mobility-on-Demand Systems" at the 25th Int'l Joint Conference on Artificial Intelligence (IJCAI-16) held in New York, NY in July. The paper is co-authored by his advisor, Prof. **Crista Lopes,** and Jacob W. Crandall of the Masdar Institute of Science and Technology, UAE.

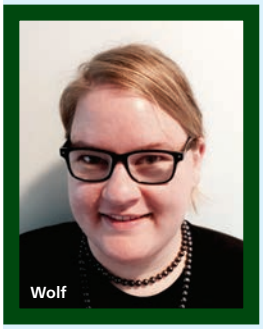
Shen

Vijay Krishna Palepu (J. Jones, advisor) is spending his summer interning at Microsoft in Redmond, WA with the Microsoft Word Engineering team. Pelapu is working on the iOS app for Microsoft Word.

Pelapu

ISR STUDENT NEWS

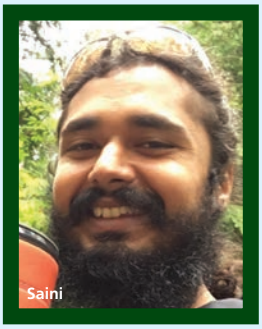
Chris Wolf (P. Dourish, advisor) has received an IBM Ph.D. Fellowship for 2016-17. The IBM Ph.D. Fellowship Awards Program is an intensely competitive worldwide program, which honors exceptional Ph.D. students who have an interest in solving problems that are important to IBM and fundamental to innovation in many academic disciplines and areas of study.


Wolf

Noopur Raval (P. Dourish, advisor) has been appointed as an affiliate of the Berkman Klein Center for Internet & Society at Harvard University for 2016-17 where she will continue her research on ridehailing technologies and digital labor issues.

Raval

Vaibhav Saini (C. Lopes, advisor) presented his paper "SourcererCC and SourcererCC-I: Tools to Detect Clones in Batch mode and During Software Development" in the Demonstrations Track at the 38th International Conference on Software Engineering (ICSE) held in Austin, TX in May. The paper is co-authored by alumni **Hitesh Sajnani** and **Jaewoo Kim**, and Saini's advisor Prof. **Cristina Videira Lopes**.


Saini

Spotlight on Paul Dourish

ISR would like to congratulate Prof. **Paul Dourish** for a number of recent notable achievements:

Professor Paul Dourish

Prof. Dourish has been named a 2015 ACM Fellow for contributions in social computing and human-computer interaction. The ACM Fellow, ACM's most prestigious member grade, recognizes the top 1% of ACM members for their outstanding accomplishments in computing and information technology and/or outstanding service to ACM and the larger computing community.

The CSCW 2016 Lasting Impact Award was presented to Prof. Paul Dourish and Victoria Bellotti of PARC for their CSCW 1992 paper, "Awareness and Coordination in Shared Workspaces."

Prof. Dourish has also been awarded the title of Chancellor's Professor. This title is designed to recognize persons who have earned the title of Professor and who have demonstrated unusual academic merit and whose continued promise for scholarly achievement is unusually high.

duplication. Just within the non-fork projects coming from Github, they found the following:

- out of 2.6M Java files, 62% of them have an exact- or near-duplicate within that subset of projects;
- out of 14.5M C/C++ files, 90% of them have an exact- or near-duplicate within that subset of projects;
- out of 18,000 Java projects, the entire source code of 9% of them can be found in other projects;
- out of 42,000 C/C++ projects, the entire source code of 11% of them can be found in other projects.

When analyzing the entire corpus, which contains projects from many origins, these figures are even higher, because many open source projects have replicas in different software repositories. Data mining and machine learning efforts need to be informed about this duplication and avoid it, or target it, depending on what they are trying to achieve.

Clone detection at scale is performed using a special clone detection tool developed by Lopes' team, SourcererCC, which is publicly available (https://github.com/Mondego/SourcererCC). The tool is currently being improved and expanded in order to be able to work on code written in any programming language. Besides its use in the MUSE program, SourcererCC can also be used to detect plagiarism and license violations.

In addition to clone detection, the buildability of projects is another important characteristic for software analytics: projects that build are usually more valuable for the ability to learn from them than projects that fail to build. Prof. Lopes and her team are leading the way in devising heuristics for automatically building projects at scale, without manual intervention. Out of the 134,000+ non-empty Java projects, they were able to successfully resolve dependencies and build 31% of them. This ongoing effort is expected to increase the build rate over the next two years. Similarly, finding projects with test cases is also important for many uses of large corpora.

Prof. Lopes MUSE team includes postdoctoral researcher **Pedro Martins**, a recent Ph.D. graduate **Hitesh Sajnani** (now at Microsoft Research) and graduate students **Rohan Achar**, **Vaibhav Saini**, and **Di Yang.**

More about Prof. Lopes and her team can be found at: http://mondego.ics.uci.edu/

Contact Lopes at lopes@ics.uci.edu.

Keynote Dr. Eric Dashofy

Keynote Dr. Marija Mikic

2016 ISR Research Forum: *Where Research meets the Real World*

ISR held its twelfth Research Forum on May 27th. The goal of the ISR Forum is to foster interaction between industry and ISR researchers, and encourage research collaborations amongst all. The day-long event featured two keynote speakers from industry; seven faculty talks; an Open House with posters and demonstrations of research projects, and a reception with posters to close the day. This year's Forum attracted over 120 attendees from 28 companies and law firms, and 6 universities.

The morning keynote, "Software Architecture: The Dismal Science," was delivered with wit and insight by alumnus Dr. **Eric Dashofy**, Principal Director of Development, Enterprise Information Services at The Aerospace Corp.

Dr. **Marija Mikic**, Software Engineering Manager at Google, gave the afternoon keynote,"Software Engineering at Google Scale," where she addressed challenges faced by their software engineers.

The seven faculty talks covered a broad range of topics: simulation of cities; crowd design; mobile app security; global software engineering; IoT privacy; and a software engineering perspective on expert witness engagements.

Ph.D. student Reyhaneh Jabbarvand Behrouz presents her research poster at the Forum Open House.

The Open House provided an ideal opportunity for attendees to interact with researchers one-on-one and learn about projects firsthand. Ph.D. student **Vaibhav Saini** noted, "One thing I really appreciate about the Forum Open House is that we get feedback from both researchers and practitioners. The Open House has just the right number of attendees, making it easy to get people's attention and have valuable conversations."

Dr. Dashofy reflected on the event and Aerospace Corp.'s relationship with ISR: "As an ISR alum now working in industry at The Aerospace Corporation, events like the ISR Forum help us maintain and strengthen our connection to the research, people, and products being developed at UCI. Aerospace's long relationship with ISR via our Corporate University Affiliates Program (CUAP) has resulted in mutually beneficial exchanges for years: UCI and Aerospace personnel regularly give seminars and talks at each other's facilities, collaborate on research projects, and partner on student capstone classes. The knowledge exchange that occurs helps keep Aerospace aware of emerging and innovative ideas, technologies, and products that we can incorporate into our work. The ISR Forum is also a unique opportunity to make industry-to-industry connections with other attendees from different companies in different domains – many of them ISR alumni as well.

"In addition to exchanging knowledge, we also exchange people! Many ISR students have come to work for Aerospace over the years as interns and full-time staff, and occasionally an Aerospace employee will pursue continuing education opportunities at UCI. In fact, my first exposure to Aerospace was as a grad student at ISR events like the Forum, and now I'm proud to represent Aerospace on the other side of that relationship."

For more information, including videos of most talks and presenters' slides, visit: http://isr.uci.edu/isr-events/forum/2016/

ISR STUDENT NEWS

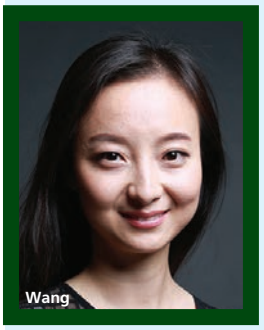
Katherine Lo (P. Dourish, advisor) has received a three year NSF Graduate Research Fellowship. The NSF Graduate Research Fellowship Program recognizes and supports outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines.

Lo

Lee Martie (A. van der Hoek, advisor) has received a 2016-17 IBM Ph.D. Fellowship. This fellowship program is an intensely competitive worldwide program, which honors exceptional Ph.D. students who have an interest in solving problems that are important to IBM and fundamental to innovation in many academic disciplines and areas of study. Additionally, Martie is spending his summer as an intern at IBM T.J. Watson in New York for the second summer in a row. His mentor at IBM is Peri Tarr.

Martie

Yiran Wang (G. Mark, advisor) was selected to attend the 2016 Human Computer Interaction Consortium (HCIC) held in Watsonville, CA in June where she gave a 'boaster' to introduce her research on youth and technology, and how the Millennial generation engages with information and communication technologies.


Wang

ISR STUDENT NEWS

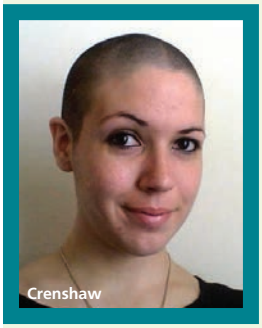
Caitie Lustig (B. Nardi and G. Bowker, advisors) was a co-organizer and co-moderator of a panel on "Algorithmic Authority: the Ethics, Politics, and Economics of Algorithms that Interpret, Decide, and Manage" at the ACM Conference for Human-Computer Interaction (CHI 2016) in San Jose, CA in May.

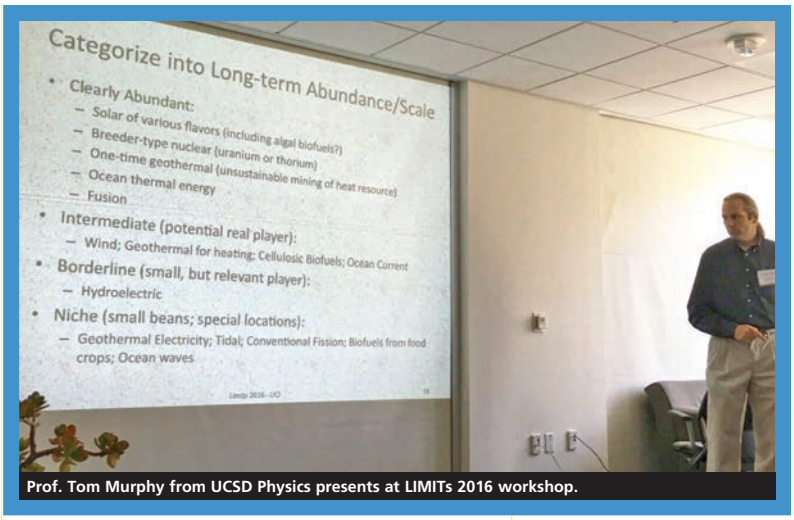
Lustig

Daniel Gardner (B. Nardi, advisor) is presenting his paper "Gatekeeping Games: A Topographic Consideration of Para-Ludic Borderlands" at the First International Joint Conference of DIGRA (Digital Games Research Association) and FDG (Foundations of Digital Games) in August at Dundee, UK.

Gardner

Nicole Crenshaw (B. Nardi, advisor) is co-author on the paper "'Its'a Me, Mario!': Costumed Gaming's Effects on Character Identification" which is being presented at the First International Joint Conference of DIGRA (Digital Games Research Association) and FDG (Foundations of Digital Games) in August at Dundee, UK. The paper is co-authored by ICS Prof. Joshua Tanenbaum and ICS project scientist Karen Tanenbaum.


Crenshaw



Prof. Tom Murphy from UCSD Physics presents at LIMITs 2016 workshop.

Prof. Bonnie Nardi Reports on LIMITS 2016 Workshop

The Second Workshop on Computing within LIMITS was held at UCI on June 9-10. Among the organizers of the workshop were ISR faculty members **Debra Richardson** and myself, Professor **Bonnie Nardi**. The objective of this series of workshops is to foster discussion on the impact of present and future ecological, material, energetic, and/or societal limits on computing. These topics are seldom discussed in contemporary computing research. A goal is to foster concrete research that innovates on technologies, techniques, and contexts for computing within fundamental physical planetary limits. Phenomena such as climate change, air and water pollution, soil erosion, declining fisheries, finite oil reserves, and a host of environmental problems, argue that we must consider out of the box approaches for new forms of computing that build on what we have developed so far, but that innovate to recognize the finiteness of the planet.

What did we do at the Workshop? We talked! Participants presented excellent papers and there was plenty of time for informal discussion. We heard three featured talks. Professor Lisa Nathan from UBC's iSchool spoke about long-term design—beyond a single human lifespan, which is very relevant to the time scale of the problems we are concerned with. Professor Tom Murphy from UCSD's Department of Physics discussed his analyses of energy and the economy. Some of what he spoke of can be found on his website "Do the Math" (http://physics.ucsd.edu/do-the-math/) where he writes about economic growth, the meaning of sustainability, his chickens, and his view of the kind of personality people who care about limits tend to have. Professor Sarah Taylor Lovell from the Department of Crop Sciences at the University of Illinois spoke of her research on finding sustainable alternatives to industrial agriculture whose externalities of pollution, erosion, and similar problems indicate the need for study of other modes of food production.

The papers considered computational approaches to building shelter in a future of limits, the role of popular culture in creating technological narratives, the development of an Internet quine (i.e. a set of networking technologies and components required to create a self-sustainable Internet), approximate networking, systems complexity, digital Commons, and an online course on global disruptions and information technology. The papers clustered within the subfields of SHCI (sustainable human-computer interaction), ICTD (information and communication technologies for development), networking/systems, and crisis informatics. The focus on crisis informatics was new this year, and represents the understanding that many "crises" and "natural disasters" are actually the outcome of long-term sociopolitical processes that have altered the climate, topography, and so on, and thereby altered the populations and cultures who live in affected regions.

Students participated including **Samantha McDonald** who will join the Department of Informatics and ISR as a graduate student in the Fall, where she will be co-advised by ICS Professor Bill Tomlinson and me. McDonald presented a paper on sustainable 3D printing.

The papers are available at http://limits2016.org (click on Program).

In addition to presentations, LIMITS 2016 featured small breakout sessions and lively discussions, with several people ultimately discussing collaborations they might form in the future—which was one of the key goals of the workshop.

Participants came from seven countries (Abu Dhabi, Canada, Pakistan, Spain, Sweden, the UK, and the US), which was fitting for our topic which is inherently global.

We videotaped this year's workshop, and while the videos are not edited, you can get a good sense of the talks:

Day One: https://www.youtube.com/watch?v=tQYE5SoPwAA

Day Two: https://youtu.be/MlvuZQSMmwc

The organizers would like to thank the Newkirk Center for Science and Society for their generous funding and logistical support, as well as the Center for Research in Sustainability, Collapse-preparedness, and Information Technology (Professor Debra Richardson, Director) for additional funding. We also thank our community volunteer, Kathryn Hansen, who helped make sure everything ran smoothly and contributed to the discussions.

LIMITS 2016 was held in cooperation with ACM SIGCAS—the Special Interest Group on Computers & Society.

More information about LIMITS 2016 is available at:

http://www.limits2016.org/

The papers from last year's workshop, LIMITS 2015, are available at:

http://firstmonday.org/ojs/index.php/fm/issue/view/460

Another LIMITS workshop will be held next year; contact me if you are interested. I can be reached at nardi@ics.uci.edu.

RESEARCH BRIEFS

Prof. **Walt Scacchi** gave a talk titled "Emerging Research Issues in the Defense Open Architecture Ecosystem" at The Aerospace Corporation in El Segundo, CA in April as part of their CSD Tech Forum series.

Prof. **Sam Malek**, and Profs. Daniel A. Menasce and Hassan Gomaa at GMU, have been awarded $1,016,641 by the Air Force Office of Scientific Research (AFOSR) for their research on "RASS: Resilient Autonomic Software Systems."

Associate Director Prof. **Crista Lopes** gave a keynote talk titled "Designing for Attention in Virtual Environments (or: How a Camera Changes Everything)" at the Immersive Learning Research Network (ILRN) annual conference held in Santa Barbara, CA in June.

Prof. **Gloria Mark** served as keynote speaker at the Kyoto University International Design Symposium in March. Her talk was titled "Using Precision Data Tracking for Design: Identifying patterns of Attention Focus, Mood and Stress."

Prof. **James A. Jones** served as Doctoral Symposium Co-Chair at the 38th International Conference on Software Engineering (ICSE 2016) held in Austin, TX in May.

Dr. **Shinobu Saito**, a Senior Research Engineer in the Software Engineering Project at the NTT Software Innovation Center in Japan, is spending a year visiting ISR beginning July 1.

Assistant Project Scientist **Joshua Garcia** presented the paper "Reducing Combinatorics in GUI Testing of Android Applications" at the 38th International Conference on Software Engineering (ICSE 2016) in Austin, TX in May. The paper is co-authored by Ph.D. student Nariman Mirzaei at George Mason University, Assistant Project Scientist **Hamid Bagheri**, Ph.D. student **Alireza Sadeghi,** and Prof. **Sam Malek**.

Prof. Walt Scacchi and Eric Dashofy at GSAW.

ISR Participates in 2016 Ground System Architectures Workshop (GSAW)

The annual Ground System Architectures Workshop, sponsored by The Aerospace Corporation, is held in cooperation with ISR each year. GSAW 2016 was held February 29 – March 3 in Los Angeles, CA. This year ISR Prof. **Walt Scacchi** delivered a half-day tutorial titled "Beyond Open Architecture: Issues, Challenges, and Opportunities in Open Source Software Development (OSSD) for Aerospace and Defense Applications." The goal of the tutorial was to provide software developers, system architects, project managers, program managers, and others with an introduction to the state of the art in open source development processes, work practices, and community dynamics. Over 30 attendees participated in this informative tutorial. This is the third time Prof. Scacchi has given a tutorial at GSAW.

"GSAW continues to go from strength to strength," says ISR Director **Richard N. Taylor,** who serves on the GSAW Steering Committee. "The challenges of creating and maintaining forward-looking space ground systems encompass virtually every area of software engineering research. It is thus natural for ISR to continue to be a part of GSAW's mission. I am especially encouraged by the interest and desire of the GSAW organizers to develop new ways to encourage graduate student participation, including taking leadership roles in associated workshops."

For more information on GSAW, visit:

https://gsaw.org/

New York: Justin Erenkrantz (Ph.D. 2009; R. Taylor, advisor); Benjamin Koehne (Ph.D. 2014; D. Redmiles, advisor); ISR Director Prof. Richard N. Taylor; Alegria Baquero Merino (Ph.D. 2014; R.Taylor, advisor); and Sameer Patil (Ph.D 2009; A. Kobsa, advisor). Photo by Bin Song.

San Franciso: Prof. André van der Hoek; and Arthur Hitomi (Ph.D. 2010; R. Taylor, advisor).

Alumni Events in New York and San Francisco

The Schools of ICS and Engineering recently held two exciting alumni events providing a great opportunity for ISR faculty and alumni to reconnect, network, and establish new relationships.

The first of the two events was held April 13 in New York City at Park Imperial. ISR Director Prof. **Richard N. Taylor** attended, and was delighted to catch up with two of his Ph.D. graduates – **Justin Erenkrantz**, Head of Compute Architecture at Bloomberg, and **Alegria Baquero**, Software Engineer at ZocDoc. Other ISR alums in attendance included **Benjamin Koehne**, a User Experience Researcher at Google, and **Sameer Patil**, incoming Assistant Professor in the School of Informatics and Computing at Indiana University, Bloomington and an ISR faculty associate.

On May 18, a second alumni event was held in San Francisco at Autodesk where ISR alum **Erin Bradner**, a Design Researcher at Autodesk, gave a talk on "Generative Design: How humans and algorithms team up to design." Also present were: **Arthur Hitomi**, CTO and Co-Founder of Numecent; ICS Alumni Hall of Fame inductee **Owen O'Malley**, Founder and Technical Fellow at HortonWorks; and **Leyna Cotran**, a Requirements & Process Manager at ARMUS Corp. They were joined by ISR Prof. **André van der Hoek** and ISR Associate Director Prof. **Crista Lopes**.

San Franciso: Owen O'Malley (Ph.D .1996; D. Richardson, advisor); ISR Associate Director Prof. Crista Lopes; Erin Bradner (Ph.D. 2001; G. Mark, advisor); and Leyna Cotran (Ph.D. 2013; R. Taylor, advisor).

ISR Technical Reports Available Online

ISR technical reports present information resulting from student and faculty research carried out under the auspices of the Institute. They showcase early results not available in print elsewhere. ISR technical reports are available in PDF on the ISR website. Recent reports include:

"Lightweight, Obfuscation-Resilient Detection and Family Identification of Android Malware"
Joshua Garcia, Mahmoud Hammad, Sam Malek
UCI-ISR-16-2, January 2016

"A Taxonomy and Qualitative Comparison of Program Analysis Techniques for Security Assessment of Android Apps"
Alireza Sadeghi, Hamid Bagheri, Joshua Garcia, Sam Malek
UCI-ISR-16-1, January 2016

All ISR technical reports are available at: ***http://isr.uci.edu/publications/***

Yubo Kou, Thomas Debeauvais, Prof. Crista Lopes , Hitesh Sajnani, Prof. André van der Hoek and Gerald Bortis at Ph.D. commencements.

Congratulations to ISR Graduates!

Join us in wishing our recent graduates well as they move on to new jobs around the country and the world. Three cheers to one and all!

Gerald Bortis (Ph.D., advisor A. van der Hoek) is now VP of Platform at Mirth.

Thomas Debeauvais (Ph.D., advisor C. Lopes) is now a Data Scientist at Twitch.

Michael Gorlick (Ph.D., advisor R. Taylor) has resumed his role as a senior member of the technical staff at The Aerospace Corporation.

Maryam Khademi (Ph.D., advisor C. Lopes) is now a Research Scientist at Intel Corp.

Shibani Konchady (M.S., advisor D. Redmiles) has accepted a position at Amazon in Seattle.

Yubo Kou (Ph.D., advisor B. Nardi) has taken a post-doctoral position at Purdue Polytechnic in the Department of Computer Graphics Technology.

Consuelo Lopez (M.S., advisor A. van der Hoek) is returning to her home country, Argentina, where she is planning to continue her education and pursue a Ph.D.

Hitesh Sajnani (Ph.D., advisor C. Lopes) has taken a position with the Tools for Software Engineering (TSE) group at Microsoft Research.

Martin Shelton (Ph.D., advisor B. Nardi) is a 2016 Knight-Mozilla OpenNews Fellow at the *New York Times*.

Fernando Spanghero (M.S., advisor A. van der Hoek) is on the job market.

Sara Triplett (M.S., advisor A. van der Hoek) is a Lead Development Actuary at FIS.

Bagheri

Congratulations to Post-doctoral Researcher!

Assistant Project Scientist **Hamid Bagheri**, who has been at ISR for the past year working with Prof. **Sam Malek**, has taken a tenure track Assistant Professor position at the University of Nebraska-Lincoln (UNL) in the Department of Computer Science and Engineering.

ISR ALUMNI NEWS

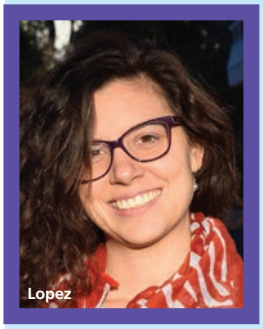
Ken Anderson (Ph.D. 1997, R. Taylor, advisor) has been promoted to Full Professor and Associate Dean for Education at the University of Colorado Boulder, College of Engineering & Applied Science, Department of Computer Science.

Marcio Dias (Ph.D. 2005, D. Richardson, advisor) is now a Technical Architect at Scott Logic Ltd., in Newcastle upon Tyne, UK.

David W. MacDonald (Ph.D. 2000, M. Ackerman, advisor) is now a Full Professor at the University of Washington, College of Engineering, Department of Human Centered Design & Engineering.

Girish Suryanarayana (Ph.D. 2007, R. Taylor, advisor) has been promoted to Senior Key Expert at Siemens Corporate Research & Technologies in Bengaluru, Karnataka, India.

Consuelo Lopez (M.S. 2016, A. van der Hoek, advisor) was awarded the Miguel Velez Scholarship in Spring. This award is given to Masters or Ph.D. students who demonstrate outstanding past academic achievement as well as future promise and are citizens of a Latin American country. Lopez also presented the paper "Toward Microtask Crowdsourcing Software Design Work" in May at the 3rd International Workshop on CrowdSourcing in Software Engineering, held in conjunction with the International Conference on Software Engineering (ICSE 2016) where she was a student volunteer. The paper was co-authored with graduate student **Edgar R.Q. Weidema**, undergrad student **Sahand Nayebaziz**, alumnus **Fernando Spanghero** and her advisor Prof. **André van der Hoek.**



Lopez

Prof. Walt Scacchi with Mark Yampolsky

High School Student Learns Game Design and SE through a Game Prototyping Experience

Many students have an active interest in playing computer games on a variety of different devices. Some students want to transform their interest in game play to game design or game making. Many games employ game mechanics and software development kits (SDKs) that are designed to encourage or embrace game making or modding. While making and modding are important modalities for learning about game design, they primarily rely on informal game design practices and observational learning (e.g., watching online tutorial videos). Such learning modality may be effective, but may also be ad hoc, difficult to systematize and assess, and thus often inefficient or ineffective.

The question now is how best to engage students who want to learn about game design and development, but who may not be ready to commit to a multi-year educational program, or who want to try before they buy into such a program. For example, does computer game development represent an opportunity to introduce high school or undergraduate students to Computer Science or Software Engineering? Can students who know little about CS, but who are familiar with computer game play, social media usage, and Web browsing learn about game design, SE, or CS principles without first learning computer programming? What is an effective way to engage students or others new to game design to learn replicable methods of inquiry and discovery through game design and development? Questions like these helped motivate a study conducted by Prof. **Walt Scacchi**.

His investigation centers around a small case study where a high school student engaged as an ISR Summer intern in 2015, **Mark Yampolsky**, with no prior experience in computer programming or SE was directed by Scacchi to take on the task of learning how to make a new game. Along the way, the task was anticipated to surface many common challenges in SE practice. Likely challenges in requirements, design, prototyping, and playtesting were all expected to emerge, all prior to a formal education in coding or introductory level CS or SE. Game programming would be supported through an interactive game SDK that focuses attention to design of an event-driven, rule-based game, while providing parametric domain-specific code/expression or scripting templates that can be instantiated with data values or control variables. Coding is thus often implicit.

The results of this case study are detailed in a research paper titled "Learning Game Design and Software Engineering through a Game Prototyping Experience: A Case Study" by Yampolsky and Scacchi and were presented at the Fifth Int'l Workshop on Computer Games and Software Engineering (GAS' 2016), held at the 38th Int'l Conference on Software Engineering in Austin, TX in May. A central focus of the study was the analysis of the functional and non-functional requirements, design, and operational prototype of a new Web-based, single user, multi-level game for helping high school and undergraduate students learn about optics and beam physics (and a little quantum teleportation), and how to playfully solve problems in optical beam routing through different configurations of mirrors and lenses. The resulting game prototype addresses more than a dozen functional and non-functional requirements, and its architecture configures six sets of event-processing rules, totaling more than 120 rules. Overall, the approach was successful and can serve as a candidate for follow-on studies that seek to explore the Software Engineering First approach to learning game development.

Prof. Scacchi can be reached at wscacchi@ics.uci.edu.

ISR EVENT SCHEDULE

Mark your calendars!

August 2-5, 2016
International Conference on Global Software Engineering (ICGSE 2016)
Supported by ISR. *http://www.icgse.org*

March 6-9, 2017
Ground System Architectures Workshop (GSAW 2017)
Held in cooperation with ISR. *http://gsaw.org*

Friday, June 2, 2017
ISR Research Forum: *Where Research Meets the Real World*

The 2016-2017 ISR Distinguished Speaker Series will be announced in Fall.

We look forward to seeing you!

For more information, visit: ***http://isr.uci.edu/isr-events***

SPECIAL THANKS

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NTT
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