HOT RESEARCH

GoT: An Architectural Style for Replicated Objects

Global tracking systems, multi-user games, collaborative editors, geo-replicated databases, and real-time collaborative tools are designed around the concept of replicated objects. A replicated object is a single conceptual data unit for which multiple copies exist, one in each node of the distributed application. The reasons for replication are simple: we want the nodes to be highly responsive to local manipulations of the data. Waiting for round-trips to a single, central object would make for a terrible experience at the terminal nodes. Hence, replicas that are, at least partially, autonomous.

Prof. Cristina Lopes

However, replicated objects add considerable complexity to distributed applications. Because they are meant to represent a single conceptual data unit, the state of the replicas must be synchronized. This synchronization opens up a Pandora's box of design and implementation details that are extremely hard to get right. What if two or more nodes change the same fields of the replicas in incompatible ways at the same time? How do we deal with transactional effects, that is, objects whose value depends on the state of other objects? When changes need to be propagated, how can we avoid sending the entire objects all the time to every node? Should we propagate state changes immediately as they occur, or should state updates be buffered, and even throttled? What happens to state updates on replicas upon network partitions?

A common solution to a broad category of synchronization problems in these applications is to use a server-mediated architecture; that is, have one of the nodes be the container of the authoritative replicas.

This solves the issue of inconsistent state updates by making the authoritative node decide what the true state really is. Massive multi-user games, and the ever increasing family of Web-based collaboration tools, use this approach. But even with this approach, the problems around *when* and *what* to send to *whom* make these systems complicated, stateful, and error-prone. Additionally, central servers, although useful for many purposes, are always bottlenecks. Peer-to-peer architectures help in offloading work from central servers, and could be used, if state synchronization wasn't so tricky in those architectures.

Prof. **Cristina Lopes** and her Ph.D. student **Rohan Achar** have been working on this problem for a few years. Their work comes on the heels of Prof. Lopes' hands-on experience with OpenSimulator, a virtual word server similar to Second Life. Lopes and Achar's new approach to replicated objects is to embrace the

RESEARCH BRIEFS

Prof. **Michael Franz** has been elected as an IFIP Fellow, in the inaugural cohort of 48 fellows. The International Federation for Information Processing (IFIP) Fellow Award recognizes individuals of the highest professional standing and expertise in one of IFIP's constituent societies (which includes ACM) who have also contributed directly to IFIP. Prof. Franz is already a Fellow of the ACM and IEEE.

Prof. **Gloria Mark** is part of a three-university Collaborative NSF Future of Work Grant on "Intelligent Facilitation for Teams of the Future via Longitudinal Sensing in Context." UCI is the lead for the $1.1 million grant. University of Notre Dame and University of Colorado at Boulder are the other two partners.

Prof. **Michael Franz's** 2009 paper "Optimization of Dynamic Languages Using Hierarchical Layering of Virtual Machines" received the Most Notable Paper of DLS 2009 at the October 2019 edition of the Dynamic Languages Symposium, the main academic conference on dynamic programming language design and implementation. The paper is co-authored by Alexander Yermolovich, Christian Wimmer, and Franz. The jury wrote, "we believe the last 10 years have shown this paper to be one of the early notable works on Meta VMs and Tracing."

Prof. **Cristina Lopes** gave a keynote talk titled "Virtual Conferences" at the 32nd ACM User Interface Software and Technology Symposium (UIST 2019), which was held in New Orleans, LA in October.

ISR Director Prof. **Sam Malek** and Prof. **Nenad Medvidović** of USC have received an $85,000 gift from Google for their research on Mining Architectural Information to Stem Technical Debt.

Technical Debt

An increasingly important concern for many software organizations is the accrual of technical debt in their software systems. Technical debt is a concept in software development that reflects the implied cost of additional rework caused by choosing an easy (limited) solution now instead of using a better approach that would take longer. Technical debt may manifest itself in any software engineering artifact, such as architectural models, source code, and tests. By accruing technical debt, a software system becomes increasingly difficult and costly to develop and maintain over time.

Technical debt is a symptom of refusing to follow certain basic software engineering principles. In fact, historically, a significant body of software engineering research has aimed to develop solutions to prevent the occurrence of technical debt. Take for example research on architecture-based software development, advocated by a number of prominent scholars in our field. Architecture-based development advocates spending time, particularly in the early stages of software development, to properly identify and evaluate alternative architectural choices for a software project. In this paradigm, software architecture further serves as a centerpiece that guides all other software development activities, including implementation, validation and verification, and maintenance.

Despite its promise, many prominent software organizations do not follow such an approach to software development. At these organizations, modeling and architecting are considered harmful, as they are deemed to slow down the developers, and do not help achieve what really matters: working code. The irony of this is that the same organizations that refuse to document the architecture of their systems soon find themselves in a situation in which they have no idea of what is the structure of their systems and why they behave in abnormal ways to smallest changes in code. Subsequently, significant effort, arguably more than would have been required to carefully document the architecture from the get-go, is spent on recovering the architecture of the software to determine its properties and identify ways in which it has decayed. In the end, however, considering the developer turnover and complexity of modern systems, most such efforts at recovering the architecture tend to fail. It is indeed extremely difficult to determine the intuition behind the architectural decisions in a system from its lines of code. The short-term gain of working code without proper consideration and documentation of architectural choices leads to unwieldy software that is exceptionally difficult to maintain.

This is also an area of research that does not receive the attention it deserves. Although there are a few specialized events targeting issues of technical debt in software (notably TechDebt, a conference collocated with ICSE), there are not many publications on this topic at the premier software engineering conferences. Yet practitioners have significant interest in effective solutions to understand, measure, and eliminate technical debt in their systems. In my own experiences, almost every large software organization that I visited in the past few years expressed interest in one form or another for solutions to tackle the challenges posed by technical debt. While the research community has many good preventive measures in the form of principles and methodological approaches to development, there are actually not many effective reactive measures to mitigate technical debt once it affects a system. Tools for calculating code quality metrics, for instance, provide a good starting point, but do not capture the more complex properties of the system, e.g., architectural degradation. This appears to be yet another industry-relevant, but grossly neglected topic, in the top-tier software engineering conferences, possibly explaining why industry participation at these events have been declining. Perhaps the research community is disheartened by the fact that our preventive solutions to this problem are not adopted by industry, and thus do not find value in pursuing research in this space any further. Or, maybe it is one of those areas that is exceptionally difficult to publish, since proper evaluation would require complex experiments with industrial collaborators over long periods of time.

Whatever the reasons may be, advancements in this area will require close collaborations between industry and academia. In fact, in addition to myself at ISR, we have a number of other faculty members, including Profs. **Joshua Garcia**, **Iftekhar Ahmed**, and **Nenad Medvidović**, that have ongoing collaborations with companies such as Google and SAP aimed at studying the emergence of technical debt and proper eradication methods. Stay tuned for updates on these collaborations in future editions of the *ISR Connector*.

Prof. **Sam Malek** can be reached at malek@uci.edu.

problem as one of version control, specifically decentralized version control. Their conceptual framework is called GoT, the Global Object Tracker. GoT takes inspiration from Git, one of the most popular decentralized version control systems for files. GoT is Git, but for objects.

Programming under the GoT architectural style makes use of an API that is very similar to that of Git: *commit*, *checkout*, *push*, *pull*, *add*, etc. Incompatible changes to the same object are detected in the same way that merge conflicts in Git are detected. Unlike Git, however, these applications
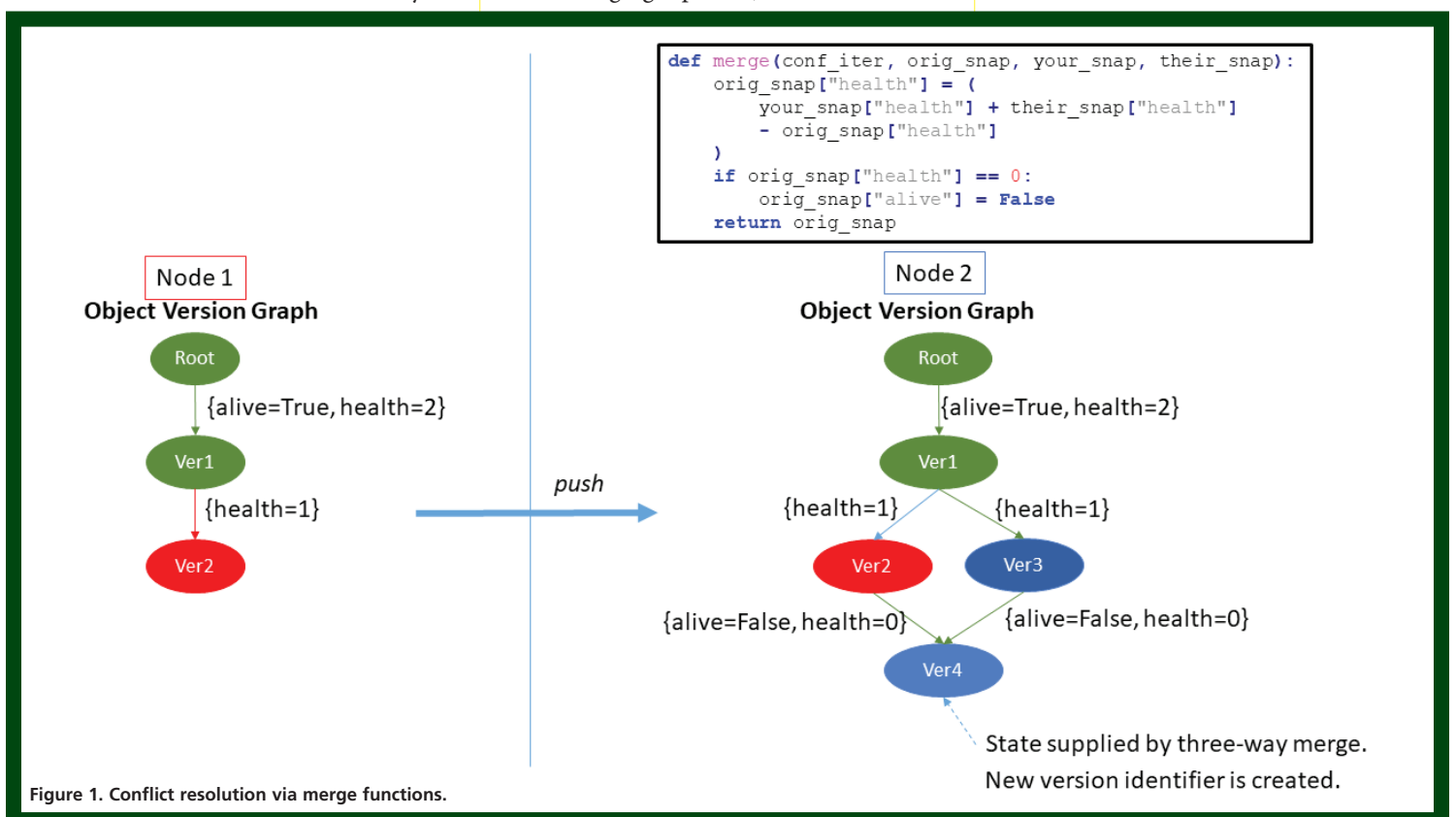
share part of the history, specifically the root node and version 1 (Ver1). From then on, they proceed independently with local commits Ver2 and Ver3, respectively. At that point, node 1 pushes its changes to node 2, which detects a merge conflict due to the fact that both nodes independently decreased the value of the field `health` from 2 to 1. The conflict is detected because both Ver2 and Ver3 have the same parent, Ver1, and both edges include that field. In this case, the programmer-provided function *merge* is called, in which the merge conflict is resolved by adding both changes and testing if the result is 0, in which case the field `alive` is set to False.

Just like Git, GoT establishes a separation between the working data (snapshot) that is immediately available to application code in every node, and which may be mutually inconsistent, and the graph of versions that have been committed via *commit* and shared via *push/pull*. The version graph is guaranteed to be causally consistent, and, under some constraints, can also be globally consistent. Causal consistency means that every node has the same understanding of the order of state updates, even if the updates end up with diverging replicas (like the resolu-

tion of certain merge conflicts in Git, for example). Replica divergence can also be avoided in GoT if the programmers define merge functions that are both commutative (the order of the *mine* and *theirs* parameters does not matter for the resolution of the conflict) and associative (given two different conflicts for the same version, sent by two different nodes, the merge order does not matter, i.e. *[original, (original, mine, theirs1), theirs2] = [original, (original, mine, theirs2), theirs1]*). Under those constraints, GoT is guaranteed to support convergent replicas, even in peer-to-peer architectures.

GoT has been implemented in a framework called Spacetime (https://github.com/Mondego/spacetime). Spacetime addresses several challenges of the GoT implementation in practice, namely the potentially unbound growth of the version graph and the delta-style communication of state updates. Spacetime comes with an interactive debugger, something that is only feasible when node interactions are well defined. That is the case in GoT.

For more information, contact Prof. Lopes at lopes@uci.edu.

cannot ask the end user what to do – that would not make sense! Instead, GoT supports programmer-facing three-way merge functions, by which programmers establish what happens when there are merge conflicts in certain objects, types of objects, and even at the scale of the entire application state. These merge functions are of the form *merge(original, mine, theirs)*.

Figure 1 shows one example of two nodes, each with replicas of an object with fields "alive" and "health". The nodes already

```python
def merge(conf_iter, orig_snap, your_snap, their_snap):
    orig_snap["health"] = (
        your_snap["health"] + their_snap["health"]
        - orig_snap["health"]
    )
    if orig_snap["health"] == 0:
        orig_snap["alive"] = False
    return orig_snap
```

Node 1
Object Version Graph

Root
{alive=True, health=2}
Ver1
{health=1}
Ver2

push →

Node 2
Object Version Graph

Root
{alive=True, health=2}
Ver1
{health=1}   {health=1}
Ver2   Ver3
{alive=False, health=0}   {alive=False, health=0}
Ver4

State supplied by three-way merge.
New version identifier is created.

Figure 1. Conflict resolution via merge functions.

Alumni News

Di Yang (Ph.D. 2019, advisor C. Lopes), who graduated in Fall quarter, has joined the Azure team at Microsoft in Redmond, WA as a software engineer. Yang also co-authored the paper titled "Aroma: Code Recommendation via Structural Code Search" which won the distinguished paper award at OOPSLA 2019. The authors are Sifei Luan (Facebook), Di Yang, Celeste Barnaby (Facebook), Koushik Sen (UC Berkeley), and Satish Chandra (Facebook).

Yang

Lilly Irani (Ph.D. 2013, advisor P. Dourish), has been awarded the 2019 Diana Forsythe Prize for her book titled *Chasing Innovation: Making Entrepreneurial Citizens in Modern India.* The book was based on work conducted at UCI for her Ph.D. dissertation. The citation describes her book as "a fearlessly ambitious work of scholarship that weaves together history, ethnography, and a critique of a seductive vision of entrepreneurial citizenship.

Irani

Yang Feng (Ph.D. 2019, advisor J. Jones), who graduated in Fall quarter, is now an assistant professor in the Department of Computer Science and Technology at Nanjing University, China.

Feng

First incoming class of professional Master of Software Engineering students with, in front row, Jaclyn Kung, Career Development Manager; David Lennox, Career Counselor; Connie Cheng, Program Director; and Prof. Cristina Lopes, Faculty Director.

Welcome to the First Class of Professional Master of Software Engineering Students

UCI welcomed the inaugural class of the professional Master of Software Engineering (MSWE) students in September. The thirty-seven students are drawn from six countries, and from a broad array of backgrounds.

The Master of Software Engineering (MSWE) is an advanced 15-month professional degree program designed to prepare students for software engineering careers. The program accepts applicants with any undergraduate major, as long as they already have experience with programming. MSWE takes in programmers, and trains them to become software engineers capable of understanding what it takes to design, build, test, and maintain software systems in the context of development teams.

The incoming cohort of students spent the Fall quarter sharpening their programming skills by taking a host of programming-intensive courses, including Data Structures and Algorithms, Network Programming, Databases, Concurrency, GUI Programming in Java, Mobile Programming, Information Retrieval, and Neural Networks. The rest of the program focuses on Software Engineering. Winter quarter courses include: Software Testing and Debugging; Distributed Software Architecture; and Reverse Engineering and Modeling.

A highlight of the MSWE program is the requirement for students to do an internship at a company in the summer before they graduate. This provides valuable industry experience for the students. It's also an opportunity for companies to hire these extremely motivated students.

"I am delighted with our first cohort!" says Prof. **Crista Lopes**, Director of the MSWE program. "Being the first time we offered these courses, they may have been a little too intensive. But the students worked really hard, and, by and large, they were able to finish all the coursework. Many of them did that, while at the same time juggling technical interviews for summer internships. I have seldom seen such a level of energy, dedication, and talent-in-the-making. Whoever ends up hiring these young professionals will be very well served!"

MSWE is currently accepting applications for the Fall of 2020. Domestic applicants have until March 15 to apply. Besides the full-time option, the program offers a flexible part-time option for working professionals living in Southern California. The part-time option takes one more year to complete than the full-time enrollment. "This option targets people who have IT-related full-time jobs, and want to switch roles within their companies to take on more challenging, and better-paid, software engineering tasks" says Prof. Lopes. The current cohort has one part-time student whose enrollment in the program is being sponsored by his employer. "We hope to attract more of these students, as this is a really good, and cost-effective, program for retraining and advancing existing staff."

If you are interested in hiring our MSWE students as summer interns, contact:

Connie Cheng, MSWE Program Director connie.cheng@uci.edu, (949) 824-8956

To learn more about the MSWE degree program, visit:

https://mswe.ics.uci.edu/

ICS Dean Prof. Marios Papaefthymiou, Informatics Chair Prof. André van der Hoek, Alumna Dr. Rosalva Gallardo Valencia, and ISR Assistant Director Debra A. Brodbeck celebrate establishment of award.

Alumna Rosalva Gallardo Valencia Establishes Graduate Award to Honor Heritage

In Fall quarter, the Rosalva Gallardo Valencia Graduate Award in ICS was established by alumna **Rosalva Gallardo Valencia** (Ph.D. 2012) to honor her heritage and support graduate students in need. The establishment of this $10,000 annual award fulfills her dream of supporting students as they pursue their degrees.

Gallardo Valencia, a native of Peru, first came to UCI in 2006 after receiving a fellowship. She left her job as a software engineer in Lima to pursue her Ph.D. at UCI in ICS, specializing in Software Engineering. "For the first three years, I didn't have a car," she says, recalling how it took her two hours by bus to get to Ikea — less than 10 miles from campus — to buy items for her apartment. "And with all the stress of working on my Ph.D., I really wanted see my family, but that was something I just couldn't afford."

As Gallardo Valencia worked on her candidacy exam during her third year of studies and served as a teaching assistant, her advisor, Informatics Professor Susan Sim, learned about the Miguel Velez fellowship for Latin American graduate students. "She saw my struggles financially and applied on my behalf," says Gallardo Valencia, who knew nothing about the application. When Sim showed her the acceptance letter, she could hardly believe she had been awarded $10,000. She was shocked to learn there were no restrictions on the funding.

"The first thing I did was buy a car and also a ticket to go back home to see my family," says Gallardo Valencia. While she did use some of the funds to buy books and attend conferences, she says the initial purchases were just as important to her academics. "It took a huge weight off my shoulders and had such an impact on my well-being." Everything became so much easier with a car that she had more time and energy for her studies. Similarly, she found she could better focus on work after taking a break to visit family. "It's good to have a balance, but sometimes you don't have the resources to have that balance."

The fellowship had such a positive influence on her life as a Ph.D. student, both physically and emotionally, that she vowed to one day return the favor. "I don't know when or how," she recalls telling herself, "but someday, I want to offer a fellowship to help other students."

Today, Gallardo Valencia is a data ana-lytics program manager for Partner Developer Relations at Google. Through Google.org, the philanthropic arm of Google, she returned to Peru a few years ago to collaborate with Laboratoria, an organization that trains low-income Latin American women as front-end developers and UX designers.

Gallardo Valencia is also a co-founder of the Network of Professional Peruvians in Science and Technology in Silicon Valley (PeruSV.org), a group of Peruvian tech professionals committed to closing the technology and innovation gap in Peru.

"Studying at UCI opened so many doors for me," she says. "The great education that I received enabled me to work at Intel and now at Google, and because of that, I am in a position to share my story, to amplify my voice and to share with other Latinos that they too can dream about doing similar things."

This desire to help others is something she learned from her parents. "My family is very generous and likes to give back to the community," she explains. "You don't need to have a lot to give. You just need the determination to give. And I have seen that my whole life through my family."

"I really hope this award will make a difference in someone's life," says Gallardo Valencia.

This is a condensed version of an article by Senior Writer Shani Murray which appeared on the ICS website in October. Read the full article at:

https://bit.ly/2P3Qz3o

How to Contribute to the Graduate Award

Would you like to join Gallardo Valencia in her mission to support graduate students through this award?

Make a gift to UCI. Give online»

Your tax-deductible donation can be made online at: https://bit.ly/2DLZkJ3

Does your company match donations? If so, please apply for the match to make your donation go farther!

Questions? Or do you prefer to send a check? Contact:

ISR Assistant Director **Debra Brodbeck**, brodbeck@uci.edu
Informatics Dept. Chair Prof. **André van der Hoek**, andre@ics.uci.edu

Ph.D. student Negar Ghorbani (left) and Ph.D. student Adriana Meza Soria (right).

First Richard N. Taylor Graduate Award in Software Engineering and Rosalva Gallardo Valencia Graduate Award in ICS Recipients Selected

Congratulations to the first recipients of the Richard N. Taylor Graduate Award in Software Engineering and the newly established Rosalva Gallardo Valencia Graduate Award in ICS!

Fourth year Ph.D. student **Negar Ghorbani** has been awarded the first Richard N. Taylor Graduate Award in Software Engineering. Ghorbani, who is co-advised by Prof. **Joshua Garcia** and ISR Director Prof. **Sam Malek**, will receive a $5000 award.

Ghorbani's research focuses on addressing the need for sophisticated automated analysis tools to detect architectural inconsistencies in software and bridge the gap between the prescriptive and descriptive architectures. She utilizes the Java Platform Module System (JPMS), one of the most widely used programming languages in the world. She is working on designing and developing a self-adaptive framework through which software developers and architects can load and unload each component of their Java application at runtime and on demand without introducing any architectural inconsistencies. If successful, her work will allow software practitioners to streamline expensive and error-prone system maintenance and evolution efforts through the automation of architectural detection and repair, which

has an inherently system-wide scope. Additionally, her project would be a major step forward to addressing one of the most difficult problems in software engineering and software architecture, i.e., the decay arising from differences in a system's prescriptive and descriptive architecture.

"It is an honor to recognize the first recipient of the Richard N. Taylor Graduate Award," says Chancellor's Prof. Emertus **Richard Taylor**. "Established through gifts of former graduate students, alumni, and friends, it enables the recipient to focus more intently on their research. Negar's research is heading along a successful path following those donors' own journeys, and I am very pleased to note, within the field of software architecture."

Third year Ph.D. student **Adriana Meza Soria** has been awarded the first Rosalva Gallardo Valencia Graduate Award in ICS. Meza Soria, who is advised by Prof. **André van der Hoek**, will receive a $10,000 award.

Meza Soria's research involves the design and evaluation of a novel suite of tools that enable software designers working at the whiteboard to: (1) efficiently and in-the-moment capture important information produced during that meeting, and (2) deliver, either by request or proactively by the tools, relevant information captured in the past when it is needed in a future design meeting. You can read more about it in the article on page 8.

"It is a 'dream come true' for me to congratulate the first recipient of the Rosalva Gallardo Valencia Graduate Award," says alumnus Dr. **Rosalva Gallardo Valencia**. "Congratulations to Adriana on receiving this award! Adriana's research on how to preserve important information from design meetings is relevant and promising for both academia and industry. Adriana's leadership in creating opportunities for underrepresented communities to pursue graduate degrees in STEM is impressive and inspiring. Keep up the good work, Adriana!"

For more on Negar Ghorbani, visit: https://www.ics.uci.edu/~negargh/

For more in Adriana Meza Soria, visit: https://www.ics.uci.edu/~amezasor/

Contribute to the Richard N. Taylor Graduate Award in Software Engineering

The UCI Donald Bren School of Information and Computer Sciences (ICS) established the Richard N. Taylor Graduate Award in Software Engineering in Fall 2018. This is the first award in ICS specifically dedicated to software engineering. It honors the legacy of ISR Founding Director Prof. Emeritus **Richard N. Taylor**.

Would you like to support graduate students in software engineering? Or show your support for the Richard. N. Taylor Graduate Award?

Your tax-deductible donation can be made online at: https://bit.ly/2VsX6se

Does your company match donations? If so, please apply for the match to make your donation go farther!

Questions? Or do you prefer to send a check? Contact:

ISR Assistant Director **Debra Brodbeck**, brodbeck@uci.edu
Informatics Dept. Chair Prof. **André van der Hoek**, andre@ics.uci.edu

Jones receiving Most Influential Paper award at ASE 2019.

Professor James A. Jones Receives ASE 2019's Most Influential Paper Award

Congratulations to Prof. **James A. Jones** for being honored with the Most Influential Paper award at the 34th IEEE/ACM International Conference on Automated Software Engineering (ASE 2019)! This award recognizes the most influential ASE paper of the past 15 years. The 2019 award was bestowed for the 2005 ASE paper titled "Empirical Evaluation of the Tarantula Automatic Fault-Localization Technique," which was co-authored by Jones and the late Prof. Mary Jean Harrold of Georgia Tech.

Jones's paper is the most cited ASE conference paper of all time. According to Google Scholar, it has more than 1,000 citations.

Jones's paper is largely responsible for introducing and popularizing the field of work that is now called Spectra-based Fault Localization. The main contribution of this paper and work is to analyze correlations between execution information that were gathered in white-box testing practices, and the pass/fail status of the test cases that produced them. Doing so can point to locations in the software's code that are likely to contain the bugs that caused the testing failures, and thus can provide automated debugging assistance to software developers.

"I'm truly honored to be recognized with this award," said Jones. "Our work has been the subject of a lot of discussion and subsequent work, both in extending and improving spectra-based fault localization and in the use of the technique for other purposes (such as in automatic program repair). This award is a wonderful acknowledgement of that body of work and reflection upon its influence."

This is the second time Jones's work has been recognized in such manner. In 2015 his 2002 International Conference on Software Engineering (ICSE) paper titled "Visualization of Test Information to Assist Fault Localization," co-authored by Prof. Mary Jean Harrold and Prof. John Stasko of Georgia Tech, was bestowed the venerable SIGSOFT Impact Paper Award.

Jones's ASE paper is available at:

https://doi.org/10.1145/1101908.1101949

For more information on Jones and his research, visit:

http://jamesajones.com/

Negar Ghorbani (J. Garcia and S. Malek, advisors) interned over the
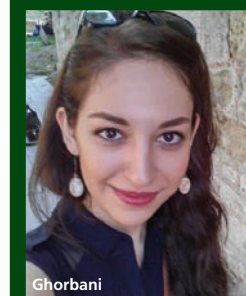
Ghorbani

summer at Morgan Stanley in New York, as part of the "Optimus Graph" team in the Institutional Securities Technology department. She devised optimization techniques to improve the runtime of parallelization in an internal platform which is responsible for compiling and running distributed calculations within the company around the world.

David Kutas (A. van der Hoek, advisor) has launched a startup com-

Kutas

pany called Linecept; Kutas serves as CEO. Linecept's product is a conceptual design coordination tool that helps you invent new products. Linecept was used in Prof. **André van der Hoek's** undergraduate course, Software Design I, in Fall quarter. More information at: https://linecept.com.

Reyhaneh Jabbarvand (S. Malek, advisor) was selected to participate

Jabbarvand

in RISING STARS 2019, an Academic Career Workshop for Women in EECS, which was held at UIUC on October 29 - November 1. Jabbarvand presented a poster on her research on advancing energy testing of mobile apps.

Chancellor's Professor Michael Franz Honored as AAAS Fellow

Prof. Michael Franz

Congratulations to Chancellor's Prof. **Michael Franz** for being named a Fellow of the American Association for the Advancement of Science (AAAS). Franz was bestowed this lifetime distinction for his "distinguished contributions to computer science, particularly to the areas of just-in-time compilation and optimization and techniques for computer security," per the AAAS citation.

Franz is one of nine awardees from UCI this year who are being honored for their efforts to further science or its applications. The 2019 Fellows will receive an official certificate and a rosette pin in gold and blue, colors symbolizing science and engineering, at the annual meeting of the AAAS being held on February 15, 2020 in Seattle, WA.

Prof. Franz directs UCI's Secure Systems and Software Laboratory and is a leading authority on cyber-security. He is also a fellow of the Association for Computing Machinery, a fellow of the Institute of Electrical and Electronics Engineers and an inaugural fellow of the International Federation for Information Processing.

Undergraduate Sanghoon Kim, Prof. André van der Hoek, undergraduate Nayoung Lee, Ph.D. student Adriana Meza Soria, and undergraduate Seunghwan Hong.

I-SURF Students Collaborate with SDCL on KNOCAP's Development

Professor **André van der Hoek** and Ph.D. student **Adriana Meza Soria** from the UCI Software Design and Collaboration Laboratory (SDCL) are collaborating with a team of undergraduate students from Kookmin University in Korea on the implementation of KNOCAP, a tool for collecting important design bits (IDBs) from whiteboard design meetings. Students Seunghwan Hong, Nayoung Lee, and Sanghoon Kim came to Irvine as part of the UCI I-SURF summer research program and extended their visit to Fall quarter to continue working on this project.

The KNOCAP project pursues building an understanding of how designers document their design progress during whiteboard design meetings, and how this activity could be improved upon through tool support. Meza Soria is particularly interested in observing what information designers consider relevant to keep – with an eye toward later meetings, and what tools would be ideal to collect design bits, by which she means decisions, constraints, alternatives, assumptions, key stakeholders, and so on.

KNOCAP is an electronic whiteboard application which, during sketching, allows designers to keep voice notes from their conversation by relying on light-weight interactions (e.g., button clicks, short voice commands). Some of these interactions are part of the whiteboard interface, while others are external (e.g. a mobile interface that works as remote control). This project is part of Meza Soria's long-term research, which comprises not only the collection of IDBs, but also the smart retrieval of them in future meet-ings. Meza Soria views KNOCAP as the ideal tool to explore lightweight interfaces that are able to aid design knowledge collection. At the same time, she envisions KNOCAP as an instrument to build a rich knowledgebase of IDBs, which in future she will be able to use for other stages of her research.

Over two quarters, the Kookmin University undergrads have used advanced technologies (e.g., React and Google Cloud Services) to implement multiple features of KNOCAP. The students have also supported Meza Soria in conducting a series of pilot studies using the tool. While these pilot studies are in early phases, they are already showing the potential of KNOCAP. The studies have also pointed out important considerations such as the need for actually assigning a dedicated notetaker, as otherwise designers in the throes of brainstorming and deciding may simply forget to indicate to KNOCAP when something important just happened.

While the Kookmin students have returned home, the KNOCAP project continues. Soon, Meza Soria will be conducting an actual comparative experiment to demonstrate the value of KNOCAP. She will also be developing the smart retrieval side of KNOCAP, pushing the tool into understanding the conversations that go on and interjecting, on its own, relevant knowledge from past meetings.

To learn more about KNOCAP, contact Meza Soria at amezasor@uci.edu.

Prof. David Redmiles and visiting Prof. Tayana Conte.

Visitor from Brazil Investigates User Experience and Software Engineering

From February 2019 through February 2020, ISR hosted Prof. **Tayana Conte** on invitation by her ISR faculty host Prof. **David Redmiles**. Conte is a professor in Software Engineering and Human-Computer Interaction in the Department of Computer Science at the Federal University of Amazonas (UFAM) in Manaus, Brazil. She is the head of Usability and Software Engineering (USES) Research Group at UFAM. Conte is also a collaborator in the Collaboration

Research in Action, Design, and Learning (CRADL) Research Group at UCI, led by Professor Redmiles.

At her university in Brazil, Conte teaches human-computer interaction, requirements engineering, software modeling, and architecture, and she conducts research in software engineering, user experience (UX) and usability. Conte has advised five Ph.D. dissertations, and 26 master theses in these areas. She is currently advising seven Ph.D. and two Master degree students at UFAM.

Conte's research visit at ISR/UCI is supported by a grant from CNPq – the Brazilian National Council for Scientific and Technological Development. Conte

RESEARCH BRIEFS

Prof. **Michael Franz** was received by the President of Germany, Frank-Walter Steinmeier, at the official Presidential Residence, Bellevue Palace, in Berlin, Germany in June, in honor of Franz's receipt of the Humboldt Research Award by the Alexander von Humboldt Foundation of Germany.

Prof. **Yang Wang** has accepted a new position and is now an Associate Professor of Information Science at the University of Illinois at Urbana-Champaign.

ISR Director Prof. **Sam Malek** served as a co-organizer of the 2nd International Workshop on Advances in Mobile App Analysis (A-Mobile), at the 34rd IEEE/ACM International Conference on Automated Software Engineering (ASE 2019) held in San Diego in November. The other co-organizers were: Li Li, Monash University, Australia; Guozhu Meng, Chinese Academy of Sciences, China; and Jacques Klein, University of Luxembourg, Luxembourg.

Prof. **Janet Burge** from Colorado College in Colorado Springs, CO is visiting ICS for Winter and Spring quarters. Her faculty host is Prof. **André van der Hoek**. Prof. Burge's research focuses on design rationale, AI in design, software engineering, and computer science education.

chose to visit UCI and ISR for several reasons. Mainly, she wanted to increase collaboration with Prof. Redmiles. Conte and Redmiles started their collaboration some years ago, in joint work with professors **Igor Steinmacher** and **Marco Gerosa** (ISR visitors at the time), in the area of open-source software. For Conte's visit, the focus is on the integration of software engineering and human-computer interaction. Secondly, UCI has many strong research groups and excellent faculty in areas that perfectly match Conte's research areas, such as usability and user experience (UX), software architecture, and machine learning for software engineering. Thirdly, UCI has a sound history of fruitful visits from Brazilian researchers in the Informatics and Computer Science fields. Through the years, many successful collaborations have been built.

Conte's research focuses on two topics: software product quality, mainly regarding usability and user experience (UX); and software process quality, concentrating on supporting developers and teams. She is currently investigating three themes in collaboration with Professor Redmiles and her graduate students in Brazil: (1) Playability Customizable Evaluation Technique for Digital Games, with Master student Felipe Manzoni; (2) Making Sense out of User eXperience (UX) Evaluation, with Ph.D. student Leonardo Marques; and (3) Comprehending User eXperience through Data Science and Empirical Studies, with Ph.D. student Walter Nakamura. The latter research about UX aims to identify which UX Dimensions have a stronger influence on the users' perception of their experience. Current UX evaluation methods consider that all dimensions have the same weight in users' experience. However, some UX dimensions may have a stronger influence on users' perceptions of their experience. At the center of this work is an exploratory longitudinal study employing two generic UX evaluation methods. The results show that the tendency of UX dimensions varies according to the type of product and context of the evaluation over time.

Conte is also collaborating with UCI Professor **Iftekhar Ahmed** on two other graduate students' projects: (1) Mining Developers' Instant Messages Log Data to Identify Project Knowledge, with Ph.D. student Marcia Lima, and Lima's main advisor Professor Bruno Gadelha (UFAM);

and (2) Software Engineering supporting the development of Machine Learning systems, with Ph.D. student Elizamary Souza. Conte and Professor Ahmed have already published two papers at the ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM 2019), results from these collaborations: "Land of Lost Knowledge: An Initial Investigation into Projects Lost Knowledge" (Lima et al., 2019) and "Understanding Development Process of Machine Learning Systems: Challenges and Solutions" (Nascimento et al., 2019).

Currently, Conte, her students, Professor Ahmed, and Professor Redmiles are working on new studies (and new papers). This joint collaboration has been an enriching experience for Profs. Conte, Ahmed, and Redmiles, and for the Brazilian students too.

Prof. Redmiles reflected on Conte's visit: "It's been great having Prof. Conte in residence this year. Previously, we have collaborated on research in open source software communities, but this visit has given us a chance to collaborate in another area dear to me, usability inspection methods. With her students, we have a chance to extend these kinds of methods for more realistic usability assessment. Prof. Conte has also been great at helping to mentor my graduate students, giving them a fresh perspective on their research as well as guest lecturing in classes."

Prof. Conte can be reached at tayana@icomp.ufam.edu.br or tuchoaco@uci.edu.

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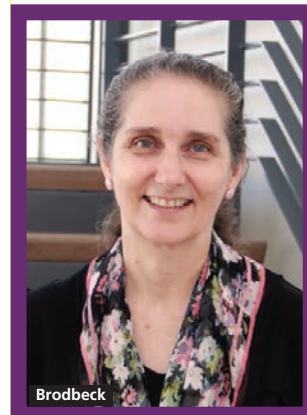
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Prof. Joshua Garcia, Prof. Cristina Lopes, and Prof. Nenad Medvidović at NJR 2019.

Towards a Normalized Java Resource (NJR) - A Workshop at ASE 2019

Prof. **Cristina Lopes** and UCLA Prof. Jens Palsberg have organized a series of workshops with the goal of establishing a Normalized Java Resource (NJR). The first workshop was held in 2017 at the SPLASH conference in Vancouver, Canada. The most recent was held in November at the 34th IEEE/ACM International Conference on Automated Software Engineering (ASE) in San Diego. This was the sixth workshop on the topic; two additional workshops are planned.

The goal of the NJR workshops is to create an infrastructure that consists of 100,000 executable Java programs together with a set of working tools and an environment for building new tools. Researchers can search for Java programs with desired characteristics and they can write scripts that base their new tool on our working tools. The researchers will receive the search result as a container that can run either locally or on a cloud service. Lopes and Palsberg envision enabling scalable processing by normalizing the representation of each Java program such that one can easily run a tool on the entire collection. Additionally, they will ensure diversity by running clone detection and removing near-duplicates. Their Normalized Java Resource (NJR) will lower the barrier to implementation of new tools, speed up research, and ultimately help advance research frontiers.

At the November workshop held at ASE, Prof. **Nenad Medvidović** gave a presentation titled "ARCADE - A Workbench for Mining Architectural Information and Identifying Technical Debt" in which he

introduced ARCADE, an integrated collection of tools for isolating three types of architectural information from details readily available about a system's implementation: architectural design decisions, change, and decay.

Prof. **Joshua Garcia** gave a presentation titled "Why We're Going in SAIN: Producing a Community-Wide Software Architecture Infrastructure," in which he described how a team of software-engineering and software-architecture researchers, in collaboration with nearly 50 researchers worldwide, are producing the Software Architecture INfrastructure (SAIN), a community-wide research infrastructure to support empirical research at the intersection of software maintenance and software architecture.

And Prof. Cristina Lopes presented her work on "50K-C: A Dataset of Compilable and Compiled, Java Projects." 50K-C is a set of 50,000 Java projects collected from GitHub, with very small amounts of duplication that, along with the included dependencies, are guaranteed to compile and run. Prof. Lopes and her students are now working to make it more interactive, so that researchers can search for projects with specific properties such as using a specific API, having test cases, etc.

The workshop was successful in connecting the several Java-related research infrastructure platforms that participants are working on. Some common concerns arise from the rapid development that the Java language has been through recently. For better or for worse, up until Java 8, Java was very conservative in terms of new features. But starting with Java 9, new features such as modules, functional elements, and type inference have brought a lot of changes to the ecosystem, relatively quickly. Although not many projects rush to adopt the new language features, these recent changes will force our tools to have to adapt, too.

Additional workshops will be held in 2020.

Are you interested in participating? Contact Prof. Lopes at lopes@uci.edu.

For more information, visit:

http://compilers.cs.ucla.edu/njr/

Celebrating Automated Software Engineering

For decades, the IEEE/ACM International Conference on Automated Software Engineering (ASE), a top conference in software engineering, has brought together researchers and practitioners to address challenges of automating the analysis, design, implementation, testing, and maintenance of large software systems. This year's ASE was held in November in San Diego, CA where Prof. **Joshua Garcia** and Prof. Julia Rubin of the University of British Columbia co-organized the Celebration of ASE (CASE), a workshop which assembled members of the ASE Program Committee (PC) and other researchers to foster networking and discussions about the software-engineering community.

To support these goals, CASE included four sessions and two panels. To open the workshop, 24 PC members each gave a short talk introducing themselves and their research. Professors **Iftekhar Ahmed** and Garcia were among the PC members that presented as part of these opening talks. Ahmed discussed his research on automated testing of conversational agents and highly configurable systems, and bug-proneness prediction. Garcia presented on his work in the areas of software security, architecture, testing, and analysis.

Seven PC members gave 20-minute talks about their research projects. These talks covered topics involving machine learning, automatic program repair, program analysis, challenges in software merging, and testing for a widely used children's programming language. "It is exceedingly rare for researchers with the expertise of PC members from a top software-engineering conference to all be presenting at a single streamlined event. CASE provided exactly such an opportunity, giving attendees a rich research and networking experience," says Garcia.

The two panels focused on reviewer experience and software-engineering community-level challenges and opportunities.

The panel on reviewer experience included four PC members with reputations for producing high quality reviews. Panelists discussed characteristics of high quality reviews and how to produce them. The panel on software-engineering community-level challenges and opportunities considered the impact of software-engineering research on practice, possible directions of future software-engineering research, and means of fostering the software-engineering community in general. One of the panel members, Prof. **Nenad Medvidović** of the University of Southern California, brought valuable insights from decades worth of software-engineering community experiences to the panel.

For more information, Prof. Garcia can be reached at: joshug4@uci.edu.

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