Emma Beatty
Goldman Sachs Scholar

NSF POWER
City-Scale Testbed

World Class CS Program
#25 in the Nation

2018 Research Highlights
SoC by the Numbers

SCHOOL OF COMPUTING
UNIVERSITY OF UTAH

WELCOME

We are growing computing here at Utah.

We are growing our student body in size and diversity, as well as our faculty, with a new cohort being recruited for the fall. We are also expanding intellectually. While maintaining our strengths in traditional fields such as systems, software engineering, and theory, we are expanding our expertise in human-centered computing and data analysis by hiring, in part, in information retrieval and human interaction.

We are also expanding the kinds of students we are educating. Our new professional degree, the Master of Software Development, saw its first class of students rapidly and enthusiastically recruited by industry, both locally and nationally. We are offering a wider breadth of introductory classes which reach out to majors in other disciplines. This gives students computing and programming expertise that makes them more competitive and productive in whatever fields they study. This fall, we will introduce a new bachelor's degree in Data Science – the first new undergraduate degree the School of Computing has introduced in decades.

Our research portfolio also continues to grow, with new projects from DARPA, NSF, NIH, and other government and industry sponsors. These projects span many technologies and goals from wireless test beds to efficient high-performance computing.

With growth comes challenges. The logistics and effort of teaching so many students and managing so many projects is pushing our faculty and staff to adapt and evolve their methods (and efforts!). The process of hiring faculty in such a competitive environment stretches resources (and patience!). But with a great team of people, we continue to grow, thrive, and improve as a School. The stories in these pages are evidence of that – we hope you will agree.

Ross Whitaker
Director, School of Computing

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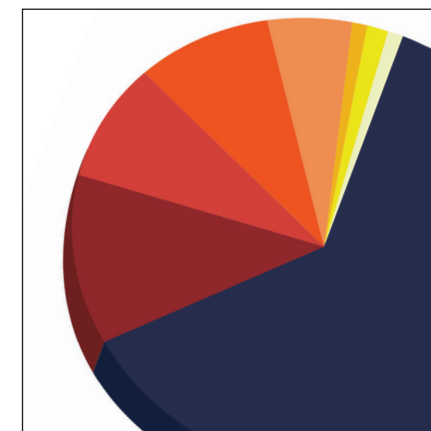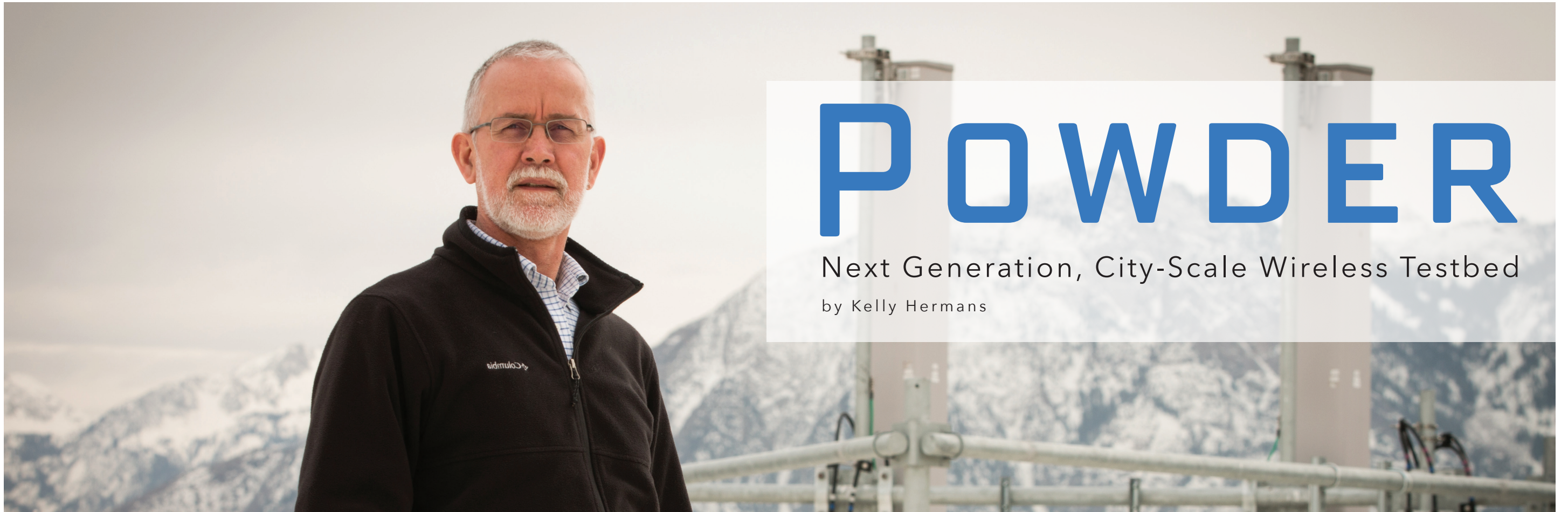## Next Generation, City-Scale Wireless Testbed

by Kelly Hermans

The University of Utah is at the global vanguard of wireless communications thanks to School of Computing Associate Professor Kobus Van der Merwe and his Flux Research Group. A National Science Foundation (NSF) affiliated initiative selected the group to build one of only four city-scale research test beds in the US, part of a $100 million public-private partnership that aims to revolutionize the country's wireless ecosystem.

"We're building a lab where people are going to design the next generation of technology we use," Van der Merwe said. "In the US, much of the work to enhance experimental wireless and mobile research capabilities has been theoretical. This is a call to action—to get our hands dirty and do it for real."

The NSF joined with a consortium representing more than 25 of the nation's leading wireless companies to fund the initiative, Platforms for Advanced Wireless Research (PAWR). During an April 9 news conference at the U, following a yearlong application process that included repeated site visits, PAWR representatives announced they'd selected the U and Rice University to build a living laboratory in Salt Lake City for telecoms, tech companies and researchers to test wireless innovations in the real world. The PAWR Project Office also tapped a group of universities in the New York City area to build a complementary platform there, the second of up to four test beds. The Salt Lake version has been dubbed the Platform for Open Wireless Data-driven Experimental Research (POWDER), and will be one of the first of its kind in the country and one of the largest and most complex in the world.

Gov. Gary Herbert called the living lab a win for Utah, which bills itself as business friendly and boasts a booming tech industry marketed as the Silicon Slopes. "The new wireless test bed in Salt Lake City will bring increased connectivity for our state—and prepare us for the future," Gov. Herbert said. "This project will significantly bolster our ability to remain at the forefront of the tech world, and I look forward to seeing how it spurs on technological innovation here in Utah."

The lab will be built on the U campus and through a section of downtown Salt Lake City. The U and Rice will receive $17.5 million from the PAWR Project Office and up to $10 million in equipment and services from the consortium to build and operate the platform for the first five years. Of the $17.5 million, $11.25 million goes to the U and will be used to buy equipment, pay researchers and developers (including hiring at least one additional software developer), and build out the actual network infrastructure around the city, Van der Merwe said.

Since the application process, city officials have worked closely with Van der Merwe's team to ensure the project's success. "We see POWDER as a public validation of the forward-looking, innovative perspective that characterizes the Salt Lake City of today," said Gregory Daly, city chief Information officer and director of information management services. "The research will yield incredibly valuable intellectual property that will benefit the citizenry and businesses of our municipality, the state of Utah, and the nation."

Van der Merwe's team secured sweeping community support for the project, one of the reasons the PAWR Project Office picked his group. U departments, the city government and local companies and organizations pledged to assist in various ways, from allowing equipment on roofs and buses to providing network monitoring and fiber infrastructure. "It was humbling to pitch our project and have the community not only buy into it, but ask how they could help," Van der Merwe said.

The Flux Research Group was also chosen because they specialize in building wireless test beds for outside researchers. This gave them an edge over some elite academic applicants that build test beds for internal use, within their own research groups. "We're smaller, but that's what we do,"

> "We're building a lab where people are going to design the next generation of technology we use."

Van der Merwe said. "We build these test beds for other people to use."

Dr. Erwin Gianchandani, NSF deputy assistant director for computer and information science and engineering, said at the news conference that POWDER could aid development in transportation, virtual reality, real-time data analytics for disasters, and more. Van der Merwe cited the possibility of connecting a network of connected vehicles—not simply self-driving cars, but cars that communicate with each other and surrounding infrastructure. "If a vehicle relies on a network for its safety functions, you want it to be more reliable than your cell phone, which drops calls," he explained. "If my car needs to know there's an accident around the corner, network reliability becomes a safety issue." And a new smartphone born from this living lab, for instance, could be faster, more reliable, and more useful, he said. "All the metrics will be better."

During the conference, U President Ruth Watkins lauded the test bed for upholding the school's legacy. "The University of Utah has a long history as a tech hub and innovation hub," Watkins said, citing Atari, Pixar and Adobe, all of which have founders who attended the University of Utah. "We look forward to POWDER being the next in this succession."

Dreams Amplified:

Inaugural Goldman Sachs Women in Computing Scholar

by Kelly Hermans

Goldman Sachs gives $15,000 to support high-achieving women starting out STEM.

As a child, Emma Beatty couldn't hear the everyday sounds many take for granted: footsteps on pavement, leaves rustling in trees, her own stomach rumbling. Now, as the inaugural recipient of the $15,000 Goldman Sachs Women in Computing Scholarship, this second-year computer science (CS) student is one step closer to her career goal of advancing hearing-aid technology.

"It's a big honor," Beatty said of receiving the scholarship. "It's exciting to set the precedent for how this award is handled."

Beatty started wearing hearing aids in third grade and said it drastically improved her life and sparked her interest in technology. For her scholarship application, she penned a stirring essay on how being hearing impaired has pushed her to think creatively and adapt to new challenges, and how she wants to engineer hearing aids that "incorporate more of today's technology and work more seamlessly with modern devices."

"Technology has positively affected my life and I know it can do the same for many others if only I continue to aspire for innovation," Beatty wrote. "With technology, my future will not only be bright, but loud."

A School of Computing committee scored scholarship applications based on academics, essays, resumes, and letters of reference. Beatty's application earned a near-perfect score—the highest of her peers, committee and faculty member Daniel Kopta said. And Goldman Sachs Vice President Mark Sharrock called Beatty—who's double-majoring

"By collaborating with the School of Computing more, we hope to open students' eyes to avenues of employment that are perhaps not traditionally thought of, but are very rewarding,"
- Mark Sharrock

in art and CS and minoring in math—a wonderful first recipient: "Her interests are diverse, her experiences different, and she has a great interest in art as well as computing," Sharrock said. "This adds a completely different viewpoint to conversations with her."

For Beatty, the award also provides welcome financial relief: she's been covering most of her own college expenses through a combination of scholarships and on-campus jobs, including her current stint as a resident advisor.

The Women in Computing scholarship is a natural extension of Goldman Sachs' ongoing School of Computing outreach efforts such as the Distinguished Lecture Series, hackathons and more. The company launched this particular award to encourage women to take and stay in STEM-related subjects, Sharrock explained.

"Diversity is vitally important to Goldman Sachs," the vice president said. "It is at the very core of who we are."

In the past year, women have comprised over half of Goldman Sachs' Salt Lake City interns and new analysts, Sharrock said. The company wants to maintain their upward momentum, but they're hoping for greater representation from Utah universities—especially the U's School of Computing.

"By collaborating with the School of Computing more, we hope to open students' eyes to avenues of employment that are perhaps not traditionally thought of, but are very rewarding," Sharrock said.

They've opened at least one set of eyes. After being named the first Goldman Sachs Women in Computing scholar, Beatty got the chance to visit the company's office in downtown Salt Lake City—she called it "exhilarating" to see the work environment.

News and Notes

National Science Foundation Career Awards

Two University of Utah School of Computing faculty members received the National Science Foundation's CAREER Award for projects in developing faster cloud-based data systems and software that can help researchers and doctors determine why they choose the medical decisions they make.

University of Utah School of Computing assistant professor Ryan Stutsman, whose research focuses on "big data" and creating more efficient databases, is receiving $550,000 over five years for a project that rethinks the common approach to cloud-based databases...

University of Utah School of Computing assistant professor Alexander Lex has received $512,000 for developing software that will capture the decision-making process of doctors and other researchers by using algorithms and human-computer interaction methods... The project is specifically focused on helping doctors with cancer diagnostics and those studying the genetic causes of suicide.

The NSF CAREER Award is given out to faculty "who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization."

Read more at:
https://www.cs.utah.edu/soc-news/

PIPELINE CAREER EXPO

Save the date – this year's event held September 20, 2019

The School of Computing held its first annual PIPELINE Career Expo in September. The event was held on September 14th in the Union Ballroom and brought together more than 350 undergraduate and graduate students with 18 companies and organizations.

"The event was a great success, we look forward to continuing this event in the years to come," says Ross Whitaker, Director of the School of Computing.

John Melchi joins school

"John's extensive career in research administration spans more than two decades at the University of Illinois at Urbana-Champaign," said Ross Whitaker, Director of the School of Computing. "He will help us deepen our partnerships with the thriving Utah technology sector and strengthen our connection to our alumni."

While at the nation's leading academic supercomputing center, Illinois' National Center for Supercomputing Applications (NCSA), he held numerous leadership positions. He was a key leader in NCSA's successful bids for nation-scale, National Science Foundation funded supercomputer and cyberinfrastructure contracts.

At Illinois' Prairie Research Institute (PRI), Melchi led the integration of the administrative services functions of five state of Illinois research agencies into a single, unified organization. PRI is the largest research institute in the Illinois system.

"Utah's remarkable, other-worldly landscape and its thriving tech ecosystem make this the perfect place for me to embark upon a new adventure," Melchi said. "The School of Computing has a tremendous legacy in computing innovation. I am looking forward to partnering with faculty and staff and key stakeholders to help sustain the growth in the academic and research programs."

2018 School of Computing Dissertations

Hyun-wook Baek
Inter-party Visibility in a Cloud Computing Platform
Advisor: Jacobus Van der Merwe

Junguk Cho
Designing performant, flexible and evolvable network systems
Advisor: Jacobus Van der Merwe

Min Du
Large scale system log monitoring and analysis
Advisor: Feifei Li

Haibo Ding
Title: Affective polarity recognition and human needs categorization for affective events
Advisor: Ellen Riloff

Yang Gao
Longitudinal segmentation for image sequence with appearance and shape change
Advisor: Guido Gerig and Thomas Fletcher

Kimball Germane
Demand environment analysis of higher-order languages
Advisor: Matthew Might and Matthew Flatt

David Hancock
Exploiting the programmable data plane via virtualization
Advisor: Kobus Van der Merwe

Alan Humphrey
Scalable Asynchronous Many-Task Runtime Solutions to Globally Coupled Problems
Advisor: Martin Berzins

Ethan Kerzner
A Framework for Creative Visualization-Opportunities Workshops
Advisor: Miriah Meyer

Philip Lundrigan
Reliable Real-time Data Upload For Wireless Networks
Advisors: Sneha Kasera and Neal Patwari

Joe Novak
Auto-Tuning Methods for Scaling Resources in Networks and Cloud-Based Systems
Advisor: Sneha Kumar Kasera

Mukund Raj
Depth-Based Visualizations for Ensemble Data and Graphs
Advisor: Ross Whitaker

Konstantin Shkurko
Dual Streaming for Hardware-Accelerated Ray Tracing
Advisor: Erik Brunvand

David Winer
Automated Film Direction for Computer-Generated Cinematic Discourse: Planning, Scheduling, and Execution
Advisor: R. Michael Young

Johnny Le awarded the Ivory Prize for Excellence in Student Leadership

HackTheU is Utah's largest hackathon and was held for the first time in 2016. Over the course of 24 hours, students from across the nation develop solutions to the various prompts through augmented reality, virtual reality, and other applications. In addition, students have access to workshops presented by members from the local industry.

Le desired to start the event after visiting hackathons throughout the country. "I started HackTheU based on a desire to give students more avenues for exposure as well as advancing their careers," Le said. "HackTheU began as an opportunity to provide students at the University of Utah and across the region a chance to not only learn skills but demonstrate them in a hands-on experience."...

Read more at:
https://www.cs.utah.edu/soc-news/

School of Computing Ranked #25

by John Melchi

The University of Utah's School of Computing continues to be recognized for its world-class scientific output and dedication to student learning as acknowledged by recent rankings of US computer science programs.

The School ranks number 25 in the nation according to CSRankings, which bases its rankings on a transparent, publicly available system that is additionally distributed as open source software. This ranking places the University of Utah's School of computing at the top among peer institutions in the American Mountain West region.

Utah's visualization program is ranked number one in the nation, placing Utah in a select group of esteemed research institutions possessing the esteemed number one positon in essential computer science subdisciplines.

In addition, Utah's program in high-performance computing program is ranked number eleven and several other subdisciplines in the School, including robotics and computer graphics are ranked in the top 20 nationally.

"These rankings indicate that Utah's computer science program is really at the center of the Mountain West for computer science research," says Professor Ross Whitaker, who is the School's Director. "Our faculty consistently publish in prestigious, tier-one journals and conferences. Our teaching and research faculty provide our students with a world-class education in the classroom and the research laboratory."

College ranking systems, objective or not, take into account a broad range of factors that prospective students, parents, faculty and university administrators consider when trying to ascertain the value of academic programs.

Emory Berger, respected computer science professor at the University of Massachusetts at Amherst, intentionally developed csrankings.org in a transparent way so that anyone can scrutinize the formula that it uses and the subsequent rankings data that it produces.

Some rankings sites, such as U.S. News and World, rely on subjective measures to rate computer science programs. The CSRankings system attempts to quantify research productivity directly by tracking publications in top venues field by field. Many in the community believe that scientific output and dedication to student learning are more effective measures of programmatic success.

Perhaps scientific output and dedication to student learning may be the true measures of programmatic success? As Rice University Professor Richard Tapia is famous for saying, "We value what we measure, because

"These rankings indicate that Utah's computer science program is really at the center of the Mountain West for computer science research"

- Ross Whitaker

we can't measure what we value."

In the last decade, public institutions of higher education have increasingly concentrated resources on branding and marketing, making it even more taxing for prospective students and parents to understand the financial value and academic benefit of attending prestigious U.S. universities.

Rankings are clearly one important technique to influence common opinion in the marketplace. In some instances, an institution's reputation alone determines 25% of its overall ranking. Reputation management, branding and marketing have a powerful effect upon the perceived value of academic programs. Rankings, ideally, will give prospective students access to data on the educational experience they can expect.

"Objective criteria may help prospective students get a clearer understanding of the level and quality of research activity in a computer science program," says Feifei Li, the School's Director of Graduate Studies and an expert in database research. CSRankings is based on the idea that the best computer science departments are the ones that publish the most articles at top-tier conferences. These conferences accept only the best of the best papers submitted for publication each year.
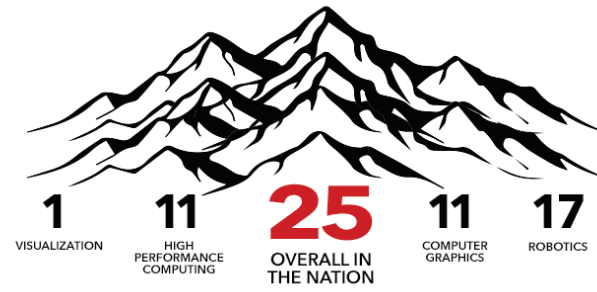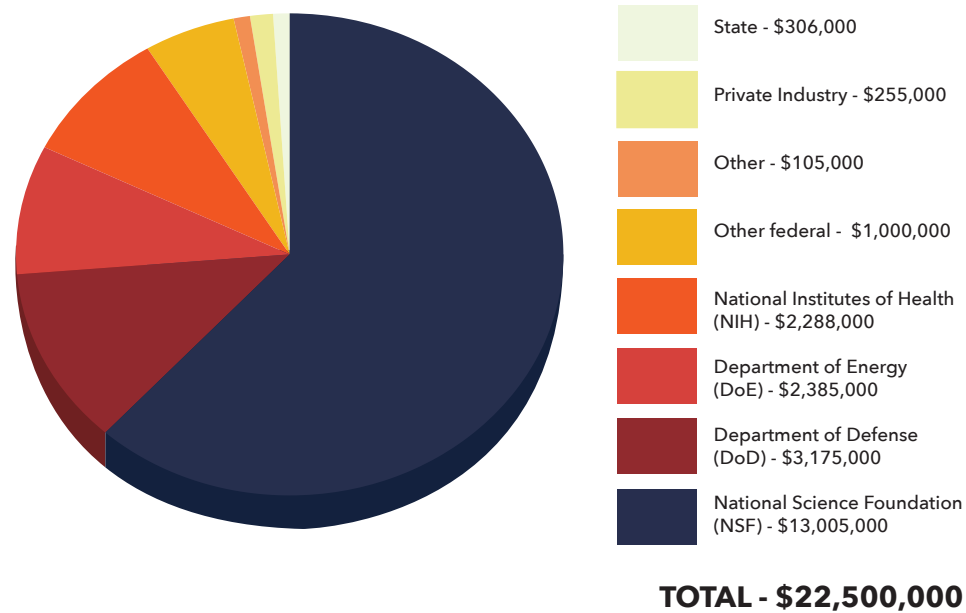
The University of Utah is nationally recognized for being a Tier 1 research institution and for having a world-class computer science faculty who are committed to providing students with a high-quality educational experience that amalgamates classroom learning and with first-class academic research.

Utah's School of Computing is uniquely situated to sustain a leadership position in the Mountain West by generating world class research impacting the national computer science community and by turning out talented students who are well equipped to further advance the Utah economy.
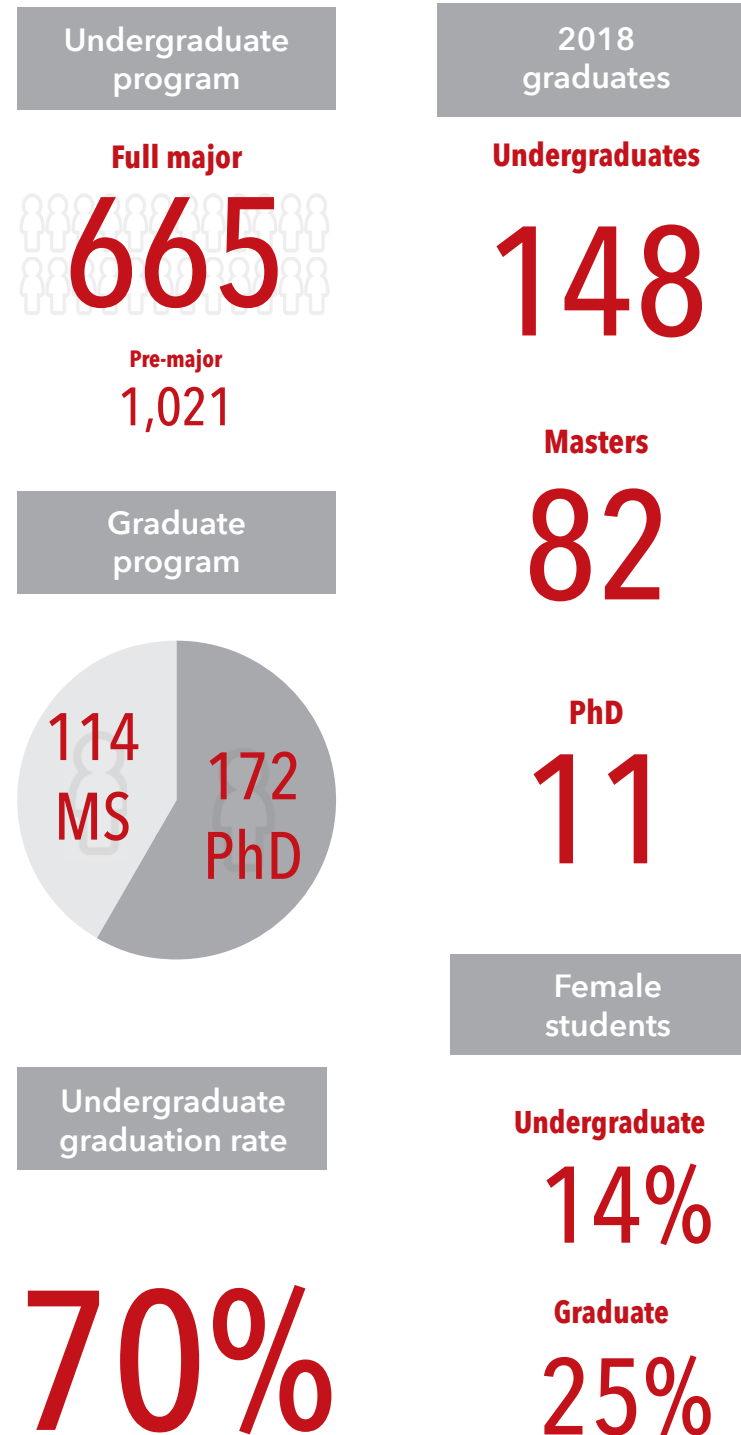
SoC by the Numbers

2018 Research Expenditures

State - $306,000
Private Industry - $255,000
Other - $105,000
Other federal - $1,000,000
National Institutes of Health (NIH) - $2,288,000
Department of Energy (DoE) - $2,385,000
Department of Defense (DoD) - $3,175,000
National Science Foundation (NSF) - $13,005,000

TOTAL - $22,500,000

1	11	25	11	17
VISUALIZATION	HIGH PERFORMANCE COMPUTING	OVERALL IN THE NATION	COMPUTER GRAPHICS	ROBOTICS

Undergraduate program

Full major

665

Pre-major

1,021

Graduate program

114 MS   172 PhD

Undergraduate graduation rate

70%

2018 graduates

Undergraduates

148

Masters

82

PhD

11

Female students

Undergraduate

14%

Graduate

25%

2018 Projects

CAREER: Safe and Efficient Extensions for Low-latency Multitenant Storage
NSF, PI: Ryan Stutsman

A Memory-Centric Hardware Accelerator for Large Scale Data Clustering
NSF, PI: Mahdi Bojnordi

A Domain-Specific Language for Designing Cognitive-Science Experiments
NSF, PI: Matthew Flatt

Result Variability and Mitigation
DOE, PI: Ganesh Gopalakrishnan

Toward Safe and Fast Compiler Flags
NSF, PI: Ganesh Gopalakrishnan

Rapids: Institute for Resource and Application Productivity through Computation and Data Science
DOE, PI: Mary Hall

Persistent Data Summaries for Temporal Analytics on Big Data
NSF, PI: Feifei Li

Large-Scale Anomaly Detection and Diagnosis from System Logs
NSF, PI: Feifei Li

Factors for STEM Student Success: The Relative Influence of Self-Efficacy, Mentorship, Leadership, & Belonging
NSF, PI: David Johnson

Motion Imagery Elements
Live Earth Imaging, PI: Chris Johnson

BSAM Modernization Project
AFRL, PI: R. Michael Kirby

In Situ Feature Extraction and Visualization from Discontinuous Galerkin Based High-Order Methods
ARO, PI: R. Michael Kirby

New methods and approaches to help take Neptune to Exascale
NRL, PI: R. Michael Kirby, coPI: Martin Berzins

CAREER: Enabling Reproducibility of Interactive Visual Data Analysis
NSF, PI: Alexander Lex

Reproducible Visual Analysis of Multivariate Networks with Multi-Net
NSF, PI: Miriah Meyer, coPI: Alexander Lex

Extracting the Full Information Content of Astrophysical Data Cubes
Carnegie Institution for Science, coPI: Bei Wang Phillips

Collaborative Research: Verified Operating Systems in Rust
NSF, PI: Zvonimir Rakamaric

Enabling NeTwork Research and the Evolution of a Next Generation Midscale Research Infrastructure
Institution, PI: Rob Ricci

Technology Facilitated Therapist Training
NSF, PI: Vivek Srikumar

Collaborative Research: Strategies for Managing Data in Uncertainty Quantification at Extreme Scales
NSF, PI: Hari Sundar

POWDER: Platform for Open Wireless Data-driven Experimental Research
NSF, PI: Kobus Van der Merwe

Prostate 8
Institution, PI: Jason Wiese

Mesh Color Filtering
Industry, PI: Cem Yuksel

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