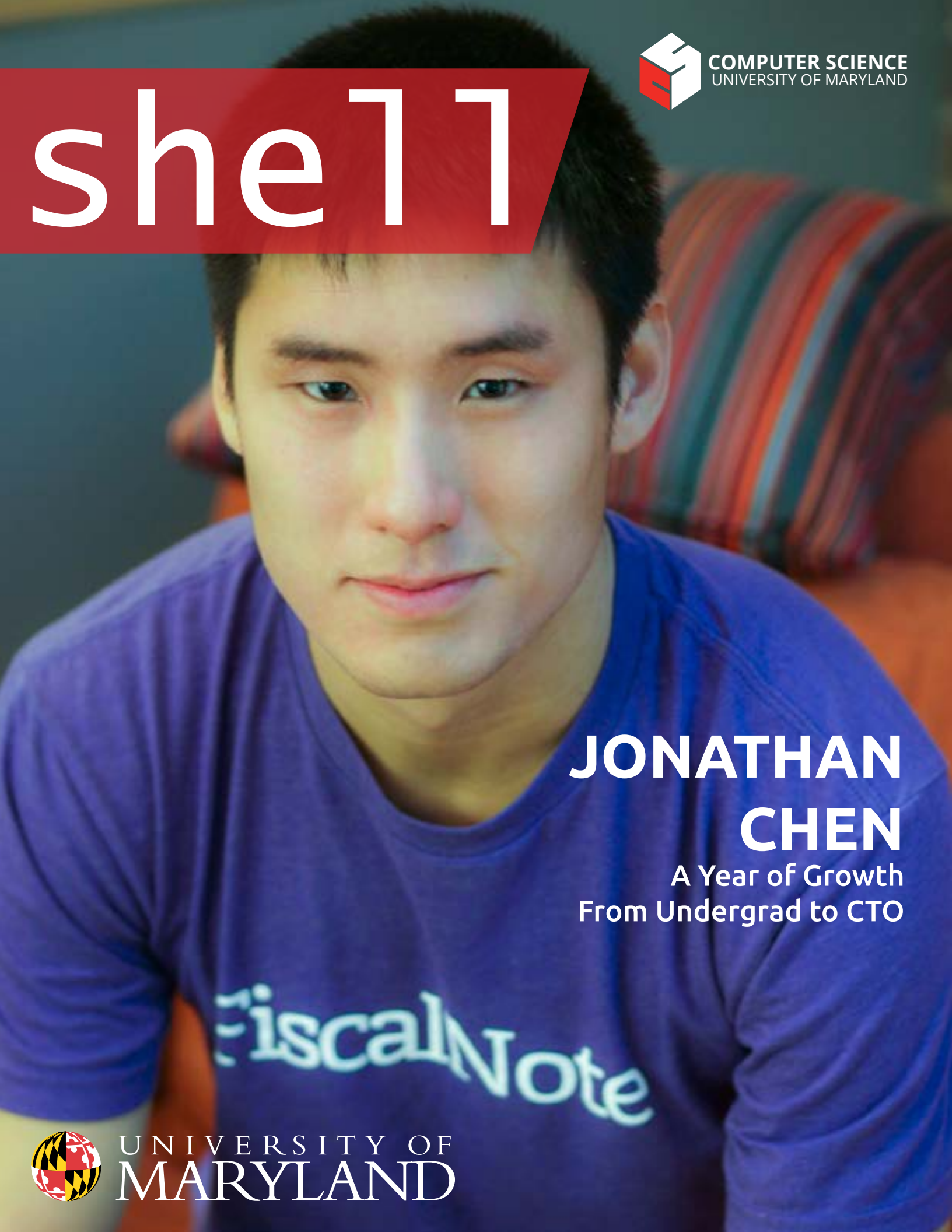

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COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

JONATHAN CHEN

A Year of Growth From Undergrad to CTO

UNIVERSITY OF MARYLAND

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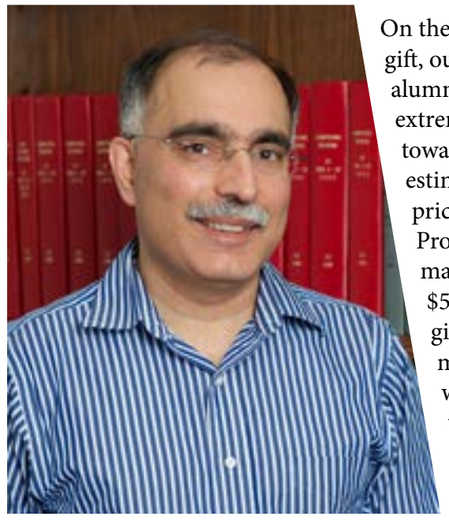
Dear Friends,

As scientists, we work towards certainty. But we love surprises.

I can think of no better surprise than the day Brendan Iribe, CEO of Oculus VR declared that he wanted to help our department construct a new building. This was during a visit to the department as our students invited him to be the keynote speaker at Bitcamp 2014. Less than six months later, he formalized his commitment to help with a record-setting $31 million donation that establishes the Brendan Iribe Center for Computer Science and Innovation. The Center—which will be prominently placed at the main entrance to campus—will provide an open, collaborative space to support our next-generation teaching and research. Michael Antonov, Chief Software Architect of Oculus VR, also donated $4 million to CS for new scholarships and to support the new building for computer science. Elizabeth Iribe, Brendan's mother, added to the generous gifts by endowing two chairs in Computer Science.



On the heels of this historic gift, our professors and several alumni have made their own extremely generous donations towards the building's estimated $140-$149 million price tag. Notably, Emeritus Professor Bill Pugh inspired many by his personal gift of $500,000. Whether through giving, sponsorship, or mentoring, I am grateful when our alumni honor their connection to us through continued involvement through funded scholarships, mentoring programs and visits to the department.

With mixed emotions, we said thank you and farewell to three of our faculty in 2014. Professor Dianne O'Leary announced her retirement and was named both an Emerita and a Distinguished University Professor. Professor Bonnie Dorr also retired and was named an Emerita. Associate Professor Chau-Wen Tseng announced his retirement as well.

We are delighted to welcome several new faculty hires. Eytan Ruppin joined us as Professor and Director of the Center for BioInformatics and Computational Biology (CBCB). Andrew Childs joined us an Associate Professor and co-Director of the Quantum Institute for Computer Science (QUICS). Marine Carpuat (Natural Language Processing), Tom Goldstein (Scientific Computing) and Michelle Mazurek (HCI/Cybersecurity) joined as Assistant Professors. I look forward to seeing the fruits of their research in the coming years.

We continue our efforts to improve diversity in computer science as the department joined the BRAID Initiative, which seeks to increase the number of women and people of color who major in CS.

I enjoy hearing from each and every one of you and the stories of your successes and travails provide us all with inspiration. Shayan Zadeh, co-founder of Zoosk and Gear Zero will be visiting campus in April. Many of our alumni are continuing their successes in academia and industry. Please keep us informed of your good news.

Here's to a 2015 that continues to provide the sorts of surprises that we like.

Best wishes,

Samir Khuller
Elizabeth Stevinson Iribe
Chair of Computer Science

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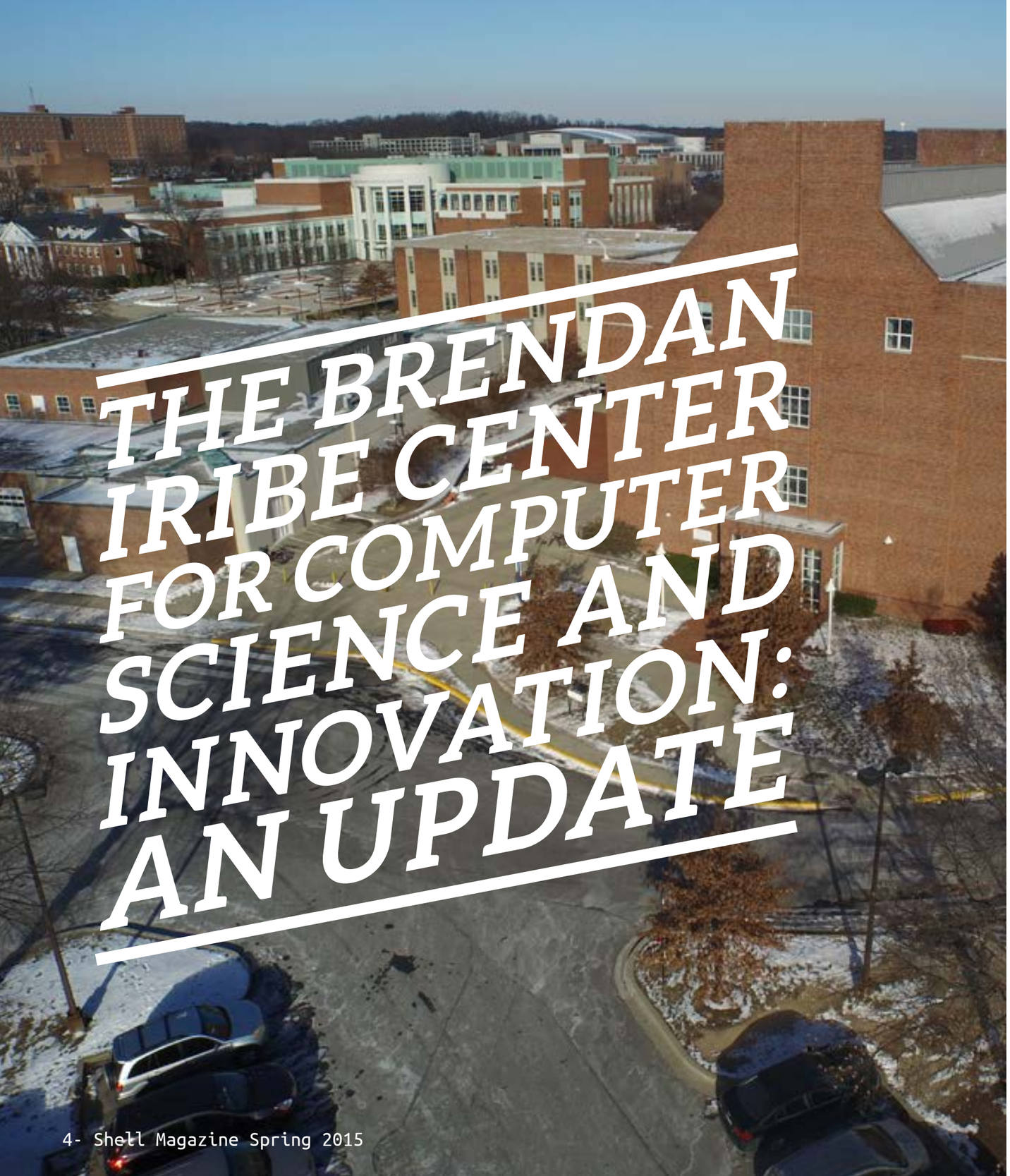

THE BRENDAN IRIBE CENTER FOR COMPUTER SCIENCE AND INNOVATION: AN UPDATE

In September of 2014, President Wallace Loh, Provost Mary Ann Rankin, and CMNS Dean Jaynath Banavar formally announced Brendan Iribe's transformative gift of $31 million to the University to begin construction for a new building to house the Department Computer Science and UMIACS (University of Maryland Institute for Advanced Computing Studies). Iribe, who is cofounder and CEO of Oculus VR, spent time as an undergraduate at UMD, and notes that he fondly remembers his classes in Computer Science, as well as advice that he received from faculty including Emeritus Professor Bill Pugh. Another cofounder of Oculus VR and alumnus of the Computer Science Department, Michael Antonov ('03), gave $4 million dollars for the Iribe Center, and cited his computer vision course as one of the most memorable of his time at UMD. Before giving these gifts, both men worked with Ms. Stacey Sickles-Locke, Senior Director of Development and Corporate Relations and Professor Samir Khuller to endow a scholarship named after their dear friend and alumnus Andrew Reisse ('03), who passed away in 2013.

Ms. Elizabeth Iribe, Brendan's mother, gave $3 million dollars to endow two professorships in Computer Science. In late September 2014, Professor Samir Khuller became the first Elizabeth Stevinson Iribe Chair of Computer Science.

To demonstrate their full support of the construction of The Iribe Center, emeritus and current faculty contributed an unprecedented $733,000 to the project. They have also hosted fundraising events, and met with many alumni to garner support for the building. Following this tremendous spirit of giving, many other alumni have contributed major gifts to the project and to scholarships.

The Computer Science Department is still in the process of raising funds in order to create Iribe's vision of having "The Iribe Center Feel like Silicon Valley just hit College Park." The cutting-edge research and classroom facility will be home to over 1900 undergraduate computer science majors, along with graduate students, postdocs, faculty, and staff members. It will have new classrooms, a tutoring center, and hacker/maker spaces.

As one of his first acts as Maryland's new governor, Larry Hogan, with the Maryland State Board of Public Works, approved part of a contract with HDR Architecture for the design of the center on January 29, 2015. Once board approved the contract, HDR architects met with members of the university and the department's Space and Planning Committee, to begin the process of creating an aesthetic for the building. Professor Jeff Hollingsworth and Associate Professor Neil Spring head this committee. The meeting also marked the first step to bring Silicon Valley to College Park. HDR is the firm that designed the Physical Sciences Complex, which has been used as a stand in for a tech company on HBO's comedy *Veep*.

The lead designer for the building is Brian Kowalchuk(AIA, LEED AP), the Vice President for Design at HDR Architecture. Kowalchuk's work includes the Roslin Institute at the University of Edinburgh, and a forthcoming Chemistry Building Project at King's College London.

In the coming months, the committee will meet with campus representatives as well as Kowalchuk and his team at HDR, as they begin drafting plans for The Iribe Center.

To read more about the new building, and to add your own contribution to the future of Computer Science at UMD, please visit: csctr.cs.umd.edu.

COMMITMENTS

The Iribe Center

Ashok and Radhika Agrawala
Acharya Anurag
Yiannis Aloimonos
Aisya Aziz
Dave Baggett
Benjamin Bederson
Joshua Berenhaus
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Jon Froehlich
William Gasarch
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Larry Herman
Michael and Kimberly Mary Hicks
Jeff and Petrina Hollingsworth
David Jacobs and Elizabeth Edlind
Maurice Jacobs
Micah Jayne
Jonathan Katz
Pete Keleher
Samir Khuller and Dr. Kalyani Chadha
Lawrence Koved
Clyde Kruskal
Ajoy Mallick
Jack Minker
Dana Nau
Feng Peng and Xin Lei
Don Perlis
Bill Pugh
James Reggia
Vibha Sazawal and Vijay Ravindran
Udaya Shankar
Elaine Shi
Ben Shneiderman
Neil Spring
Aravind Srinivasan and Anupama Govindarajan
Alan Sussman and Linda Moniz
Amitabh Varshney
Sze Wong
David Wonnacott
Marvin Zelkowitz

Scholarships

Michael Antonov
Nirupama Chandrasekaran
Brendan Iribe
An Zhu

GRACE HOPPER

The Anita Borg Institute's Grace Hopper Celebration (GHC) is held every October to celebrate and honor the work that women do in computing fields. The GHC brings together thousands of women in technology to hear from technology leaders, to share their research, and to learn about the challenges that women encounter in Computer Science. Women also gather to network and interview for jobs, to see old friends, and to encourage women of all ages to pursue careers in computing. It is the largest gathering of women in tech in the country, and in 2015, the celebration will be held in Houston, Texas. The Computer Science Department anticipates sending at least as many graduate and undergraduate women as it did in 2014—which was a banner year for women in Computer Science at UMD.

"I had a lot of great conversations that filled me with confidence that I do have a place in this industry"

From October 8-10 2014, thirty-seven undergraduate and graduate women in Computer Science attended GHC in Phoenix, Arizona. Also in attendance with them was Dr. Jandelyn Plane, the Director for the Maryland Center for Women in Computing. The department has been fortunate to send women to the conference for the last several years, but this year, the department earned honors as one of the top ten universities represented at GHC. As the eighth largest contingent, women from UMD were featured in photos with Telle Whitney, the CEO and President of the Anita Borg Institute and Maria Klawe, activist and President of Harvey Mudd College. PhD candidate Snigdha Chaturvedi also distinguished herself by winning first place in the GHC graduate poster competition for her work on *Predicting Intervention in MOOC Forums*.

The women in attendance praised the format of the celebration and the experiences that they shared with one another. Senior Computer Science major and Co-chair for the Association of Women in Computing at UMD, Aboli Kumthekar, emphasized the strong community that GHC establishes for women. "Grace Hopper is full of different opportunities for women in every stage of their academic careers[…]Everyone can attend panels to improve her individual skills or to learn something completely new," she said.

Junior CS major Sara LeRoy was impressed with the variety of women present. She said, "There [at GHC], you had women in industry, women in academia, women in graduate school, and young women in college all celebrating together!" Senior Shefali Shah commended the celebration for helping her to find a place as a double major in Biology and Computer Science. "I had a lot of great conversations that filled me with confidence that I do have a place in this industry and [that] there are plenty of opportunities [for someone] with my skill set," she said. Junior Safiyah Sadiq enjoyed meeting mentors: "The conference gave me the opportunity to communicate and network with professional women in industry. I was able to find mentors who can help, guide, and advise me in my future endeavors."

In the weeks leading up to the conference, alumnae from UMD posted on social media encouraging women from UMD to meet with them and to network. The women in attendance said that they planned on attending the celebration in years to come, and were thankful for the CS Department's participation in the BRAID initiative, a coalition of fifteen schools headed by Maria Klawe, who have pledged to increase the number of underrepresented people in computing fields.

BRAID INITIATIVE

During the summer of 2014, Samir Khuller, the Elizabeth Iribe Stevinson Chair for Computer Science, attended a conference with Maria Klawe, the President of Harvey Mudd College. At the conference, Klawe told those in attendance to send her an email if they were interested in securing additional funding to send women to the Grace Hopper Conference and to host programs to encourage underrepresented people to major in computer science. "I sent her an email as I sat in front of her," Khuller said, "I did not want to miss this chance."

Soon after Professor Khuller sent that email, he learned that the University of Maryland was one of fifteen universities selected to participate in the Building Recruiting And Inclusion for Diversity (BRAID) initiative for Computer Science. Led by Professor Klawe and the Anita Borg Institute, and funded by Facebook, Google, Intel and Microsoft, the BRAID initiative promises $30,000 for three years to help participating universities to find new ways to ensure that all students have excellent opportunities in Computer Science.

CS DEPARTMENT WELCOMES NEW FACULTY

MARINE CARPUAT

Assistant Professor Marine Carpuat comes to the Computer Science Department from the National Research Council Canada. Her main areas of interest include natural language processing and machine translation. Her PhD is from Hong Kong University of Science and Technology (2008) where she focused on multilingual Natural Language Processing. She also has an MPhil in Electrical Engineering. Before moving to the NRC, Carpuat was a post-doc researcher at Columbia University Center for Computational Learning Systems. During the spring semester of 2015, she is teaching a graduate seminar on Multilingual Processing.

MICHELLE MAZUREK

Assistant Professor Michelle Mazurek returns to the University of Maryland after earning her PhD in Computer Engineering from Carnegie Mellon University in 2014. She earned a B.S. in Electrical Engineering from UMD. Her research involves the human factors of Computer Security, and she is interested in collecting data from users to better understand security and the behaviors of users. Mazurek is teaching a graduate seminar on Human Factors in Security and Privacy during the Spring 2015 semester. She also has an appointment in the Maryland Cybersecurity Center.

ANDREW CHILDS

Associate Professor Andrew Childs (CS, UMIACS) joins us from the University of Waterloo in Canada where he was an Associate Professor in the Department of Combinatorics and Optimization. He is also a Senior Fellow at the Canadian Institute for Advanced Research. Childs is currently the Co-director of the Joint Center for Quantum Information and Computer Science (QuICS) at UMD, which "advances research and education in quantum computer science and quantum information theory." His research focus includes Quantum Systems, Quantum Algorithms, and Quantum Query Complexity. Childs earned his PhD in Physics from Massachusetts Institute of Technology (2004). In the Fall of 2015, Childs will teach a graduate seminar on quantum information processing. He has just published a paper on Momentum Switches in Quantum Information and Computation.

TOM GOLDSTEIN

Assistant Professor Tom Goldstein's research interests inhabit the intersection of optimization, machine learning, distributed computing, and image processing. After completing his PhD in Applied Mathematics from UCLA in 2006, Goldstein was a postdoctoral fellow at both Rice and Stanford Universities. He is the recipient of the Richard DiPrima Prize. He is currently teaching a graduate seminar on Topics in Optimization: Machine Learning and Sparsity during the Spring 2015 semester. He taught CMSC250H: Discrete Structures during the Fall 2014 semester.

ANGJOO KANAZAWA
A VISION OF THE FUTURE

"I went from creating physical things to creating virtual things."

Angjoo Kanazawa had all of the makings of a computer scientist as she grew up in Japan. She was very good at math, and spent time creating things: she liked to knit and craft. She also loved video games, and she found that as her interest in all of these things easily translated over to making websites. "I went from creating physical things to creating virtual things," she says. As a high school student, she decided to take AP Computer Science at her American high school in Japan.

But then, she decided to attend NYU and major in politics and attend law school.

After an internship with the DA's office, Kanazawa had an epiphany of sorts. She realized that she wouldn't be able to litigate her way to fixing political systems quickly, but she know that she would be able to build software that could help others. She changed her major to computer science, and after a semester, she knew that this was what she was meant to do. She took a lot of different courses, and found that she really liked machine learning and computer vision, but she had no interest in going to graduate school. Instead, she concentrated on web development projects and internships.

Even though the professor of her Computer Vision course, Rob Fergus, asked her to do summer research, she turned him down. At the time, she thought that it was better for her to go to industry and do a summer internship at Goldman Sachs instead. "This was before the start up wave, and Goldman was one of the best companies to go to. There was a good culture there, and people were nice, but then I realized that everyone doing really interesting things there had a PhD," she recalls.

After the internship at Goldman Sachs, she was a fourth year Computer Science student, and thought that she had made the biggest mistake of her life by not doing research. She got a second chance when she encountered Fergus at a colloquium at NYU that introduced senior undergraduates and first year graduate students to research areas, and he offered to do research with her. Kanazawa ended up working with him for her last year, and she read papers on vision and machine learning. She really connected with vision. "It is related to how I perceive the world," she says.

After coming to the University of Maryland, Kanazawa began working with Professor David Jacobs and she has worked on many projects including DogSnap—a mobile application that uses visual recognition software to help identify a dog's breed. This project, which resulted in a paper for the European Conference on Computer Vision, highlights some of her interests in deep learning and fine-grained classification. Most recently, she has published a paper entitled "Locally Scale-invariant Convolutional Neural Network" with Abihishek Sharma and David Jacobs for Deep Learning and Representation Learning Workshop for the Neural Information and Processing Systems Foundation in 2014.

Her interests also led her to Google X during the summer of 2014 to work on the self-driving car.

Kanazawa, of course, worked on vision. The self-driving car, now able to work on highways fairly well, had to tackle the problem of surface streets — the roads where drivers encounter pedestrians, bicyclists, and stoplights. The team at Google X realized that they needed vision experts to solve problems using a camera and Kanazawa's talents in computer vision. She enjoyed working with team, and describes the environment as one filled with smart, motivated, and talented people.

"Working on the car [was] very nice, because my motivation was very strong. I got to go in the car and work with it…so I was pretty close to [the project]," she says. She explains that for driving, moves that are relatively easy for humans—simple lane changes or moving ahead—are easy, but one has to think very carefully while developing software for a car. "Being in a car is such a normal thing, that we don't always think about all of the perception that is involved. Then you realize that no human will be doing anything," she says. There are numerous challenges involved in this process of ensuring that a machine does everything a human would do.

She encourages undergraduates who are interested to do research in the field because now is fantastic time to be in vision. "It is finally starting to work. There are startups that deal with vision and the industry is blooming."

Kanazawa has two years before she completes her degree, and in that time, she will be working on problems related to 3D reconstruction and may be looking into Virtual Reality as well. Perhaps by the time she finishes her degree, some of the work that she has done on self-driving cars will be available to the public—making manifest the talents she has always had: creating things, doing complex math and computer science, and helping others.

JONATHAN CHEN

A YEAR OF GROWTH

The last year of undergraduate study can be filled with decisions that are coupled with a great deal of uncertainty. At the start of their final year, senior computer science majors at UMD begin to make difficult choices about what job offers to take, whether or not to attend graduate school, and where in the world they want to live. There are still other students who decide to refuse the lucrative job offers that their friends have taken, or forgo more time to study what they love in order to work on their own ideas and start their own companies. In the middle of 2013, a few months before the start of his senior year as a CS major, Jonathan Chen (BS, Computer Science, '14) made the decision to take a risk and start a company.

Chen founded FiscalNote with his good friends Tim Hwang (CEO) and Gerald Yao (CSO). Chen and Hwang met in fourth grade, and together, they met Yao while attending sixth grade. All three men went to Wootton High School in Montgomery County,

Maryland. This risk (or *plan* if you ask Chen) has resulted in a good deal of early success. In the last thirty-six months, while most of his peers have been settling into apartment living, learning about company culture, or finding research advisors, Chen's decisions and life have revolved around his position as a co-founder and Chief Technical Officer of a rapidly expanding company that was named as one of the top-10 startups of 2014 by CNN, and has been featured in *The Economist*. In February of 2015, Chen, Hwang, and Yao were named as a part of "Washington's Top entrepreneurs under 40."

FiscalNote takes unstructured and unorganized legislative, regulatory, and judicial open government data—from both federal and state sources—and sets to organize, aggregate, and understand it. As a result, their clients, ranging from lobbyist firms, to law schools and law firms, to businesses with government affairs divisions, are able to better understand trends and patterns contained in this enormous amount of information. "[Our clients] want to seriously track and understand how government affects them," says Chen. The three friends decided to work on data that is free to the public, but clean and organize it, making it easier for people to use and interpret. Their clients include such diverse companies as New Balance, JP Morgan, UVA Law, and Aetna.

The FiscalNote team's first summer together took place in a Motel 6 in Sunnyvale, CA while working with a start-up accelerator. Before they left for the west coast, the team participated in the first annual FISH Bowl Entrepreneur competition for new and emerging companies, hosted by the CS Department. They came in second place. While on the west coast, Chen and his co-founders spent hundreds of hours programming, honing their ideas, and structuring their organization. Their relentless work paid off. By late August, the three friends had secured $1.2 million in investments from Mark Cuban, New Enterprise Associates, Jerry Yang, and First Round Capital Dorm Room Fund. But rather than stay in Silicon Valley with thousands of other start-ups, they returned from California to settle in Bethesda, Maryland to open their first offices. FiscalNote grew from three to thirty-seven employees who work in areas including Software Engineering and Data Science as well as Product, Business Development, Marketing, and Policy.

As of February 2015, FiscalNote has offices in Washington DC, and New York City, and they have gone through two more rounds of funding—Series A in November 2014, for $7 million (led by Visionnaire Ventures), and Series B in January 2015 for $10 million (led by RenRen, also called 'China's Facebook'). The company has shifted from a small start up to a growth stage start up. Jonathan Chen and his colleagues are growing and maturing right along with the company. In a short period of time, he has had to learn how to lead a team of developers, work with his cofounders to make big decisions, and handle the growing pains associated with a rapidly expanding company. This next year will be one filled with change as the company plans on growing to 100 employees, and will need to add to the engineering team.

After they settled in to their first offices in Bethesda, the FiscalNote team was working long days and evenings to develop the company further. There were still a few things left for Chen to do at UMD. He still had two semesters left of his Computer Science degree, and he was determined to finish. He knew that he had no choice but to work full time on his company while taking senior-level CS classes. He also had to worry about finding good people he could work with.

Chen found that he needed to hire engineers to help him develop his code base as well as front-end software. One of FiscalNote's first employees and friends to help Chen with this task was Dan Maglasang, a fellow Computer Science major at UMD. Maglasang is now the lead Front End Engineer for the company, and he has helped put together a strong technical group. Now, sixteen people comprise the technical team that includes software engineers, data scientists, and UX designers, some of whom are UMD CS alumni. He also hired interns from UMD.

Jacqueline Chen (no relation), a sophomore Computer Science major, worked on front-end development and designed the company's website. "Interning at FiscalNote was really meaningful because my work was a direct contribution to the company, and I got to see my designs actually being implemented," she says. "I also had this amazing flexibility and was able to work in and learn about a wide variety of fields from web development, to product design, to marketing."

As Jonathan Chen set about putting his engineering team together initially, he was able to reflect on the importance of certain CS classes he had taken as an undergrad and why strong fundamental skills in programming are important in the field. "At UMD, a top school in CS in America, we take our education for granted. What we learn is important, and we learn that there's a difference between Computer Science and just coding." He mentioned that when he started looking for software engineers that he thought of Introduction to Systems (CMSC216), and Discrete Structures (CMSC250) as courses that were fundamental to his education. He thinks that making it through CMSC216 makes UMD CS students better than "half of the developers out there." He says that professors and instructors at UMD taught him that almost anyone can push code, but that it is not easy to make efficient code. He believes that his time in the department helped him to mature into a computer scientist.

As he finished the major with an impressive GPA, Chen hired developers, data scientists, and interns. Then the College of Computer, Math, and Natural Science selected Chen to be the graduation speaker. After excitedly taking a selfie with his audience, he encouraged fellow graduates to embrace creativity and take risks: "Don't be afraid to be creative and tackle the impossible. Even if you don't think that you're good enough." He stopped his speech to thank his team, who were still working, as they had been since the company started.

Well before he was the CTO for a company that could process information large amounts of data on bills that pass or fail, and predict with an accuracy of 94%-95% of how a legislator will vote on a given issue, he was trying to come up with the next big idea. "By sophomore year, I knew that I wanted to do something—helm a company in some way." Chen always knew that he wanted to be an entrepreneur. He tried creating a Craigslist for books, something that he says many people try. He joined the Hinman CEO program, and he worked on medical devices. He tried many different ideas and most of them did not work out. "I wanted to do something so badly that even if I failed," he says, "I did not give up, and I didn't care about failing. I just kept going and going and going."

This desire to push forward helped get him and his team through Series A funding, which took six months. He admits that spent time worrying that the funding might fall through, but he knew that he had to keep working. During this period, the company moved from Bethesda to Gallery Place, Washington DC and they added a location in New York. The Washington DC office is not going to be able to sustain the planned growth and new hires. Eventually, they'll need a new space for new employees, and the cofounders will have to learn how to manage their time and their employees' time even better.

Chen will adapt to the inevitable change and he will continue to push his technical team to build efficient code and be the best computer scientists they can, all the while working, growing, maturing with his good friends and cofounders. Jonathan, Tim, and Gerald enjoy working with each other and seeing where this company born at the end of their college careers will take them. "Working with Jonathan has been a great rollercoaster, because we had that initial trust. We've always been friends," says Tim Hwang, "plus, he's so much fun to work with."

CRYPTOCURRENCIES, RELIABLE STORAGE, AND ANDREW MILLER

By William Woodruff '18

Cryptocurrencies (think Bitcoin) are a relatively new and disruptive form of decentralized payment in tune with the online world's love for anonymity and independence. For Andrew Miller, a PhD student in Computer Science at the University of Maryland, they are also a solution to a problem that has frustrated users and programmers alike for decades: that of permanent, reliable storage. In order to address this problem, Miller has worked alongside researchers from Maryland, Cornell, and Microsoft to develop Permacoin, a Bitcoin inspired cryptocurrency with the ability to store and distribute real-world information within its network.

Miller vividly remembers the first time he heard of Bitcoin. "I was listening to [a story] about Wikileaks on NPR while reading the Free Haven anonymous [paper collection] from the first cypherpunk era," he recalls. "I'd never really thought about cryptography before, […] but I remember having the thought that this [technology] could be used for money." After originally searching for anonymous TOR money, Miller encountered the Bitcoin community and immediately became fascinated by the concept of cryptocurrency in general. When he realized that his newfound interest in cryptocurrencies was usurping his graduate studies in CS at the University of Central Florida, Miller made the decision to send a "cold call email and a draft of the paper" to Professor Johnathan Katz at UMD. Much to Miller's surprise, Katz offered to fund him, setting into motion the very beginnings of the Permacoin project.

To understand Miller's vision, it is important to first understand how cryptocurrencies—particularly Bitcoin—operate on a transactional level. Over the past five years, cryptocurrency has gone from a virtually unknown topic speculated about on mailing lists and forums by self-described 'cypherpunks,' to one of intense public interest, culminating in successes like Bitcoin which have become household names. But for all their popularity and public interest, not many people understand the complexities associated with cryptocurrencies, much less their vulnerabilities and flaws.

"I WAS LISTENING TO [A STORY] ABOUT WIKILEAKS ON NPR WHILE READING THE FREE HAVEN ANONYMOUS [PAPER COLLECTION] FROM THE FIRST CYPHERPUNK ERA."

Created in 2008 and open-sourced online by a mysterious programmer by the pseudonym Satoshi Nakamoto, Bitcoin is the world's first, and most successful, cryptocurrency. Operating through a decentralized computer network of hard-working peers known as 'miners' and acting on a cumulative transaction log known as the 'blockchain,' Bitcoin is resilient, scalable, and, above all else, anonymous. It has a market capitalization of nearly $4 billion, fueling interest and adoptions from banks, governments, and even corporations looking to appeal to a new and vibrant online economy. The future of cryptocurrencies in commerce, both online and offline, is looking bright.

Bitcoin does, however, have drawbacks. Due to the intensive nature of the hashing calculations it uses to generate value, the Bitcoin network is heavily supplanted by so-called 'botnets,' or large networks of personal computers being controlled remotely by malware for their computational resources. This has had two negative effects: a history of criminal usage that Bitcoin has had difficulty shaking, and uncalculated electrical costs absorbed by the owners of infected computers. The efficacy of these botnets has been partially alleviated by the creation of efficient application-specific integrated circuits (ASICs) to aid in the hashing process. However, this development has revealed yet another significant flaw in Bitcoin's design:

earnings stratification. Because the high-end ASIC arrays required to effectively mine on the Bitcoin network can cost tens of thousands of dollars, the majority of Bitcoin's payouts go to those who have the resources to have already paid for a head start, exacerbating an oligarchy among miners.

Worst of all is the so-called '51% attack,' which affects every currently popular cryptocurrency. The Bitcoin network's design encourages clients to band together into "mining pools" for increased payouts. Additionally, the network does not enforce a central authority responsible for maintaining the state of the transaction chain. Therefore, any pool of miners that manages to accumulate a majority of the network's hashrate could, in theory, change the public ledger by maliciously modifying transactions. Although this vulnerability has not been exploited yet, a large pool known as 'Ghash.io' did, for a few brief hours in June 2014, manage to gain the majority network share required to manipulate the blockchain. While the Ghash consortium did not abuse this temporary power, its very ability to do so underlies the surprising vulnerability of Bitcoin. Despite their strengths in cryptography and decentralization, today's cryptocurrencies are by no means infallible, and indeed possess network-crippling flaws.

This is where Permacoin comes in. With the flaws of Bitcoin and the other major cryptocurrencies in mind, Miller worked with Ari Juels of Cornell Tech, Elaine Shi of UMD, Bryan Parno of Microsoft, and Jonathan Katz to adapt the existing system into one both more secure and more useful.

Right off the bat, Permacoin's design fixes a number of problems endemic to Bitcoin and other common cryptocurrencies. Although Permacoin's current iteration uses the same family of hashing algorithms (SHA) as Bitcoin, its approach to peer relations is completely different. Whereas Bitcoin makes it easy for miners to band together and create trusted pools, Permacoin creates a so-called 'web of distrust' between clients by tying payouts to each user's cryptographically secure 'private key.' As Miller puts it, Permacoin "sows the seeds of distrust to prevent [pools] from forming," which allows "whoever is doing the actual mining work to steal the [Permacoin] reward in a way that [the client] couldn't get legally incriminating evidence or even necessarily be able to detect [the theft]."

With respect to earnings stratification on other cryptocurrency networks, "the [...] problem is large mining coalitions. It's one thing if there's people at the top of the pyramid who invest [...] to mine faster, but more often than not hosted mining companies with shareholders are essentially offering a service," says Miller. Permacoin solves this, and the thorny '51%

attack,' as no rational miner would entrust a pool with their aforementioned private key and "risk theft of their coins." This also reduces the already diminished efficacy of cryptocurrency botnets, as their operators can no longer count on public mining pools being available and trustworthy.

These improvements make Permacoin appealing enough as an alternative cryptocurrency on its own, but are just the beginning of the network's capabilities and potential. As Miller sees it, the rise of cryptocurrency isn't just an online economic phenomenon. It is a great opportunity to leverage the massive combined resources of miners worldwide for low-cost information sharing, and Permacoin does just that.

Apart from the aforementioned improvements, Permacoin's divergence from ordinary cryptocurrencies also appears on the so-called 'scratch-off puzzle' (SOP) level, or in the difficult tasks that cryptocurrencies challenge their networks with for payouts.

Although Permacoin uses the SHA family in its SOP just like Bitcoin, it differs in that it uses files instead of semi-arbitrary sequences as the basis for its computational difficulty, and therefore value. As a result, a computer's ability to mine effectively depends not just on its computational power but also on its ability to rapidly seek and retrieve files from its storage medium, a further "barrier to outsource ability." With Permacoin, any files can be used, allowing the network to operate in a second capacity as a peer-to-peer file sharing system while simultaneously incentivizing the data archival process by making real-world data "part of the mining process." Miller sees this as a solution to the thorny problem of data preservation, since it resiliently distributes the dataset and incentivizes the very process through cryptocurrency payouts.

So, where is Permacoin going in the future? As part of his research, Miller has used it to distribute open data sets like Project Gutenberg, which is famous for archiving and making public tens of thousands of cultural works. He also sees Permacoin as a way to integrate good record keeping with the process of mining itself, as the Bitcoin network does not reward its members for storing the records that are so vital to legitimate commerce. By tightly integrating storage into the Permacoin mining process, Miller hopes to "lower the marginal cost" of best practices.

Miller's Permacoin is a brilliant and unique development away from the interchangeable cryptocurrencies of today. It eliminates the problems of uneven payout distribution and vulnerabilities, like the 51% attack that have plagued Bitcoin and its brethren, all while putting the computational weight normally wasted by cryptocurrencies to good use for archiving and record keeping. As Miller notes, Permacoin is the next logical step in the "full decentralization" of data, a step that could be key to the future of both the growing cryptocurrency economy and the growing trend towards freedom of information as perpetuated by the Internet.

Miller is co-teaching a graduate level course on cryptocurrencies, CMSC818I, along with one of his research advisors Professor Elaine Shi. The course will cover popular cryptocurrencies like Bitcoin, as well as their secure implementation, implications, and impact.

RESEARCH CENTER FOCUS:

THE MARYLAND CYBERSECURITY CENTER

Immediate threats—your compromised email password, a hacked credit card database, or a website made exactly to replicate your favorite retailer's—are of concern to researchers and graduate students in the Maryland Cybersecurity Center (also known as MC2). However, these threats, while troublesome, are not necessarily the subjects of their research. Instead, according to Jonathan Katz, Professor of Computer Science and the Director of MC2, the research focus is quite different and it has to be more forward-looking. "We look for the next event—five to ten years out—that could impact the security of your personal information," he says.

To try to predict the next wave of cybersecurity threats, Katz and the researchers of MC2 consider both technical and non-technical ways to keep our information secure. Professors and researchers from the Computer Science Department mostly focus on the technical facets of cybersecurity including cryptography, programming-language and software security, and network and system security. In the area of cryptography, research includes both theoretical and more applied methods of approaching security. In programming-language and software security, research involves developing techniques to support the creation of reliable and secure software, and programming languages with security properties. In network and systems security, research encompasses ways to secure network protocols, develop secure (and perhaps anonymous) communication, and study network attacks.

While experts in computer science and computer engineering who understand the technical aspects of security (both software and hardware) lead MC2, the center very much engages in interdisciplinary work. MC2 houses academics specializing in education, business, economics, public policy, criminology, and information studies. Affiliates of the center collaborate to research ways that ensure the future stability and security of computing systems that people need for banking, shopping, communicating, as well as security for their health records and information storage.

CS Professors and Researchers at MC2

Cryptography

Jonathan Katz, Professor and Director
Elaine Shi, Assistant Professor

Programming-Language and Software Security

Jeff Foster, Professor
Michael Hicks, Professor
Atif Memon, Associate Professor
Bill Pugh, Professor Emeritus
David Van Horn, Assistant Professor

Network and Systems Security

Bill Arbaugh, Associate Professor Emeritus
Bobby Bhattacharjee, Professor
Dave Levin, Assistant Research Scientist
Michelle Mazurek, Assistant Professor
Neil Spring, Associate Professor

JONATHAN KATZ

THE FUTURE OF CYBERSECURITY

Thanks to invention of yellow dry-erase paint, one is able to map a small part of the complex scientific work on cryptography and computer security that Professor Jonathan Katz (CS and UMIACS) engages in on a daily basis. A large wall in his office is covered in algorithms and formulae, the result of his own efforts, his work with colleagues, and his research with graduate and undergraduate students. The work on the wall also only represents a part of his work at the university. Katz is a world-renowned computer scientist who is co-author of *Introduction to Modern Cryptography* (with Yehuda Lindell, now in its second edition), and he is also an editor of the *Journal of Cryptology*. Since October 2013, he has been the Director of the Maryland Cybersecurity Center (MC2). The Daily Record named him as one of "50 Influential Marylanders" for 2014, and in January 2015, he received a Humboldt award for his continued outstanding contributions to the field.

Katz speaks candidly and compellingly on a variety of topics in computer security and he highlights three (of several) exciting areas of cutting-edge technical work that occurs at MC2: Cloud security and privacy, BitCoin, and Program Obfuscation. This includes collaborative work that computer scientists from Systems Security, Programming Languages, and Cryptography must engage in to ensure safety and protection of information. He also discusses the qualities of a good cybersecurity student and professional.

ON CLOUD SECURITY AND PRIVACY

Over the last two to three years, many people have come to outsource storage completely to cloud services (think Google or Dropbox). Others outsource large computations to cloud services, and there is an inherent assumption that no one will look at or change the information that a user entrusts with a cloud service. Katz and his colleagues at MC2 do not take the safety of information for granted. Instead, they play devil's advocate. "How do you secure that [information]," Katz asks, "if you don't fully trust the cloud service?" He also mentions that users of these services need a way to ensure that their information has not been altered by the cloud service itself, a malicious attacker, or software or a disk error.

At the same time, if users are doing a set of computations using a cloud service, they need to trust that data is being used correctly, and the answers coming to them from the cloud service are correct. "You could redo the computation to verify it," he adds, "but then you didn't gain anything from pushing the computation to the cloud in the first place." Katz praises researchers at MC2 who are working on efficient techniques to verify computation in the cloud that allow the services to give a proof that they have done the correct computation on information provided.

Because users do not want their cloud services to be able to read or examine data that they have stored, there are privacy issues to consider as well. "In some cases, there might be legal reasons why a cloud service cannot have access to information stored there," Katz says. For him the main question is "How can you store and operate on data in the cloud while still ensuring privacy?" In order to begin to solve this problem, Katz explains that experts from several different technical areas need to work together to begin to solve these types of problems. "Cryptography, Systems Security, and Programming Language techniques are important for giving people easier ways to use the various technologies."

"SECURITY IS THINKING ABOUT THE CONSEQUENCES—WHAT HAPPENS WHEN SOMEONE DOES NOT USE A SYSTEM IN AN EXPECTED WAY."

ON BITCOIN... AND ELECTRONIC CURRENCIES IN GENERAL

Although a non-academic proposal (Satoshi Nakomoto's BitCoin: A Peer to Peer Electronic Cash System) emerged to fascinate people on the subject, Katz explains that the research community has been working on electronic cash systems for twenty-five years. However, to him, what is truly exciting about the BitCoin protocol is that this burst of interest was the result of a non-academic proposal. The anonymous paper "caught fire" and got people interested in an electronic cash system that then had an impact on the marketplace. "And since the paper came out, people are trying to understand the security properties it actually achieves," he says. BitCoin's security properties are quite unknown, and according to him "We don't yet have a handle on whether or not it is secure, or how to talk about security for a distributed electronic currency, or what kind of model [of security] even makes sense to talk about when dealing with distributed electronic currency, or how the protocol might be modified to give other properties that it currently doesn't have." He mentions that several people in MC2 and elsewhere are working on these problems to pose different alternatives to BitCoin. One of these alternatives is Permacoin, a project he is working on with Andrew Miller, a PhD student.

PROGRAM OBFUSCATION (SECURITY THROUGH OBSCURITY)

Very recently, there has been a breakthrough on program obfuscation techniques (a way to deliberately create code that is difficult for people to understand). Researchers are trying to understand and come up with efficient ways to create program obfuscation. "This has been going on industry for years, but in an ad hoc way. But now [because of work going on at MC2] there is a provable way to do program obfuscation, and this a very exciting direction of research."

ON CYBERSECURITY AND EDUCATING UNDERGRADUATES IN CYBERSECURITY

During the fall semester of 2014, Katz taught future security experts to think more carefully about security through his 400-level Cryptography class taught at UMD, and a Coursera seminar on the same subject, for which 35,000 students registered.

Katz defines Cybersecurity as that which relates to techniques for preventing unauthorized access of computer systems and data. This can include nearly every discipline in Computer Science. Whether students are interested in Theory, Systems, Programming Languages, HCI, or Databases, security ties all of these areas together. "You might be interested in the mathematical part of security, designing secure access control for an operating system, or writing software with secure programming languages. You need networking for secure connections, you will need secure databases, and you'll need to make sure that users are able to access data securely—these things are all part of cybersecurity." He adds that the notion of privacy is also a part of cybersecurity, but because it is at the edge of a very technical aspect of security, things may seem a bit more complicated. "You might give Facebook your information, but you don't want them to publish it online. If they choose do a study, you want them to be able to anonymize it sufficiently. This is also a part of cybersecurity."

Katz believes that most people have a clear understanding of cybersecurity and what it means, but in order for a student to be talented in the field, he or she must have a hacking mentality. This does not include breaking into systems for the sake of breaking into them, but a desire to understand how things work, understand what is going on in a given system, and determine what, if anything, could go wrong. An ideal cybersecurity expert can determine the ways that a system can be exploited, figure out how to defend against any exploits, and then be able to repair those same exploits. "Security is thinking about the consequences—what happens when someone does not use a system in an expected way," he explains.

ALUMNI RECEIVE SLOAN FELLOWSHIP

Mike Schatz, PhD ('10) and Cole Trapnell, PhD ('10), are 2015 recipients of Sloan Fellowships for Computational and Evolutionary Molecular Biology. Shatz is currently an Associate Professor of Genomics at the Cold Spring Harbor Laboratory in New York. Trapnell is currently an Assistant Professor of Genome Sciences the University of Washington, School of Medicine. Both Shatz and Trapnell were advised by Steven Salzberg.

ARAVIND SRINIVASAN NAMED ACM FELLOW

Professor Aravind Srinivasan (CS, UMIACS, and AMSC) is now a 2014 Association for Computing Machinery fellow. ACM chose Srinivasan and forty-six other computer scientists from universities, industry, and research labs for their significant contributions to computing research and development. The new fellows have been recognized for their achievements which are "driving innovation and sustaining economic development around the world."

"I feel an enormous sense of gratitude for several people and institutions: our own UMD, its faculty, staff and students; family and friends; and several colleagues, educators, and mentors," Srinivasan said when asked about the award.

Srinivasan's new award adds to an impressive list. He is also a fellow of AAAS (American Association for the Advancement of Science), IEEE (Institute of Electrical and Electronics Engineers), and he holds three patents. He currently serves as the Vice Chair of the IEEE Technical Committee on the Mathematical Foundations of Computing, and he is the Editor-in-Chief of the ACM *Transactions on Algorithms* (TALG).

"Aravind Srinivasan is brilliant and I am so glad that we were able to recruit him to the University of Maryland," said Professor Samir Khuller, Elizabeth Stevinson Iribe Chair of Computer Science. "His thinking and insights in randomization are simply unparalleled, and he has both developed and applied a lot of the techniques in the field, to very practical problems. His work is both foundational and practical at the same time."

In addition to teaching graduate and undergraduate courses in theoretical computer science, Srinivasan does research in the area of randomized algorithms, networking, social networks, and combinatorial optimization.

He also works on the growing confluence of algorithms, networks, and randomness in fields including the social Web, learning, public health, biology, and energy. He has published more than 100 papers in these areas, in journals including *Nature*, *Journal of the ACM*, *IEEE/ACM Transactions on Networking*, and the *SIAM Journal on Computing*.

After completing his B.Tech in Computer Science from Indian Institute of Technology, Madras, Srinivasan earned both his M.S. and Ph.D. in Computer Science from Cornell University in 1993. He became a Joint Postdoctoral fellow for the Institute for Advanced Study at Princeton (which he later joined), as well as a postdoctoral fellow for DIMACS (Center for Discrete Mathematics and Theoretical Computer Science) at Rutgers University. After earning tenure at the School of Computing, National University of Singapore, he moved to Bell Laboratories before finally joining the CS Department at the University of Maryland as an Associate Professor in 2001. He became a full professor in the Computer Science Department in 2006.

Srinivasan joins Professors Vic Basili, Larry Davis, Ray Miller, Jack Minker, Dana Nau, Dianne O'Leary, Hanan Samet, and Ben Shneiderman as an ACM Fellow.

ABOUT THE ACM FELLOWS PROGRAM:

The ACM Fellows Program, initiated in 1993, celebrates the exceptional contributions of the leading members in the computing field. ACM will formally recognize the 2014 Fellows at its annual Awards Banquet in June 2015 in San Francisco.

ACADEMIC PLACEMENTS

The department has had the pleasure of granting PhDs to some of the brightest and most innovative students in the country. Many of our alumni have gone on to work in academic departments, research labs, government agencies, and industries all over the world. In this edition of shell, we are highlighting those alumni and former postdocs over the last several years who have been appointed as professors in Computer Science or another field.

*Keep us informed about your news at **www.cs.umd.edu/community/alumni**.*

PhDs

Nizar Habash, PhD ('03), New York University, Abu Dhabi, Computer Science Department.
Advisor: Bonnie Dorr.

Julian Mestre, PhD ('07), University of Sydney, School of Information Technology.
Advisor: Samir Khuller.

Tsz-Chiu Au, PhD ('08), Ulsan National Institute of Science and Technology, South Korea, School of Electrical and Computer Engineering.
Advisor: Dana Nau.

Adam Lopez, PhD ('08), University of Edinburgh, School of Informatics.
Advisor: Philip Resnick.

Abinav Gupta, PhD ('09), Carnegie Melon University, School of Computer Science.
Advisor: Larry Davis.

Azarakhsh Malekian, PhD ('09), University of Toronto, Rotman School of Management.
Advisor: Samir Khuller.

Mustafa Bilgic, PhD ('10) Illinois Institute of Technology, Department of Computer Science. Advisor: Lise Getoor.

Sandro Fouche, PhD ('10), Towson University, Computer and Information Science.
Advisor: Adam Porter.

Sorelle Friedler, PhD ('10) Haverford College, Department of Computer Science.
Advisor: Dave Mount.

Mike Schatz, PhD ('10) Cold Spring Harbor Laboratory, Simons Center for Quantitative Biology.
Advisor: Steven Salzberg.

Gerardo Simari, PhD ('10), Universidad Nacional Del Sur in Bahia Blanca, Argentina, Department of Computer Science and Engineering.
Advisor: V.S. Subrahmanian.

Il-Chul Yoon, PhD ('10), State University of New York, Korea, Department of Computer Science,
Advisors: Alan Sussman, Atif Memon, and Adam Porter.

Ryan Farrell, PhD ('11), Brigham Young University, Computer Science Department.
Advisor: Larry Davis.

Jian Li, PhD ('11), Tsinghua University, Institution for Interdisciplinary Information Science.
Advisors: Amol Despande and Samir Khuller.

(Maria) Vanina Martinez, PhD ('11), Universidad Nacional Del Sur in Bahia Blanca, Argentina, Department of Computer Science and Engineering.
Advisor: V.S. Subrahmanian.

Barna Saha, PhD ('11), University of Massachusetts Amherst, School of Computer Science
Advisor: Samir Khuller .

Paulo Shakarian, PhD ('11), United States Military Academy, West Point, Department of Electrical Engineering and Computer Science.
Advisor: V.S. Subrahmanian.

Ben Langmead, PhD ('12), Johns Hopkins University, Department of Computer Science.
Advisor: Steven Salzberg.

Jaehwan Lee, PhD ('12), Korea Aerospace University, College of Engineering.
Advisor: Alan Sussman.

Rob Patro, PhD ('12), Stonybrook University, Computer Science Department.
Advisor: Carl Kingsford.

Shivrubramani Krishnamoorthy, PhD ('13), Amrita University, India.
Advisor: Ashook Agrawala.

Adam Groce, PhD ('14), Reed College, Department of Mathematics.
Advisor: Jonathan Katz.

Mike Lam, PhD ('14), James Madison University, Department of Computer Science.
Advisor: Jeff Hollingsworth

Alex Quinn, PhD ('14), Purdue University, Department of Electrical and Computer Engineering.
Advisor: Ben Bederson.

Master's Degree Students

Maryam Farboodi, MS ('06), (PhD in Economics at University of Chicago), Department of Economics, Princeton University.
Advisor: Amol Deshpade

Bachelor's Degree Students

Noah Smith, BS ('01), (PhD Johns Hopkins University), Department of Computer Science and Engineering, University of Washington.

Svetlana Yarosh, BS ('05), (PhD George Institute for Technology), Department of Computer Science, University of Minnesota.

Katrina LaCurts, BS ('08), (PhD MIT), Lecturer, Department of Electrical Engineering and Computer Science.

Postdocs

Dan Goldwasser, Postdoc with Hal Daumé III, Purdue University.

Seung Geol Choi, Postdoc with Jonathan Katz, U.S. Naval Academy

Bert Huang, Postdoc with Lise Getoor, Virginia Tech.

Yan Huang, Postdoc with Jonathan Katz, Indiana University.

Stanley Kok, Postdoc with Lise Getoor, Singapore U of Technology and Design

Junhui Li, Postdoc with Philip Resnik and Hal Daumé III, Soochow University.

Morteza Monemizadeh, Postdoc with Mohammed Hajiaghayi, Charles University, Czech Republic.

Smaranda Muresan, Postdoc with Philip Resnik, Columbia University.

Dominique Schroeder, Postdoc with Jonathan Katz, Saarland University, Germany.

Sinead Williamson, Postdoc with Hal Daumé III, University of Texas at Austin.

Tom Yeh, Postdoc with Larry Davis, David Jacobs, and Ben Bederson, University of Colorado, Boulder.

Vassilis Zikas, Postdoc with Jonathan Katz, ETH, Zurich.

Hong-Sheng Zhou, Postdoc with Jonathan Katz, Virginia Commonwealth University.

PhD PLACEMENTS 2014

We are pleased to announce the placements of our PhD students for 2014. As they are settling in to their new lives, we wish them success, and look forward to hearing about their accomplishments.

Adam Groce, PhD ('14), Visiting Asst. Prof., Reed College, Portland, OR

Megan Monroe, PhD ('14), IBM, Cambridge, MA

Jiarong Jiang, PhD ('14),Two Sigma Investment LLC, New York, NY

Alex Quinn, PhD ('14), Asst. Prof., Electrical and Computer Engineering, Purdue Univ.

Kan Leung Cheng, PhD ('14), Google, Mountain View, CA
Yuening Hu, PhD ('14), Yahoo Labs, Sunnyvale, CA
Ke Zhai, PhD ('14), Yahoo! Labs, Sunnyvale, CA

Ashwin Kayyoor, PhD ('14), Symantec Research Labs, Culver City, CA

Ronald Alford, PhD ('14), U.S. Naval Research Lab, Washington, DC
Sujal Bista, PhD ('14), Research Associate, UMIACS, UMCP
Peter Fontana, PhD ('14), NIST, Gaithersburg, MD
Michael Lam, PhD ('14), Asst. Prof., James Madison Univ, Harrisonburg, VA
Yuancheng Luo, PhD ('14), Visisonics, College Park, MD
Hassan Sayyadi, PhD ('14), Comcast Cable, Washington, DC
Douglas Summers-Stay, PhD ('14), Army Research Lab, Frederick, MD
Jared Sylvester, PhD ('14), Booz Allen Hamilton, Annapolis Junction, MD
Gleneesha Williams, PhD ('14), Dept. of Defense, Ft. Meade, MD
Derrick Wood, PhD ('14), Postdoc, Johns Hopkins Univ., Baltimore, MD

Arijit Biswas, PhD ('14), Xerox Resesarch Centre India, Bangalore

Rajesh Chitnis, PhD ('14), Postdoc, Weizmann Institute of Science, Rehovot, Israel

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Corporate Partners in Computing Program

CPIC is designed to establish mutually beneficial, strategic relationships with organizations that share a commitment to advancing the fields of computer science and interdisciplinary computing through collaborative efforts in education, research, and technology development. If you have questions or would like to visit with us about becoming a Corporate Partner in Computing, please contact Savannah Renehan srenehan@cs.umd.edu | 301.405.9695