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IMPACT

TIMA Technology is Core to Samsung's State-of-the-art Knox Platform

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Security technology developed by NC State computer science researchers, called **TIMA**, has been sub-licensed to Samsung through CellSentry Inc., an NC State start-up with support from the NC State Office of Technology Transfer. The TIMA technology is one of the core components and part of the innermost security layer of the Samsung Knox platform deployed in their mobile phones and tablets.

TIMA or TrustZone Integrity Measurement Architecture incorporates privacy and security functions at the embedded systems level, which acts as buffer between the Android OS Kernel and mobile processor hardware.

Security software can be bypassed, creating vulnerabilities for smartphone companies and users, especially enterprise users. But the TIMA technology addresses this problem by incorporating security features with continuous monitoring that is well isolated and protected by hardware based mechanisms— making it difficult, if not im-

possible, to bypass. The technology is based on research that was led by **Dr. Ahmed Azab** and **Dr. Peng Ning** (pictured above) from the Computer Science Department at NC State.

The research was funded in part by the U.S. Army Research Office through the Secure Open Systems Initiative based at ITng, and by the National Science Foundation. The technology was initially managed by the NC State Office of Technology Transfer and received additional proof of concept funding from the NC State Chancellor's Innovation Fund. The technology was later licensed to CellSentry, a NC State spinoff company led by the inventors. CellSentry further developed the technology and sub-licensed it to Samsung.

Since developing the TIMA technology, Dr. Ning is now on leave from the University and serves as senior vice president, head of Samsung KNOX R&D team at Samsung Research America; co-head of Samsung KNOX global R&D team.

TIMA is one of the core components and part of the innermost security layer of the Samsung Knox platform.

TOP 10

NC State's Online Computer Science Programs Rank 7TH Nationally

The **Engineering Online Computer Science and Networking** programs at NC State have been ranked 7th nationally in the *U.S. News & World Report*'s 2015 list of the **Best Online Graduate Computer Information Technology Programs**.

Engineering Online at NC State has again been recognized as one of the top online engineering programs in the United States coming in 11th nationally on the magazine's list of **Best Online Graduate Engineering Programs**.

The College of Engineering at NC State established what is now known as Engineering Online in 1978. The program, designed for working professionals, allows students to earn master's degrees in engineering without coming to campus. Courses offered by Engineering Online are identical to on-campus courses in terms of content, requirements and academic rigor.

Engineering Online offers master's degree programs in aerospace engineering, civil engineering, chemical engineering, computer engineering, computer networking, computer science, electrical engineering, environmental engineering, industrial engineering, integrated manufacturing systems engineering, materials science and engineering, mechanical engineering, nanoengineering, and nuclear engineering. The program also offers a master of engineering degree.

For more information about Engineering Online at NC State, please visit engineeringonline.ncsu.edu.



A Virtual Whodunit

Police and first responders are trained to disturb as little as possible at the scene of a homicide or other violent crime. But no one's perfect, and eventually the scene must be released. Homes must be occupied. Businesses must reopen. Traffic on a busy street must flow once more.

But what if you could preserve that space virtually, so that investigators and the specialists with whom they collaborate could return to the scene of the crime during the investigation?

That is the aim of IC-Crime, a multidisciplinary project led by faculty from NC State's College of Textiles working alongside colleagues from the Department of Computer Science and the College of Design to give real law enforcement a tool that might fit on the popular television drama "CSI."

IC-Crime's development is part of NC State's Digital Games Research Center (DGRC), housed in the Department of Computer Science on Centennial Campus. Work on the design of the IC-Crime software is overseen by **Dr. R. Michael Young**, professor of computer science, director of DGRC and a co-principal investigator on the project. **Dr. David Hinks**, Cone Mills Professor of Textile Chemistry and interim dean of the College of Textiles, is the principal investigator.

On the (virtual) scene

In a world imagined by IC-Crime, an expert on blood spatter would sit down at her computer and access a secure server online. Investigators faced with a particularly vexing homicide case need her help.

She starts as an avatar walking into a virtual lobby. From that lobby, she chooses from several rooms in which

to enter. Each room is a crime scene in another state or even another part of the world that she can see without leaving her desk.

Once inside the scene, she will be able to move around the room and look at things from different angles. Just as in a real crime scene, this room is filled with markers. By clicking on these markers, she is able to pull up additional data points like high-resolution photographs, information on shell casings or lab reports.

The work done to create this virtual environment was done by crime scene investigators as the scene was processed. After CSIs dusted for fingerprints and scoured the room for fibers, they also set up a 3D scanner on a tripod that took a digital scan of the room.

The kind of traditional paper trail that is part of an investigation has been scanned and added to the virtual setting, so the avatars can quickly pull them up by clicking on those markers. The infinite power of the digital realm allows access to large databases.

Closing the case

Whether IC-Crime technology goes beyond the precinct house and into the courtroom remains to be seen. The benefits seem obvious: While jurors are sometimes taken to a crime scene, the passing of time means what they find is always different than what prosecutors and defense attorneys have described. With IC-Crime, they could see what that scene looked like the night of a murder.

It's a project that provides a different perspective on the usefulness and impact of computer games.

"There's a breadth of new capabilities that game technologies enable that go well beyond entertainment," Young said.

Researchers Aim to Improve Educational Software Through Speech and Emotion Detection

NC State researchers have won a \$1.2 million grant from the National Science Foundation to improve educational software by enabling it to assess facial expression, body language, speech and other cues to better respond to a student's emotional state during the learning process.

"Educational software can be a valuable tool, but so far these tools don't account for student emotion or affect," says **Dr. Kristy Boyer**, former assistant professor of computer science at NC State and co-primary investigator (PI) of the grant. "We're planning to develop and test techniques and technologies for incorporating affect and dialogue into educational games and other software."

The ultimate goal is to develop a software tool to support the learning process by assessing a student's verbal and nonverbal cues and using that information to customize how the program responds to each student.

The first step for the researchers will be to modify an existing game,

Crystal Island, to incorporate spoken dialogue and affect sensors that track eye movement, facial expressions and posture. The researchers will then use the program in middle schools to collect preliminary data on how students interact with the program, both in terms of natural language (what the students say) and nonverbal cues (what the students do).

"This preliminary data will serve as the basis for all of the subsequent modeling we do, as well as our development of techniques for how the game should respond to the student," says **Dr. James Lester**, a professor of computer science at NC State and PI of the grant.

The grant is for three years and focuses specifically on middle school science education, though the findings are expected to be broadly applicable to other subjects and age groups. Co-PIs on the project include **Dr. Brad Mott**, a senior research scientist in NC State's Department of Computer Science, and **Dr. Eric Wiebe**, a professor of science, technology, engineering and mathematics education at NC State.



Moore Award Helps Sullivan Put Theory Into Practice

The Gordon and Betty Moore Foundation has announced that it has selected **Dr. Blair D. Sullivan** for a \$1.5 million Moore Investigator Award – one of only 14 nationally – as part of its Data-Driven Discovery Initiative. Sullivan's work focuses on transforming theoretical algorithms into practical tools that could be used in fields ranging from biomedical science and social media research to business analytics and online retailing.

"This award will enable us to drastically advance the understanding of intermediate-scale structure in massive, real-world graph data and design targeted, efficient algorithms based on ideas from theoretical computer science," says Sullivan, an assistant professor of computer science at NC State. Graphs, in the context of computer science, are used to model discrete entities which have connections between them, for example neurons in the brain or individual users on Facebook.

Sullivan's work is based on a field of study called parameterized complexity. These algorithms leverage a graph's structure to solve time-consuming problems much more quickly. Technically speaking, this approach attains polynomial algorithms for NP-hard problems in special classes of graphs.

"The biggest challenge is that the algorithms are theoretical," Sullivan adds. "My group is working to put those theories into practice."

Department Announces Masters Track in Data Sciences

The Department of Computer Science at NC State University is pleased to announce the approval and launch of a Master Track in Data Science in the Computer Science Graduate Program curriculum.

The curriculum is effective beginning Fall 2015.

Data Science has become increasingly important in nearly every industry sector and academic field, and the discovery and forecasting of insightful patterns from "Big Data" is at the core of analytical intelligence in government, industry, and science.

According to **Dr. George Rouskas**, Professor & Director of Graduate Programs, "The Masters Track in Data Science complements various academic

and research initiatives in data science on campus." He adds that the track will provide students with the skills essential to knowledge discovery efforts to identify standard, novel and truly differentiated solutions and decision-making, including skills in managing, querying, analyzing, visualizing, and extracting meaning from extremely large data sets.

The data sciences track curriculum requirements include nine credit hours of data science core courses; nine credit hours of data science electives; twelve credit hours of computer science core courses, graduate electives or restricted electives; and a one credit hour orientation course, for a total of 31 credit hours. Students must also satisfy all the Master of Computer Science (MCS) requirements.

Enron Becomes Unlikely Data Source for Computer Science Researchers

Computer science researchers have turned to unlikely sources – including Enron – for assembling huge collections of spreadsheets that can be used to study how people use this software. The goal is for the data to facilitate research to make spreadsheets more useful.

“We study spreadsheets because spreadsheet software is used to track everything from corporate earnings to employee benefits, and even simple errors can cost organizations millions of dollars,” says **Dr. Emerson Murphy-Hill**, an associate professor of computer science at NC State and co-author of two new papers on the work.

However, there are relatively few public collections of spreadsheet data available for research purposes. For example, the collection currently used by most researchers consists of approximately 4,500 spreadsheets.

But researchers are now making two new collections available – one has 15,000 spreadsheets and the other has more than 249,000.

“In addition, we are publishing a technique that other researchers can use to collect additional spreadsheet data,” Murphy-Hill says.

The 15,000 spreadsheet collection consists entirely of spreadsheets collected from internal Enron emails, which were made public after the emails were subpoenaed by prosecutors.



“Our focus is on how users interact with spreadsheets,” Murphy-Hill says. “And these spreadsheets actually tell us a lot about how users represent and manipulate data.”

To assemble the second set of spreadsheets, called Fuse, the researchers developed their own technique to identify and extract spreadsheets from an online archive of over 5 billion webpages. Using their technique, the researchers collected 249,376 spreadsheets – including spreadsheets made as recently as 2014.

“Fuse used cloud infrastructure to search through billions of webpages to identify and extract the spreadsheets we write about in this paper,” says **Titus Barik**, a Ph.D. student at NC State, researcher at ABB Corporate Research, and lead author of the paper on Fuse. “Commodity cloud computing is incredibly exciting – searching those pages would take about

seven years of continuous computation on a single computer, but the economies of scale with cloud computing allowed us to accomplish this with Fuse in only a few days.”

“And the fact that Fuse includes recent spreadsheets is a significant advantage over other spreadsheet collections, because the information is more up-to-date and reflects changes in Excel and other spreadsheet software,” Murphy-Hill says.

“Fuse is also more reproducible than other spreadsheet collections,” says **Kevin Lubick**, a Ph.D. student at NC State and co-author of a paper about Fuse. “Reproducibility is the cornerstone of good scientific research, but many existing spreadsheet collections are difficult to reproduce. Our technique can be used by anyone, and they’ll get the same results we get. But the results will also include any new spreadsheets made available since the last time the program was run.”

The Enron collection is the subject of a paper called “Enron’s Spreadsheets and Related Emails: A Dataset and Analysis,” which was presented at the International Conference on Software Engineering May 20-22 in Florence, Italy. Lead author of the paper is **Felienne Hermans** of Delft University of Technology. The Fuse paper, “Fuse: A Reproducible, Extendable, Internet-scale Corpus of Spreadsheets,” was presented at the Working Conference on Mining Software Repositories, May 16-17, in Florence, Italy. The Fuse paper was co-authored by NC State Ph.D. students **Justin Smith** and **John Slankas**.

IMPACT BYTES



DRS. MUNINDAR SINGH and **R. MICHAEL YOUNG** (pictured at left) have been named Alumni Association Outstanding Research Award Recipients for 2014-2015. This is one of the highest honors that a faculty member can receive at NC State.

Young, who was also recently named a 2014-2015 University Faculty Scholar, is the only professor in NC State history to win university-level Outstanding Faculty Awards in all three areas they are given: Research, Extension and Outreach, and Teaching.



DR. DOUGLAS REEVES has been promoted to Associate Dean for Graduate Programs in the College of Engineering. He has served as Assistant Dean since Fall 2013.



MS. MARGARET HEIL has been named Director of the NC State Computer Science Department Senior Design Center. She served as associate director for 19 years, and served as interim director following the retirement

of Dr. Robert Fornaro in 2014.

DR. FRANK MUELLER is the recipient of a prestigious Humboldt Research Award for a one-year research visit in Germany. Mueller was recognized for being an international expert on fault-tolerance and performance analysis/tuning in high-performance computing.

New Tech Aims to Improve Communication Between Dogs and Humans

NC State researchers have developed a suite of technologies that can be used to enhance communication between dogs and humans, which has applications in everything from search and rescue to service dogs to training our pets.

"We've developed a platform for computer-mediated communication between humans and dogs that opens the door to new avenues for interpreting dogs' behavioral signals and sending them clear and unambiguous cues in return," says **Dr. David Roberts**, an assistant professor of computer science at NC State and co-lead author of a paper on the work. "We have a fully functional prototype, but we'll be refining the design as we explore more and more applications for the platform."

The platform itself is a harness that fits comfortably onto the dog, and which is equipped with a variety of technologies.

"There are two types of communication technologies," says **Dr. Alper Bozkurt**, an assistant professor of electrical and computer engineering at NC State and co-lead author of a paper on the work. "One that allows us to communicate with the dogs, and one that allows them to communicate with us."

"Dogs communicate primarily through body language, and one of our challenges was to develop sensors that tell us about their behavior by observing their posture remotely," Roberts says. "So we can determine when they're sitting, standing, running, etc., even when they're out of sight – a harness-mounted computer the

size of a deck of cards transmits those data wirelessly.

"At the same time, we've incorporated speakers and vibrating motors, called haptics, into the harness, which enable us to communicate with the dogs."

"We developed software to collect, interpret and communicate those data, and to translate human requests into signals on the harness," says **Rita Brugarolas**, an NC State Ph.D. student and co-author of the paper.

The technology also includes physiological sensors that monitor things like heart rate and body temperature. The sensors not only track a dog's physical well-being, but can offer information on a dog's emotional state, such as whether it is excited or stressed.

These technologies form the core of the platform, but it can be customized with additional devices depending on the specific application.

"For example, for search and rescue, we've added environmental sensors that can detect hazards such as gas leaks, as well as a camera and microphone for collecting additional information," Bozkurt says.

"We're also very interested in addressing stress in working dogs, such as guide dogs for the blind," says **Sean Mealin**,



an NC State Ph.D. student and co-author of the paper. "We're reliant on the physiological and behavioral sensors to give us a picture of the dog's mental and emotional state."

In addition to disaster response research, the research team has already done work that uses the platform to assist in dog training. They are now in the early stages of miniaturizing the technologies and improving the physiological sensors for use in animal shelters and hospitals.

"This platform is an amazing tool, and we're excited about using it to improve the bond between dogs and their humans," says **Dr. Barbara Sherman**, a clinical professor of animal behavior at the NC State College of Veterinary Medicine and co-author of the paper.

The paper, "Towards Cyber-Enhanced Working Dogs for Search and Rescue," is published online in IEEE Intelligent Systems. The paper was co-authored by NC State Ph.D. students **John Majikes** and **Robert Loftin**, and by former NC State Ph.D. student **Dr. Pu Yang**.



DR. SARAH HECKMAN three time graduate of the NC State Computer Science Department ('04 BS, '05 MS, '09 PhD) was recently honored with an NC State Alumni Association Outstanding Teacher Award. She was also selected as a recipient of the Outstanding Teacher Award from the College of Engineering. She was recognized for her creative and innovative teaching and learning practices.



Congratulations to **DR. TIM MENZIES** for publishing a book entitled "Sharing Data and Models in Software Engineering." The book presents guidance and procedures for reusing data and models between projects to produce results that are useful and relevant.

DR. RADA CHIRKOVA (\$40,000), **MS. MARGARET HEIL** (\$20,000), and **MR. JOHN STRECK** (\$40,000) have been selected to receive highly competitive and selective 2015 IBM Faculty Awards. The awards recognize outstanding faculty achievement and are renewable each year.

DRS. WILLIAM ENCK (\$47,500), **EDWARD GEHRINGER** (\$57,620), and **XIPENG SHEN** (\$58,110) have been selected to receive Google Research Awards. These awards are one-year awards structured as unrestricted gifts to universities to support the work of world-class full-time faculty members at top universities around the world. The intent of the Awards is to support cutting-edge research in computer science, engineering, and related fields.

6 New Members Join Department's Strategic Advisory Board (SAB)

The NC State Computer Science Department is pleased to welcome six new members to our Strategic Advisory Board (SAB), a cornerstone of the Department's strategic planning efforts. Dr. Mladen Vouk, head of the Department, recently announced the addition of the new members, including two alumni:

- **Richard Branton**, Vice President and Chief Technology Officer at Merck
- **Tracy Doaks**, Senior Director, Service Delivery at Duke Health Technology Solutions
- **Brian Lora**, Chief Information Officer at StoneRiver RegEd
- **David Schmitt**, Engineering Director at NetApp
- **Pawan Sharma**, President and Head - Manufacturing, Energy and Utilities at KPIT
- **Robert Tomasko**, Senior Principal Member, Software Architect at Oracle

The SAB is the cornerstone of the department's strategic planning efforts. This dynamic group of industry executives and academic leaders provide input and guidance, which is critical to helping shape the department's strategic focus. The SAB meets annually on campus and functions as a virtual working team throughout the year through member involvement on subcommittees, executive panels and other engagement opportunities. Membership terms are for three years and may be renewed for a second term.

Heather Miller, Director of Business Architecture, PMO and Vendor Relationship Manager of Coca Cola, is currently chair of the SAB, and **Mike Huska**, Director, Technical Architecture, Incentive Compensation COE of IMS Health, is the vice-chairman.

Cracking the Code

The attackers are winning.

Those attackers are hackers who exploit deficiencies in software code that allow them access to your credit card number and even your medical records. What's at stake is more than money. In the case of vital healthcare software, lives could be at risk.

The US National Security Agency (NSA) established lablets at NC State, Carnegie Mellon and the University of Illinois in 2012 in hopes of taking a different approach to preventing cyber-attacks, to change how code is written and take away opportunities from thieves.

This year, those three universities were asked to compete against other schools to keep their lablets. The NSA invited 190 schools to submit proposals, but the agency renewed all three schools, and the University of Maryland was added to the program.

The Science of Security Lablet at NC State is housed in the Institute for Next Generation IT Systems, a joint university/government research organization tasked with working on current information technology challenges.

Dr. Laurie Williams and **Dr. Michael Rappa**, professors in the Department of Computer Science, were the original co-principal investigators in NC State's lablet. Rappa is also founding director of NC State's Institute for Advanced Analytics, which offers the nation's first Master of Science degree in analytics. In 2014, **Dr. Munindar Singh**, also a professor in the Department of Computer Science, replaced Rappa as the co-PI with Williams.

Williams points to a number of reasons that hackers have the upper hand right now, chief among them the lure of a big financial windfall.

"For them, the payoff can be really high," Williams said. "They're willing to dedicate a lot of time to get in."

For the developers writing software code, too often the financial incentives are reversed. With a push to get products out the door, not adding code that makes a product secure means time is saved.

Add to that the fact that software engineers are not taught to code securely. The fix often is as simple as replacing

one line of code with another, but if no one knows about that secure option then mistakes are repeated. Attackers are familiar with those mistakes.

"There can be vulnerabilities that we all know about, and people just keep coding that way," Williams said. "They just keep developing more and more software with the same vulnerabilities in them."

Williams describes the current approach to security as often a reactive approach. We've been attacked — let's fix that problem.

What if cyber security was looked at with a scientific approach with hypotheses and the research to back them up, plus repeatable research methods that can be used to teach? What if, instead of plugging holes, system designers worked together to make sure there are no holes to begin with?

Maybe then, the attackers will be put on the defensive. That's the aim of the Science of Security Lablet.

At NC State, the lablet exemplifies the kind of interdisciplinary cooperation that is one of the university's strengths. The lablet is based in the Department of Computer Science, but involves faculty from the departments of Electrical and Computer Engineering and Civil, Construction, and Environmental Engineering, along with the College of Education and departments of Psychology and Statistics.

The NSA provides \$2 million to \$2.5 million in annual funding to each lablet. At NC State, 16 faculty and 18 students are involved. Six collaborating university partners — Purdue, UNC-Chapel Hill, UNC-Charlotte, Alabama, Virginia and Rochester Institute of Technology — are also part of the NC State project.

The NSA asked the lablets to come up with five hard problems to solve. Those problems look not just at security metrics and the architecture of systems but how humans behave when they are interacting with the software that is being studied.

Being selected by the NSA for three more years of funding means the lablet at NC State will continue that work.

"Three years from now, I hope that we have made a lot of progress on those hard problems," Williams said.

Researchers Roll Out Science Video Game With Demonstrated Results

Researchers are rolling out a science video game and educational curriculum, making them freely available to educators. The educational game has already been tested in 14 middle-schools and led to major improvements in literacy and science among eighth graders.

The game, "Crystal Island: Lost Investigation," and supporting materials can be downloaded for free at <http://go.ncsu.edu/crystalisland>. The game was developed by researchers from North Carolina State University's Center for Educational Informatics, led by **James Lester**, and East Carolina University.

"In our pilot study, test results showed that students in classes that used the game saw a significant improvement in their reading comprehension and understanding of science concepts," says **Jonathan Rowe**, a research scientist at NC State who worked on the project. "Student performance on science reading tests improved by at least one letter grade after the program was incorporated into the class curriculum."

The game was implemented in a four-week teaching unit that addressed both science concepts and reading skills, in line with state

and federal teaching standards. The teaching unit was used by more than 1,200 students in 14 schools in North Carolina's Johnston County.

The game and educational materials were developed with funding from the National Science Foundation, the United States Department of Agriculture, the Social Sciences and Humanities Research Council of Canada, and the Next Generation Learning Challenges program, which is overseen by the nonprofit group EDUCAUSE and funded by the Bill & Melinda Gates Foundation and the William and Flora Hewlett Foundation.

New Framework Would Facilitate Use of New Android Security Modules

Computer security researchers from NC State and Technische Universität Darmstadt/CASED in Germany have developed a modification to the core Android operating system that allows developers and users to plug in new security enhancements. The new Android Security Modules (ASM) framework aims to eliminate the bottleneck that prevents developers and users from taking advantage of new security tools.

"In the ongoing arms race between white hats and black hats, researchers and developers are constantly coming up with new security extensions," says **Dr. William Enck**, an assistant professor of computer science at NC State and a senior author of a paper describing the new framework. "But these new tools aren't getting into the hands of users because every new extension requires users to change their device's firmware, or operating system (OS).

"The ASM framework allows users to implement these new extensions without overhauling their firmware," Enck says. "The framework is available now for security enthusiasts. But for widespread adoption, either Google or one of the Android phone manufacturers will need to adopt the framework and incorporate it into the OS."

The ASM framework allows the creation of custom security control modules

that better protect phones owned by consumers and businesses. The custom security modules receive "callbacks" for every security-sensitive operation in the Android OS. In this context, a callback means that Android is contacting the security module to determine whether an operation should proceed.

"Our ASM framework can be used in various personal and enterprise scenarios. For instance, security modules can implement dual persona: i.e., enable users to securely use their smartphones and tablets at home and at work while strictly separating private and enterprise data," says Enck.

"Security modules can also enhance consumer privacy. The framework provides callbacks that can filter, modify, or anonymize data before it is shared with third-party apps, in order to protect personal information," Enck says. "For instance consider an app like Whatsapp, which usually copies all your contacts to its server – which is not needed for it to function." With ASM, the user can make sure Whatsapp only gets the information it really needs.

"In addition, we designed the framework to allow apps to create their own hooks, which could be enforced by the security module," Enck says. "This increases flexibility for app developers and allows



them to benefit from the security protections provided by the module."

The researchers also went to great lengths to ensure that the ASM framework complies with the security guarantees Google and others make with app developers. For example, the framework can only make data access more restrictive.

Co-lead authors of the paper, "ASM: A Programmable Interface for Extending Android Security," are **Adwait Nadkarni**, a Ph.D. student at NC State, and **Stephan Heuser**, a Ph.D. student at TU Darmstadt/CASED. Co-authors include Enck and **Dr. Ahmad-Reza Sadeghi**, of TU Darmstadt/CASED.

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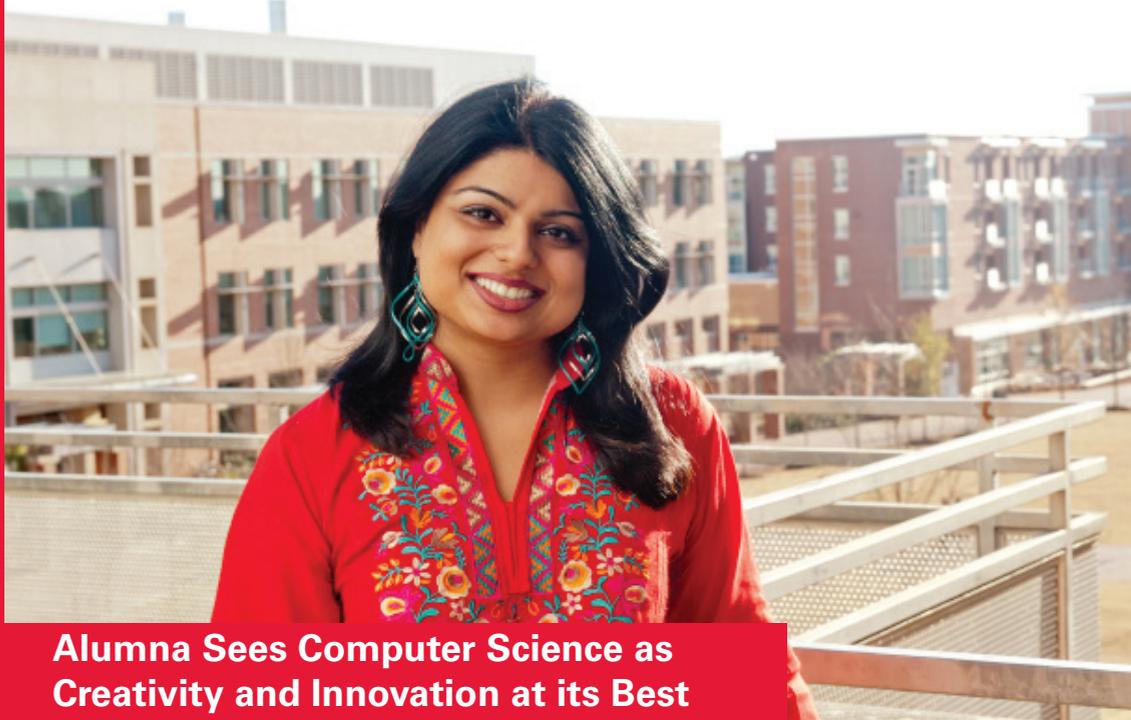
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NC State Engineering Alumni



Alumna Sees Computer Science as Creativity and Innovation at its Best

Dr. Bushra Anjum (CSC PhD 2012) is passionate about computer science. She shares that passion with her students back in her native Pakistan where she teaches and mentors computer science students. When she describes her passion for the field, she intentionally includes all the factors that make her field unique. Like a complicated recipe that lists many ingredients, combined together, it can be a masterpiece, but standing alone, each ingredient is one-dimensional. Computer science, she says, is certainly not one-dimensional.

“Students need to see the bigger picture of computer science. For example, you recognize a problem and you try to weigh out various options, then you set your goal at one solution or maybe a couple of solutions,” she says. “And then you try to find technological feasible thoughts from the problem to the solution. Programming or coding is just a little part of that process. It’s creativity and innovation at its best.”

Building a picture in the minds of her students of all the possibilities that computer science has to offer is vitally important to her, since she sees some one-dimensional thinking in her native country. She finds that students who have not had the international exposure that she has had, tend not to think outside of what is occurring in Pakistan, a gap she intends to bridge.

“There is a huge disconnect for students in Pakistan,” she said. “People who have not had the chance to have the experience I had – living and studying in the

States, making new friends and having mentors – they feel ok living in one world while the rest of the world is like another universe on another planet.”

Her desire to be a teacher and mentor was born from her experience at NC State, as a new international student, in a completely unfamiliar environment several years ago.

“I found the general environment and the people here very warm and welcoming and since NC State – especially the Computer Science Department - gets so many international students, they have developed this culture which is really encouraging and motivational,” she said. “I was the only one from Pakistan when I came here but after a few days, I didn’t feel that way at all. It’s an inclusive culture that I think was very helpful for me.”

True to form, she found exactly what she was looking for at NC State, not just simply stated in a mission statement, but lived out on a day-to-day existence on the campus.

“I still remember one line from the mission statement of the Computer Science department, that says ‘we want our graduates to be leaders and innovators in industry, education and government for the state, nation and world,’” she said. “I thought that was a very simple, yet powerful statement.”

(Anjum is currently a software development (performance) engineer at Amazon.com.)