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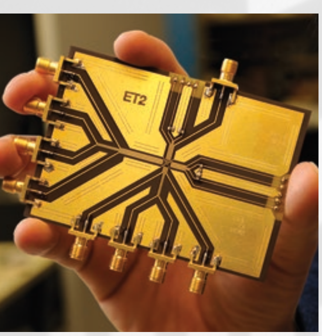
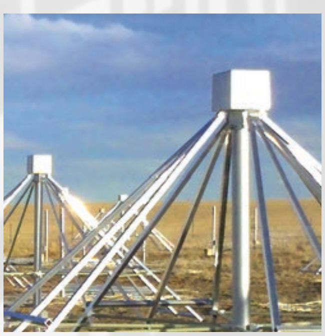
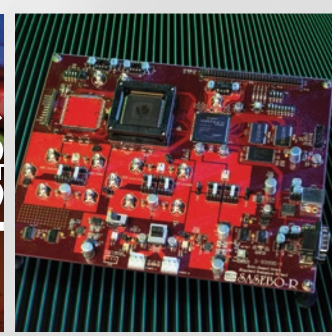
THE BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

2012







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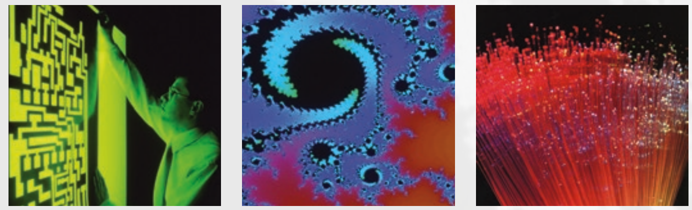

On the cover: 25 years ago students examined rubyliths of circuits on lightboxes, and fractals and fiber optics were hot topics in research.

This report was produced with funds from the Harry Lynde Bradley Foundation.

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WHAT'S INSIDE

PERSPECTIVES *from the* DEPARTMENT HEAD

It continues to be my great honor to serve as the head of the Bradley Department of Electrical and Computer Engineering. This is a special edition of our annual report in that it marks the 25th anniversary of the establishment of the Bradley Endowment. On May 11, 1987, Virginia Tech's Board of Visitors approved the naming of our department as the Harry Lynde Bradley Department of Electrical Engineering in memory of Mr. Bradley and in recognition of the generous gift of his daughter, Mrs. Marion Bradley Via, to support the department. In 1997, our name changed again to become the Bradley Department of Electrical and Computer Engineering, in recognition of the prominent roles of both computer engineering and electrical engineering to our teaching and research efforts. Of course, the history of the department goes back much further — to 1892 when the Department of Physics and Electrical Engineering was formed and to 1898 when the Department of Electrical Engineering became a stand-alone unit.

Scott Midkiff
Deparment Head

An anniversary offers an opportunity to reflect upon the past. From 1892, when electrical engineering began at Virginia Tech, until 1987, when the Bradley Endowment was created, electrical engineering had established itself as an outstanding department. But, the significant impact of the Bradley Endowment over the past 25 years is tangible. Funds from the endowment allow us to let the world know about our achievements through publications such as this annual report, hold events that bring together our extended ECE family such as the annual Bradley Banquet, and support two Bradley Professors, Gary Brown and Bill Tranter.

However, by far the greatest benefit of the Bradley Endowment is the scholarships and fellowships that attract excellent undergraduate and graduate students to Virginia Tech's ECE Department. Our students benefit from generous scholarships and fellowships, the department benefits from the contributions of these students to the department and its research, and our nation benefits from the many contributions made by our Bradley alumni. This annual report lists 96 Bradley Scholar alumni and 105 Bradley Fellow alumni and gives a small sampling of the difference they are making today.

As an aside, I wish to express my sincere gratitude to former

(continued on next page...)

from the ece DEPARTMENT HEAD *Continued*

ECE department head and Dean Emeritus Bill Stephenson whose hard work and persistence led to the nearly complete list of past Bradley Scholars and Fellows that is contained in this annual report.

The annual report also presents our current Bradley Scholar and our 13 current Bradley and Webber Fellows. These students, and our other fine students, will shape the future of the Commonwealth of Virginia, the nation, and society as whole.

25 YEARS

1990: Scott Midkiff and graduate student Wayne Bollinger in the Computer Systems Lab.

Looking internally, the future of our department lies with our faculty and staff. They apply their considerable expertise and energy to advance discovery, learning, and engagement. Here, I offer a few highlights from the past year. Dave Fritz's excellent support of undergraduate learning in the Open Electronics Laboratory earned him one of two annual Exemplary Employee awards from the College Association for Staff in Engineering. Patrick Schaumont and Yong Xu were promoted to the rank of associate professor and granted tenure, JoAnn Paul was granted tenure at the rank of associate professor, and Luiz DaSilva was promoted to the rank of professor. Jason Lai was named the James S. Tucker Professor. Kristie Cooper and Carl Dietrich were promoted to the rank of research associate professor.

As just one indication that our department's future is particularly bright, three of our assistant professors, Joseph Baker, Chao Wang, and Yaling Yang, received highly competitive Faculty Early Career Development (CAREER) Awards from the National Science Foundation during the past year. And, we are fortunate to welcome five new outstanding individuals to our faculty: Charles Clancy specializes in wireless security and serves as director of the Hume Center for National Security and Technology, Greg Earle joins our Center for Space Science and Engineering Research, Yaman Evrenosoglu teaches and conducts research in power systems, Kwang-Jin Koh brings expertise in radio frequency integrated circuits, and Chao Wang adds new depth and breadth in embedded software and systems. Also, Bob McGwier joined the department as a research professor and the director of research for the Hume Center.

The future of our department is also deeply linked to our alumni and friends. I am especially grateful for our ECE Advisory Board and, particularly, past chair Mike Hurley and new chair Michael Newkirk. The Advisory Board has contributed greatly by sharing fresh perspectives and insights, providing advocacy, and working with student design projects. Financial support from alumni, corporate partners, and other friends has never been more important than it is today as state support for universities, including Virginia Tech, meets only a small part of the cost of educating our students.

While of great help, the Bradley Endowment alone is insufficient to do the work that we must do. Private and corporate donations are essential if we are to move forward to increase quality, impact, and innovation. External support is needed for many needs, including additional scholarships and fellowships to allow the most deserving students to benefit from a Virginia Tech ECE education; innovative integrated design projects that prepare our students to meet important and increasingly complex challenges; international experiences to ensure that our graduates can successfully compete and collaborate in the global engineering workplace; research experiences for undergraduates to prepare them for advanced studies in ECE; and other innovative programs that allow our students to be tomorrow's leaders.

While this ECE Annual Report reflects on the difference that the Bradley Endowment has made over the past 25 years and offers a glimpse of our recent achievements and impact, we must continue to dedicate ourselves to the future — our students and solutions to societal challenges. Given the energy and ability of our students, the expertise and dedication of our staff and faculty, and the strong support of our alumni and friends, I am confident that Virginia Tech's ECE department will make an even greater difference over the next 25 years.

Scott F. Midkiff
Professor and Department Head

from the Chair

OF THE **ADVISORY BOARD**

It is hard to believe it has already been 25 years since Marion Bradley Via made her generous donation in her father's name to Virginia Tech, resulting in the naming of the Bradley Department of Electrical and Computer Engineering (ECE). That remarkable gift set in motion a tremendous era of growth and diversification in ECE, allowing the department to explore new areas of research by funding fellowships and scholarships that have been important to so many students. As a former Bradley Fellow ('90-'93), this is particularly relevant for me (and perhaps a remarkable coincidence), having now come "full circle" from beneficiary to contributor as the newly elected Advisory Board Chair. I am both humbled and honored to lead such a distinguished group of Virginia Tech ECE alumni and friends as we seek to help the department become even stronger and more influential than it is today. I consider this a small way for me to pay back the generosity of Mrs. Via, whom I had the great pleasure of meeting when I was a Fellow.

In this year's report we have a chance to reflect on what has changed in the past 25 years, and also to see how that has evolved into new and exciting areas of research that touch so many areas – from bioengineering to robotics, power electronics to utility modernization, space research and missions to underwater autonomous vehicles — to name but a few. We also get a closer look at what the Bradley Endowment has meant to past and current Scholars and Fellows. In addition, we get a peek at the beautiful new VT Research Center — Arlington (VTRC-A) building, which is quickly becoming a major focal point for the University in the National Capital Region, and where ECE is already strongly represented and poised for growth.

As members of the Advisory Board, my colleagues and I have the great privilege of getting first-hand accounts of these outstanding efforts, while also being in a position to offer advice, project reviews as well as material and financial support. This past year our members were able to interact with students and faculty in five ECE classes or projects as either design reviewers or guest lecturers. These activities provided a "real-world feel" for the students as they approach their new careers, as well as a highly rewarding experience for our members. We look forward to continuing and growing this service role for ECE, which I also strongly recommend and encourage to other alumni; please contact the department to see how you can get involved.

What should be clear after reviewing this report is that Virginia Tech ECE faculty and students are on the leading edge of engineering research in many areas that touch our lives, and they do this exceptionally well. Our simple goal on the Advisory Board is to provide whatever advice, experience and gifts are necessary to sustain this level of excellence.

Enjoy the report!

Michael Newkirk
(BSEE '88, MSEE '90, Ph.D. '94)
Chair, ECE Advisory Board

Michael Newkirk
Chair, ECE Advisory Board

25 YEARS

1991: The first meeting of the newly established Advisory Board.

COEXISTING CAN BE A PROBLEM ON SO MANY LEVELS

In their quest for performance gains, many wireless network engineers are proposing a cross-layer design approach that some researchers fear may prove disruptive and short-lived.

In traditional, wired network design, protocols with single goals — such as routing — are designed and optimized as separate modules, or layers in a stack. Each layer communicates with two others, typically pictured as those above and below. By breaking the layered architecture, cross-layer designs can actively exploit the dependence between protocol layers and solve the unique problems posed by wireless links, according to Yaling Yang, assistant professor of ECE. Cross-layer designs also enable engineers to explore opportunistic communications, and leverage new modes of wireless communications, she says.

Cross-layer designs are growing more popular, but their increasing numbers are creating serious coexistence problems amongst themselves and with other networking protocols, according to Yang. Problems can reach beyond poor decisions and can affect the very stability and reach of a network.

"For example, a cross-layer design that involves multiple iterative algorithms at different network entities may never be able to converge in a highly dynamic wireless network environment," she says. "Or, a cross-layer design that has a too-aggressive power control scheme in the physical layer may affect a routing system's ability to find a path."

Researchers have published warnings about cross-layer design and unresolved coexistence problems could cause the approach to be prematurely abandoned, according to Yang. "Many cross-layer designs may not be accepted, due to the fear of the unknown impact of these problems."

"Many cross-layer designs may not be accepted, due to the fear of the unknown impact of these problems."

Yang wants to resolve these uncertainties. She is leading a new effort to investigate cross-layer coexistence issues, supported by a five-year, $450,000 National Science Foundation (NSF) Faculty Early Career Development (CAREER) award. The CAREER grant is the NSF's most prestigious award, given to junior faculty members who are expected to become academic leaders in their fields.

"To the best of our knowledge, ours is the first systematic, rigorous analysis of cross-layer coexistence issues," she acknowledges.

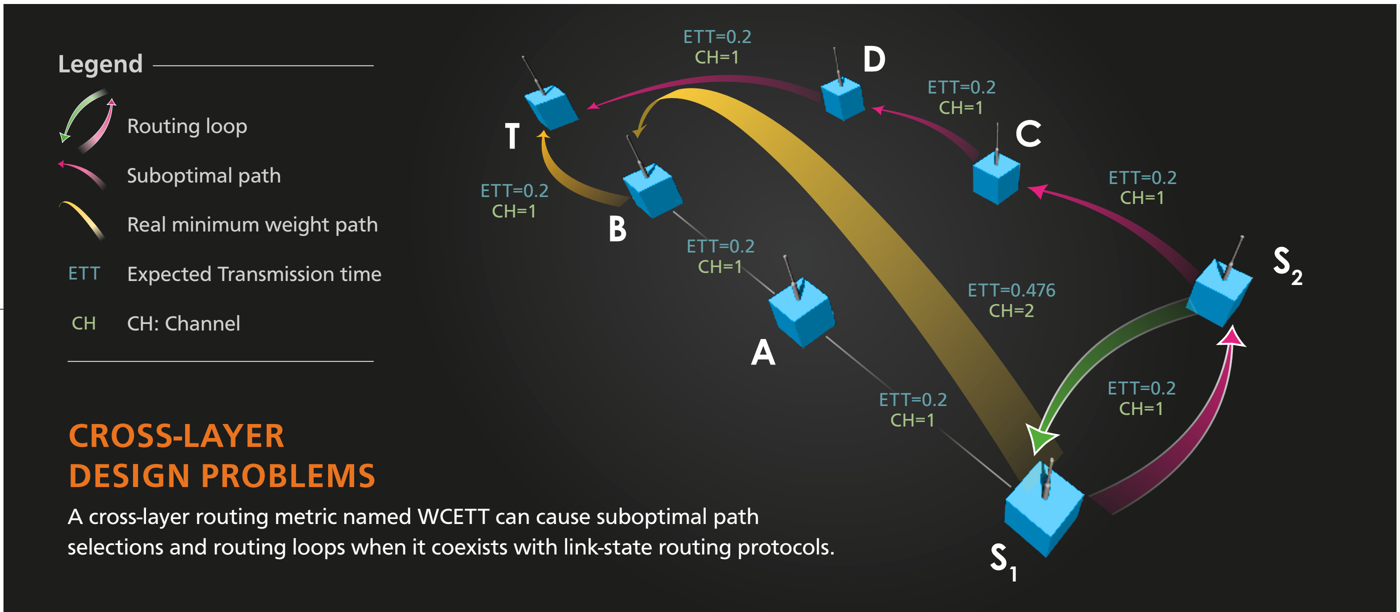
The research effort comprises three parts: modeling and analyzing coexistence restrictions of various cross-layer designs; investigating restriction-compliant design techniques; and developing an open-source testbed.

Coexistence restrictions

Yang has identified four types of coexistence restrictions that her team will model and analyze, including restrictions on optimality, distributed design, reachability and stability. While in each case, cross-layer designs could break underlying assumptions and conditions, the problems present different perils to network operation.

Optimal decision-making is the core of many networking systems, including routing and traffic she says. "While existing optimization algorithms in these networking systems guarantee optimal solutions, they may not work if cross-layer designs break their assumptions about the structures of their target problems."

Distributed design is often adopted for scalability, she says. "In these designs, while nodes need to make individual decisions, these decisions are consistent so that the overall system still functions correctly." However, if cross-layer designs break the conditions that ensure consistent decision-making, routing loops and other problems can arise.



CROSS-LAYER DESIGN PROBLEMS

A cross-layer routing metric named WCETT can cause suboptimal path selections and routing loops when it coexists with link-state routing protocols.

1 Node S1 uses Dijkstra's algorithm to calculate its minimum weight path to T. In an intermediate step, Node S1 finds that <S1, A, B> has a lower weight than <S1, B>.

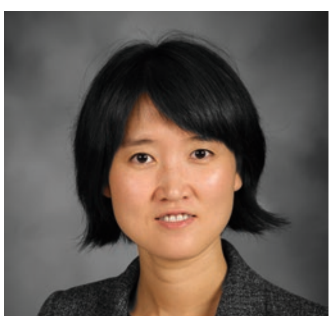
2 This causes node S1 to prematurely discard <S1, B> for further consideration and eventually select path <S1, S2, C, D, T> as the minimum weight path. Hence, link-state routing cannot always find the optimal path defined by WCETT.

3 When S2 calculates its path to T, Dijkstra's algorithm correctly computes that <S2, S1, B, T> is the minimum weight path – and a routing loop is formed between S1 and S2 due to those nodes' inconsistent routing decisions.

A cross-layer design can impact a network's reachability in many ways, she says. For example, a network can be disconnected due to excessive physical-layer power control or a wrong selection of modulation schemes. Cross-layer designs can affect stability as well. "Many designs include multiple iterative algorithms that reside on different layers.

The interactions among these algorithms can greatly slow down the convergence speed of the entire network" she says. "This may cause route flapping, buffer overflow, high control message overhead, and slow responses to changes."

Not only do the restrictions create different challenges, but they also affect networks differently, according to Yang. "Optimality restrictions are critical for networks with stringent resources. Distributed design and stability restrictions are important for large networks, and reachability restrictions are especially important for networks that require reliable communications."



Yaling Yang

Restriction-compliant design

Once the restrictions and the challenges of cross-layer design are analyzed, Yang's team plans to investigate practical techniques for building restriction-compliant cross-layer systems. They plan to develop techniques that ensure that cross-layer components satisfy given coexistence restrictions, and techniques that relax coexistence restrictions. "These techniques can serve as design guidelines for cross-layer designs and help network engineers create more adaptable and flexible networking systems," she says.

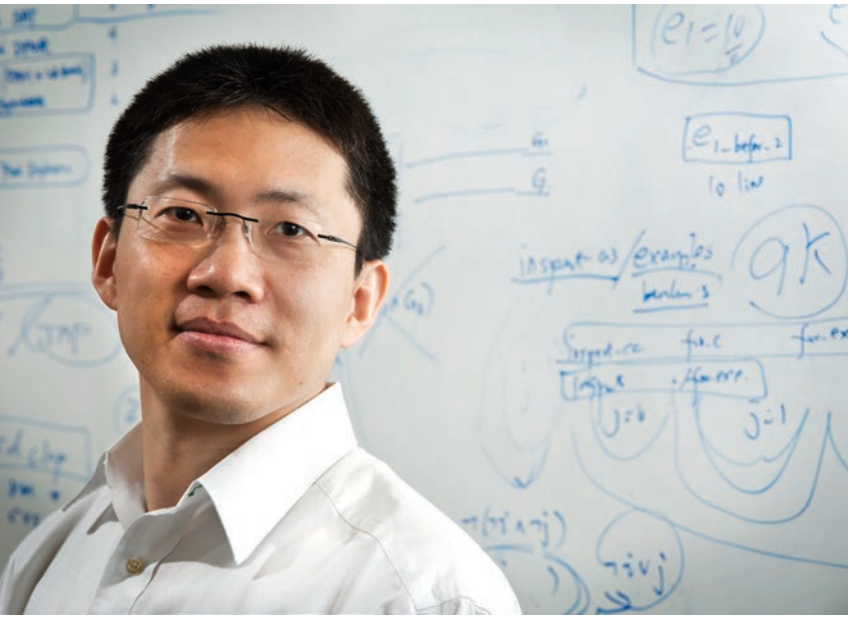
The third tier of her research effort will be building an open-source testbed to validate results, measure the impact of violating different coexistence restrictions, and serve as a proof-of-concept for the team's restriction-compliant design techniques. The testbed will initially be implemented as a hybrid wireless/wired network system that takes advantage of many of Virginia Tech's homegrown software and designs.

All CAREER awards have a strong educational component and the testbed will play a major role in Yang's educational efforts. She plans to develop a discovery-based networking course for upper-level undergraduates and first-year graduate students that incorporates competition-based projects.

At the graduate level, Yang plans to develop a course named Theories for Network System Analysis.

Yang's goal is the same in both her research and educational efforts: to develop the understanding and tools needed for flexible, robust wireless networks that enable engineers to enhance the flexibility and robustness of current and future network systems. ece

MULTI-THREAD MULTI-CORE A SINGLE BUG



Chao Wang came to Virginia Tech in August 2011, after serving seven years as a Research Staff Member at NEC Laboratories in Princeton, New Jersey. At NEC Labs, he contributed to the development of a hardware verification tool called DiVer, a software verification tool called F-Soft, and a concurrent software testing tool called Fusion. He received an NEC Laboratories Technology Commercialization Award in 2006 for contributions to F-Soft.

He earned his B.S. and M.S. degrees from Peking University, China in 1996 and 1999, respectively, and a Ph.D. degree in 2004 from the University of Colorado, Boulder.

You can run a complicated program a million times and find no evidence of the bug that will make it fail. But the bug is there, waiting. How do you find it? How do you know you found it?

According to a widely cited federal study, debugging accounts for more than 50 percent of software development costs. Software bugs have been responsible for blackouts and deaths, in addition to security vulnerabilities, product delays, financial loss, and frustration. Debugging has become a crisis, according to Chao Wang, an expert in specification and verification of complex computer systems, who joined ECE recently as an assistant professor. The crisis is compounded, he says, by the growing use of multi-core processors and multi-threaded programs.

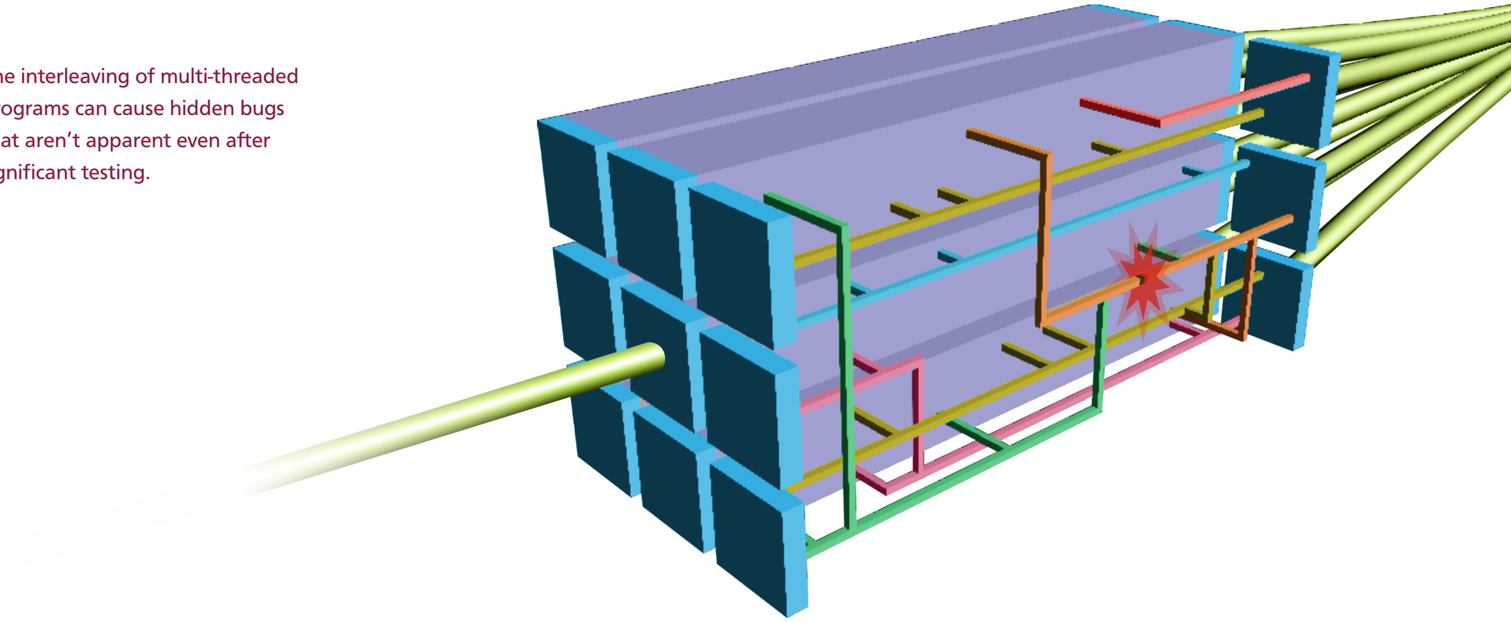
Wang wants to help resolve the debugging crisis by building tools that automatically detect and locate bugs through automated concurrency verification. To pursue his plan, he has received a $478,000 CAREER Award, the NSF's most prestigious grant for early-career faculty members.

Wang explains that "concurrent programs are typically written with multiple threads in parallel, and those threads need to coordinate." It's hard for programmers to manually reason through a program with thousands of threads.

"Debugging is a nightmare," according to Wang. "You can step through a sequential program, but you can only step through one thread of a concurrent program. When you're debugging, you have to be thinking about what all the other threads are doing. It's not easy for humans to do." In practice, he says, debugging often involves the programmer "simply staring at the source code, which is neither economical nor reliable."

Wang proposes to solve three problems, beginning with efficiently generating the failure-inducing program input and thread schedule. It isn't enough, however, to just detect a bug, Wang says. You also have to diagnose what is causing the bug, then repair it. He is seeking methods to accurately identify the failure's root cause and automatically compute a repair. He also wants to determine how to

The interleaving of multi-threaded programs can cause hidden bugs that aren't apparent even after significant testing.



fix bugs that arise from redundant or inefficient use of synchronizations — which can be common in concurrent programs.

His tools will not be fully automated, but will be a powerful debugging aid for programmers. "If it can do a certain amount of work, it will save a lot of time," says Wang. "If it's a really complicated bug in a large code base, it will typically take weeks or months for one programmer to trace it down." Wang would like to reduce this time to days or even hours.

"Today, every CPU is multi-core. You can't get away from it. We are reaching the point where we can't find many single-core processors, and if you want to leverage the computing power of the CPU, you have to write multi-threaded programs. That's why it's becoming an important problem."

> If you want to leverage the computing power of the CPU, you have to write multi-threaded programs. That's why it's becoming an important problem.

Every CAREER award has an educational component, and Wang is working to incorporate multi-core programming into undergraduate courses. This is urgent, he says, "because it will help avoid creating another generation of engineers whose first thoughts about concurrency are that it's scary and always hard."

Wang, who spent seven years working in industry, explains that although programmers in industry have more experience, on the topic of concurrent programming they aren't much better than university students. "When they were in school, we didn't teach this kind of thing."

So, Wang would like to create a two-to-three week summer course for programmers in industry. He wants to help "retrain industry professionals so they can be brought up to speed with the multi-core revolution."

The tools Wang is designing won't require the program to run more than a few times, and maybe only once. A programmer would run the program and log the execution traces, possibly even running them sequentially. "There won't be any bug," Wang explains, but the program will look at the traces and reason through all the possible interleavings. "The program could predict a bug without running into it," he says.

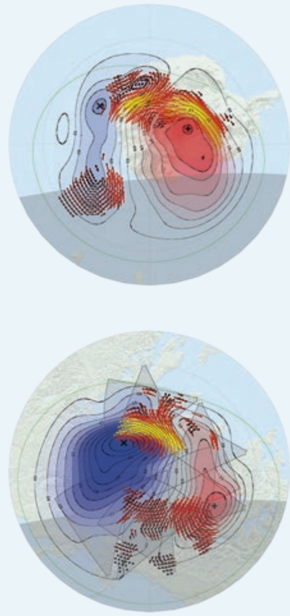
"By logging the traces and statically reshuffling the possible events, you may infer that there is another interleaving that triggers a bug. You can find a bug that you haven't observed." Then you just have to block the particular interleaving that triggers the bug.

So that bug that didn't show up when you ran the program a million times can be caught before it's a problem. ece

1997: Student Ricardo Silini works on a controls class assignment. When debugging with single-core processors, engineers used the time-honored process of staring at the source code to find problems manually.

25 YEARS

SPACE WEATHER ASYMMETRIES

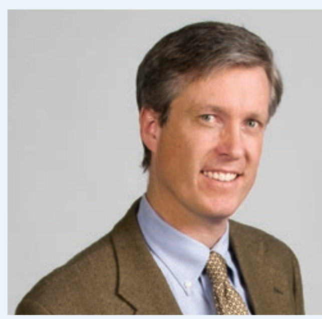


Ionospheric space weather convection patterns for the northern hemisphere (top) and southern hemisphere (bottom). According to Baker, "there are symmetries and antisymmetries in the patterns that speak to inter-hemispheric space weather connections."

The Earth is surrounded by a dynamic space plasma environment called the magnetosphere which is controlled by activity on the Sun, such as solar flares. In turn, disturbances in the magnetosphere are transmitted along magnetic field lines to the electrically charged upper atmosphere (the ionosphere). The aurora is but one example of an upper atmosphere space weather phenomenon that has its ultimate origins on the Sun. Because the Earth's magnetic field has a symmetric shape (similar to that of a bar magnet) space weather perturbations should be largely symmetric across the magnetic equator: both hemispheres should basically behave similarly. But this might not always be true.

ECE's Joseph Baker has received an NSF CAREER award to study north-south asymmetries in the Earth's ionosphere with the Super Dual Auroral Radar Network (SuperDARN) and very low frequency (VLF) receivers. Baker, along with Mike Ruohoniemi and Ray Greenwald, runs the Virginia Tech SuperDARN laboratory (see sidebar).

"Under most circumstances, space weather disturbances at middle to high latitudes in the two hemispheres should look very similar, despite the fact that local ionospheric conditions might be very different," says Baker. "For example, a large burst of upper atmosphere wind in the Southern Hemisphere should produce an ionospheric disturbance that drives a current to flow along magnetic field lines from the Southern Hemisphere into the Northern Hemisphere — at least in theory," he explains. Basically, a wind burst at one end of a magnetic field line produces a noticeable ionospheric effect at the other end. "The extent to which this actually happens is still an open question." According to Baker, "there is a lot to this dynamic that we don't yet fully understand."



Joseph Baker

Baker's goal is to identify different kinds of transient features in the SuperDARN radar data at middle to high latitudes and map them between the hemispheres using magnetic field models. If a radar system in the Southern Hemisphere sees a particular feature that was not seen by northern radars looking at the same magnetic field lines, "then there's either something wrong with the accuracy of the magnetic field model or our understanding of the extent to which the dynamics between the hemispheres should be linked together by magnetic field lines."

Baker is excited about the potential for student involvement at all levels of study. "The idea of magnetic connectivity is fairly easy to explain to an educational audience at all levels," he says. Baker has plans for pre-college students, for undergraduate students, and for his graduate researchers.

In conjunction with Virginia Tech's Center for the Enhancement of Engineering Diversity (CEED) summer camps, Baker plans to explain basic magnetism concepts to middle and high school students and send them out with very low frequency (VLF) receivers to listen for "whistlers." Whistlers are electromagnetic waves produced by lightning that then travel along magnetic field lines to the other hemisphere where they can be heard using a VLF receiver, antenna, and headphones. The sound is a musical descending tone that lasts for a second or more, depending on the distance traveled. Whistlers were first identified by radio operators during the First World War, and their origin remained a mystery for some time.

Baker would like to see his undergraduates doing the same thing, but with more understanding and analysis. Whistlers are still an active area of research to this day, he explains. "You can use the frequency characteristics of whistlers to remotely sense conditions in the magnetosphere: you can figure out what the plasma density is further out in space."

Baker teaches a new class on introductory space science called Exploration of the Space Environment, which is available to students in all majors. For this class, Baker currently offers several options for a semester project, and would like to add another option that involves analyzing whistlers. Students choosing this project option would build a VLF receiver from a kit, listen for whistlers, analyze the data, and use information from worldwide weather services to locate any lightning storms occurring in the Southern Hemisphere at the time of the whistlers they identify.

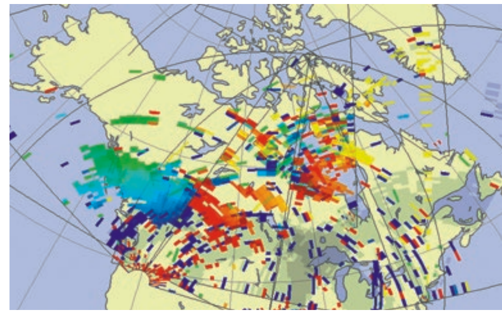
A team of students from Baker's Exploration of the Space Environment class launched a weather balloon to take pictures and measurements of the upper atmosphere.

Baker also plans for some of his graduate and advanced undergraduate students to use a more powerful receiver designed by colleagues at Stanford University that operates in the extremely low frequency (ELF) and VLF range. Baker describes this receiver, called the Atmospheric Weather Electromagnetic System for Observation, Modeling, and Education (AWESOME) monitor, as "a research-grade ELF/VLF receiver."

This monitor, Baker says, "will allow Virginia Tech undergraduate students to grasp the diversity of natural phenomena that can be studied using radio instrumentation: lightning physics, lightning-ionosphere interaction, solar flares, gamma-ray bursts, earthquake-ionosphere coupling, auroral electron precipitation, magnetospheric physics." He would like some undergraduate researchers to become a regular part of his research team's efforts. ece

SuperDARN

SuperDARN is an international collaboration involving scientists and engineers in more than a dozen countries. High frequency (HF) radars are positioned around the world and operated continuously to provide global, instantaneous maps of plasma convection in the Earth's ionosphere. Scientists around the world use SuperDARN data to help understand the many effects of space weather, according to Baker.



SuperDARN reading over North America.

The original array of SuperDARN radars was built near magnetic latitudes of 60 degrees during the 1990s and early 2000s. "That's where you normally see auroral activity," explains Baker. "But when there's a large geomagnetic storm, the Earth's geospace environment gets so disturbed that the aurora expands equatorward and people sometimes see it as far south as Texas." When this happens, a large component of the disturbance occurs southward of the original SuperDARN radars and so was not being captured in the data. Some societal impacts of these storms include degradation of satellite communication and navigation links, as well as power system disruption.

Over the past few years, the SuperDARN network has been steadily expanding to middle latitudes to study geomagnetic storms more effectively. The Virginia Tech SuperDARN group is heavily involved in a project to complete a new array of eight mid-latitude radars spanning North America and the Azores. "The combined data from these new radars is allowing us to see the full longitudinal structure and dynamics of the whole geomagnetic disturbance," says Baker.

As we move towards solar maximum next year, solar activity is picking up, Baker explains. So the team is going to have many more of these types of events to study.

SuperDARN site at Christmas Valley, Oregon.

WIRELESS SECURITY from Android to 5G

If commercial 5G devices are able to use unoccupied military channels, how can engineers ensure that users cannot infer military operations based on what frequencies are available when?

Can you take an inexpensive, commercial Android-based phone and change out the software to convert it for secure military communications? Or is the military doomed to always be spending more for its devices than civilians?

How will next-gen cognitive radios provide resilient communications when facing adversarial jammers?

From devices to network systems, wireless security issues abound at all levels for Charles Clancy, who joined the ECE department last summer as an associate professor. Clancy also serves as director of Virginia Tech's Ted and Karyn Hume Center for National Security and Technology.

The issues Clancy's team is investigating reflect the broad range of issues in the field. Some of Clancy's students are working on communications protocols, such as 3GPP Long Term Evolution (LTE). Others are investigating jamming attacks and next-gen cognitive radio. The research is a mix of classified and non-classified. As a general rule, he says, research from the attack perspective is classified, but defense is not.

> If people are trying to probe your system and it costs real money for every probe request, it will cost too much to launch an attack.

Then there is the anticipated 5G mobile network system, which is expected to enable consumer devices to use open military channels, among other commercial and federal frequency bands. Clancy describes three options currently being studied to protect against users deducing military operations. "You can obfuscate the information, making it less clear why different bands are being assigned, so that it's hard to draw the lines back. You can add dummy constraints into the system so it's hard to tell if there is a real military need, or if it's a fake one to fool you," he says.

A third approach is to charge per megahertz per second. "If people are trying to probe your system and it costs real money for every probe request, it will cost too much to launch an attack."

Secure ways to share the military spectrum will be a critical component of 5G, he says. "One of the big forcing functions for 5G will be that we've run out of cell phone spectrum to support the growing demand of mobile broadband users."

Clancy's team is also investigating improving the security of some off-the-shelf technology — Android-based phones. "The military currently spends thousands for each tactical radio,"

Security expertise: prior to joining Tech, Clancy worked for various organizations within the Department of Defense, primarily focused on applications of academic wireless research to the national security mission. In his final tour, he was the technical advisor for the Iraqi telecommunications reconstruction effort in Baghdad, and successfully led the effort to architect and activate Iraq's Internet backbone.

He earned his B.S. in computer engineering from the Rose-Hulman Institute of Technology and his M.S. in electrical engineering from the University of Illinois, Urbana-Champaign. He received his Ph.D. in computer science in 2006 from the University of Maryland, College Park.

he says, "and would love to use an Android phone instead." Commercial Android phones, however, are not designed to military security requirements. "Changing the hardware for enhanced security would be expensive, so we're looking at how to take a commodity phone and change the software to make it more secure for the military environment," he explains. "The basic question is how can the armed services feel comfortable using Android phones manufactured overseas in a military environment."

While Clancy's research spans commercial and national security, his role as director of the Hume Center focuses more on national security. The Hume Center tackles research including cybersecurity, intelligence analysis, and applications of wireless communications in what is often called C4ISR: command, control, communications, computers, intelligence, surveillance, and reconnaissance.

"We promote interdisciplinary efforts in national security that are beyond the scope of one individual laboratory," he explains. Currently 10 different research groups from around the university work closely with the center. In its second year of operation, the center's annual research expenditures are about $4 million, which is expected to grow to more than $7 million next year, he says.

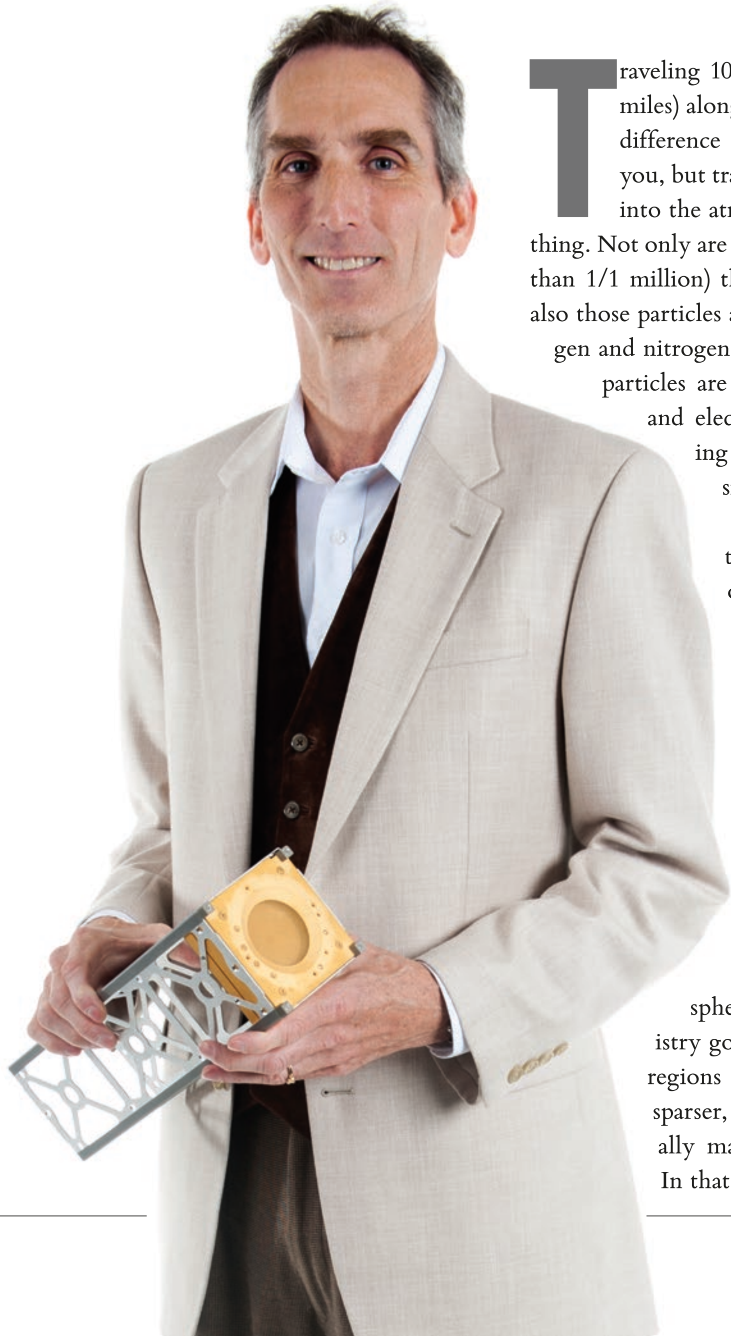
But the Hume Center is not just a research organization. With a primary mission of engaging students and developing future leaders in the Intelligence Community, the center seeks research opportunities that involve students.

Charles Clancy is stationed in the new Virginia Tech Research Center in Arlington. L-3 Communications, an industry partner of the Hume Center through the NSF I/UCRC program (see page 29) is moving its new cyber division into the building in order to continue strong ties with Virginia Tech. Last year, L-3 donated one of the largest philanthropic gifts by a company ever given to Virginia Tech to support cyber research and education.

Currently 38 graduate students are involved in research connected with the center. Twenty-eight undergraduates are involved in research, projects, and other activities. "Not all of our undergraduates are STEM [science, technology, engineering, and math]. Students in political science, international relations, and other fields are also involved."

"If we aren't doing research that involves students, then we're just another defense contractor," Clancy says. "Our focus is on educating and mentoring students interested in the field." To deepen the connections with students, all of the Hume Center research faculty teach courses and advise graduate students. "We're in an academic department for a reason." ece

INTO *thin* AIR



Traveling 100 km (approximately 62 miles) along the ground makes little difference to the physics around you, but traveling that same 100 km into the atmosphere changes everything. Not only are there fewer particles (less than 1/1 million) than at ground level, but also those particles are not the friendly oxygen and nitrogen we breathe. Instead, the particles are corrosive, unstable ions and electrons that behave nothing like their ground-level siblings.

This is the region that ECE professor Gregory Earle studies: from 100 km to about 600 km above Earth's surface. He wants to understand the different behavior — the physics — of the upper atmosphere, so he builds devices and spacecraft to measure the various particles there.

"In the lower atmosphere, there's a lot of chemistry going on, but in the upper regions the particles are much sparser, so the physics is what really matters there," says Earle. In that region, there are neutral particles, ions, and electrons interacting.

"We do some computer analysis and models, but what I really like to do is build the things that make the measurements and see how they compare to the models and radar observations. I make in situ measurements that we can compare to radar data," he explains.

Latitude matters

The physics of the upper atmosphere isn't affected only by altitude. Particles also behave differently in each latitudinal sector of the earth. Along the magnetic equator, the magnetic field lines are parallel to the earth's surface. So if an ion gets pushed north by the neutral particles, it will move north.

In the auroral region (around the poles), the field lines are perpendicular to the earth's surface. So if an ion gets pushed, it won't move. At middle latitudes the field lines are at 20 to 60 degree angles, so pushing a particle northward can actually move it upward in the Southern Hemisphere, or downward in the Northern Hemisphere.

Earle has done research in each of these regions, but is currently focusing on the equatorial latitudes. One of the unique difficulties he is studying is equatorial spread-F distortion. Spread-F typically occurs only at night, but it can distort communication signals, including GPS. Severe spread-F interference can totally disrupt GPS signals or give gross errors, Earle explains. This signal distortion is of particular concern to the military, he says.

Measuring the ultimate light breeze

Neutral particles move when the atmosphere changes temperature, like wind on the earth's surface. "Those same winds exist in space," Earle explains, "but there aren't many particles, so there isn't enough force for the wind to push very hard. You would not be able to feel a wind in space."

Measuring winds in space presents a very difficult challenge. The particles are moving fast, but there are very few of them. "We're basically trying to measure the wind in a vacuum," says Earle. "On the ground, we measure winds by how much they displace a physical part of the anemometer, but in space, these technologies don't work. You have to come up with different ways to do it. Now imagine you're trying to do it from a satellite moving at roughly 8 km/s. It's about the most complicated thing I know of to try to measure."

Earle is developing a new kind of transducer to measure pressures in space. The instrument is basically a parallel plate capacitor in which one plate is a flexible silicon membrane with a thin metal coating: the other plate is a rigid grid. "If you change the distance between the plates, the capacitance changes. So the amount that the flexible plate deflects changes the capacitance, and converts the physical phenomenon into a measurable electrical signal."

According to Earle, the last time wind measurements were made in situ was in the mid 1980s. Since then, scientists have tried remote sensing techniques, but remote sensing measures the integrated effect along a line of sight. "In situ," says Earle, "you're measuring a point, and you know where that point is."

Earle currently has two instruments on the Communication/Navigation Outage Forecast System (C/NOFS) military satellite. "These are the first in-situ wind instruments that we've tried to fly on satellites since the 1980s, though I've flown a couple on rockets," says Earle. "The neutral winds in space are probably the biggest hole in our understanding of what goes on in this altitude range."

Satellites move at approximately 8 km/s. "That's fast," says Earle. "They don't spend much time in any particular portion of the earth's atmosphere." This isn't a problem for measuring on a large scale, according to Earle, "but if you want to look at small scale phenomena, you have to sample very quickly."

One part of the solution would be more, but smaller, satellites. With more satellites, scientists can gather more data points. "You don't need such a precise measurement when you have a lot of data points," says Earle. This is the approach the weather forecasters use: they have a lot of weather stations around the world, and even if some don't give good data there are enough of them that the average can compensate. According to Earle, the same approach may apply in space. "It's the next wave of how we can improve our forecasting ability for space weather," he says.

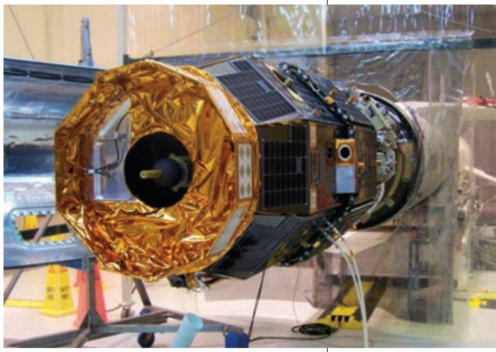
Shrinking the satellites

This can only happen if satellites become smaller and cheaper, he says. Traditionally, satellites have been very large: "they ranged from the size of a train car to the size of a file cabinet." Earle is a proponent of smaller satellites. "Within the last few years, we have been working on microsats (up to 100 kg), nanosats (up to 10 kg), and picosats (up to 1 kg)," he says. CubeSats, which are about half the size of a shoebox, fit into the nanosat category. "Not only are we building instruments to measure things that are hard to measure, now we're trying to do it on a much smaller scale," Earle explains.

The C/NOFS satellite that Earle's instruments are currently flying on is testing the idea that space weather can be predicted. "We're just at the very early stages of figuring out if it will really work," Earle explains.

"The experiment team is taking real-time data from the satellite and feeding it to the computer model to make predictions. If the predictions are accurate, we will put 10 or 11 similar satellites in space and see how much improvement there is from the greater number."

Smaller satellites, however, mean more challenges for the instruments. "Converting instruments to fly on a CubeSat instead of a larger satellite is not easy," he says. "Big satellites have enough power and volume to deal with problems stemming from the harsh environment of space, but the little ones are more constrained. Earle's research group recently received NASA funding to develop an innovative low-power transducer for use in CubeSat-sized wind instruments. They were also approved to launch two instruments on a CubeSat mission in 2014, in collaboration with NASA and the University of Illinois.



Top: Final ground-based testing of an Air Force satellite designed to study thermospheric winds.

Center: A rocket used in Earle's research rests on the launchpad at sunset.

Bottom: Ryan Davidson, who worked with Earle as a graduate student at the University of Texas at Dallas and is now a postdoctoral researcher at Virginia Tech, tests instruments inside a vacuum chamber.

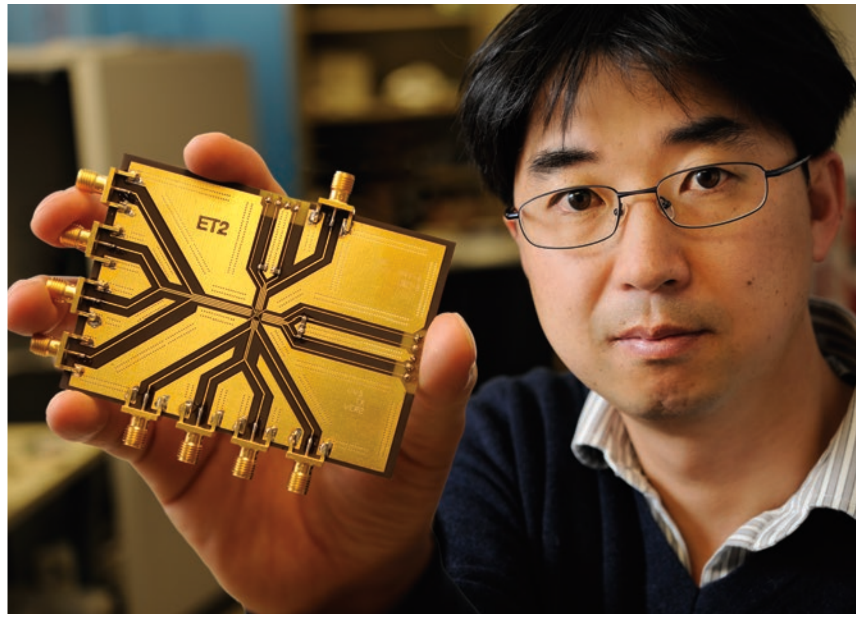
BREAKING THE TERAHERTZ BARRIER

Koh's high frequency research is a vision of the future. His efforts could mean downloading full movies in mere seconds, and the potential to see through walls.

As a young boy, Kwang-Jin Koh was captivated by science fiction novels and still remembers the impact of a story of a half man-half frog. Since the world was becoming more polluted, he pondered that perhaps with changes to our biology or technology, humankind could breathe underwater and have the whole sea as a place to live. These boyhood ruminations triggered a passion for biology and engineering.

Koh was raised in a small rural town on Jeju Island — the southernmost island of South Korea. It was such an isolated town that there was only one rotary phone in the entire village back in the early 1980s. One day it was announced via a loud speaker at the village hall that his father had received a phone call. For the first time in his life, Koh picked up a phone. "Through the cumbersome black phone came my grandma's lovely voice," he recalls. "It was such an electrifying moment for my 7-year-old self that I could not speak a single word. Ever since, I have been fascinated by communication gadgets," he says.

That passion and intellectual interest led him, as a Ph.D. student, to design a phased-array integrated circuit (IC) system that has become an industry standard in defense and commercial applications. Today, as a new assistant professor of ECE, Koh is developing integrated high frequency electronics technology that feels like science fiction — with potential applications of seeing through walls or downloading whole movies in seconds. He has also found



Kwang-Jin Koh shows a chip in a test carrier from the Wireless Microsystems Laboratory. Researchers in the laboratory work on chips that measure just a couple millimeters.

an unanticipated joy in teaching and sharing his passion for the field.

"The educational infrastructure was very weak in my home town," Koh recalls, "my parents had completed only elementary school, and a good education was just not available. Although I was the top student throughout elementary and middle schools, I was not prepared well." When he went to high school in a big city, he found a wide gap between his background and that of the other students who had had access to private schooling and better schools in general.

"I had to help my parents with farm work after school and on weekends, and study at night to catch up with the other students, but I kept making progress." He was at the top of the electronic engineering class for his whole four-year period at Chung-Ang University where he earned a B.S. in 1999. He then went to the well-known Korea Advanced Institute of Science & Technology (KAIST) for his Master's degree under a Korean government scholarship.

Following graduation in 2001, he worked for Korea's Electronics and Telecommunications Research Institute (ETRI), where he designed silicon CMOS RF chips for cell phones. After about four years there, he went to the University of California San Diego for his Ph.D.

It was at UCSD where Koh designed the first successful phased array on a silicon chip. Koh's research involved creating an integrated phased array radar defense system funded by DARPA. "When there is just a single antenna, you get a very weak signal sensitive to jamming from counterparts. When you use an array, you can focus the direction and get a stronger signal," he explains. "The main issue, however, was making the system on a tiny inexpensive silicon chip."

His chip was only 2.2 by 2.3 mm and spawned several additional chips, including a 16-element phased array chip that was 3.2 by 2.6 mm — then the most complex silicon phased array chip in the world. The chip designs were reported to the Pentagon as one of the major achievements in 2007 and transferred to the U.S. Navy, Raytheon, Lockheed Martin, Boeing, Teledyne Scientific Corp., ViaSat and Cobham for the development of advanced defense radar systems.

After getting his Ph.D. in 2008, Koh worked for Intel for two years, then moved to Broadcom. He joined Virginia Tech in November 2011 and is concentrating on three different issues of integrated systems: low power, high frequency, and terahertz electronic systems.

The low power research is urgent for today's commercial technology, he says. "Low power circuit design," he explains, "extends battery life," Koh's high frequency work is "more futuristic," he says. With extremely high frequency (millimeter-wave) electronics, full-length feature movies could be downloaded in less than a minute. Commercial radios, WiFi and cellphones currently operate below 5 GHz, and a higher frequency means higher data transfer rates. Millimeter-wave electronics allow hidden objects to be sensed and identified non-obtrusively as well, and could be used in applications in image sensing.

One project, funded by DARPA, is to develop phased arrays that operate at 94 GHz. A major challenge is the cost of defense radars: in order to make inexpensive radar systems, these phased arrays must be fabricated in silicon. Koh explains that "the silicon process itself has some limits to operate in high-frequency systems. There's a loss problem. If the frequency gets higher, the loss can be larger." Also, the signal can be weak and noisy. "To resolve these issues, we must develop new design techniques or approaches," Koh says.

Koh also is pursuing terahertz electronics systems. "It's an extremely challenging area for electronic design. Every device has some speed limitation, and the speed of the solid-state transistor itself will be lower than terahertz." The basic issue for terahertz electronics is the devices themselves, he says. "For now, silicon transistors cannot reach 1000 GHz and we may need a combined technology of silicon and compound semiconductor for active transistors. Advanced nano-technology such as nanowires should also be investigated as an interconnection material to achieve terahertz speed."

One of Koh's goals is to be an excellent teacher. "I was worried about how to develop effective ways to transfer this technical knowledge to students. I believe teaching is the greatest act of optimism and find it's very rewarding. When students ask me technical questions and then they understand, I feel something." ece

KEEPING THE GRID SECURE

From left: Mohammad Hassanzadeh, Yaman Evrenosoglu, and Hanif Livani work together in the Power Systems Laboratory, generating models to forecast energy demands and power generation. The laboratory was made possible by a donation from Dominion Virginia Power.

In a world where almost everything we do requires some amount of electricity, we take for granted that when we flip a switch the lights will go on. With the integration of alternative power sources and increasingly uneven demand for power, the problem of generating the right amount of power at the right time is getting more complicated. Power engineers like C. Yaman Evrenosoglu, who work on power grid operations must continually find new ways to keep up with evolving power systems.

Evrenosoglu, who joined ECE last fall as an assistant professor, combines both technical and energy market expertise. The variety of his research activities gives testament to the complex issues behind keeping the lights on — especially as power companies add more large-scale energy sources, such as solar and wind power.

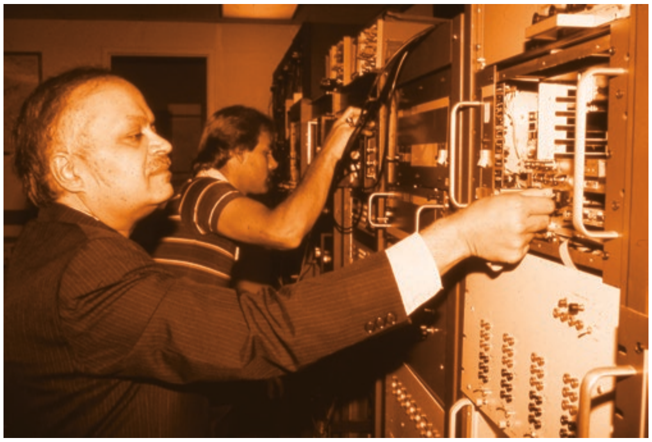
"We are trying to incorporate these kinds of energy sources while keeping the grid reliable and secure," says Evrenosoglu. Forecasting the state of the grid (i.e., complex voltages at nodes and the power flows along the transmission lines), for example, becomes more important with unconventional generators joining the grid. Some power sources, such as wind or solar power, aren't always available, he says, and we need to plan for this.

Collecting information from the network, power system engineers can estimate the current state of the system, run contingency analyses, forecast the future power consumption and plan for the worst case scenario. The price of the energy is determined in real-time energy markets, and it is bound by availability of energy as well as the demand. For the immediate reliability of the power system, power plant operators need to know how much power will be demanded in the immediate future: whether seconds or hours.

State estimation is an extremely important function, and according to Evrenosoglu it has to be complemented by forecasting. "Before, when we had extremely low levels of unconventional generation, the system state changed very slowly due to the slow nature of change in demand, so we didn't need to forecast," he says. However, integrating large percentages of large-scale alternative energy sources that depend upon the capricious weather, makes forecasting an imperative, he explains.

Conventional state estimation methods use information that is not time-stamped, along with the assumption that the state of the system won't change significantly over a couple seconds, Evrenosoglu explains. That assumption is slowly changing with the introduction of advanced measurement devices such as phasor measurement units (PMUs) invented by researchers at the Center for Power and Energy. PMUs provide time-stamped and synchronized

25 YEARS



1991: Arun Phadke, Franklin Medal recipient, works in the old Power Systems Laboratory.

We have history and there are seasonal changes we can capture, and these should be incorporated in power forecasting.

measurements at extremely fast rates (i.e., 30 samples/sec) contrary to the conventional data provided once every few seconds. Evrenosoglu proposes exploiting the data provided by PMUs and adding the use of historical measurements to forecast the system state for the future: a couple seconds, or even an hour ahead.

The amount of historical data used for these calculations depends on whether the forecast is real time or offline. "For real-time forecasting, you can't employ much data because it takes time. We use a couple minutes or hours of data. Offline, we can utilize from days to years of data."

Although Evrenosoglu admits that some events affecting the power grid may be unpredictable, he says that there is still a need for these predictive capabilities. "We have historical data and there are seasonal changes we can capture, and these should be incorporated."

A big challenge with state forecasting is the computational burden — especially if historical data is to be added. There are many possible states to analyze, compare, and calculate. He is currently pursuing two different approaches to reducing the size of the problem. The first takes a statistical perspective to determine the probable states using a dynamic programming algorithm. He is working with Chao Wang for abstracting the data and reducing the problem. The second approach exploits a regression-based model for the state transition model using historical data and a classical extended Kalman filter.

Yaman Evrenosoglu tackles forecasting, fault detection, integration of renewable resources, and other issues facing the power system.

Forecasting is just one of the issues facing power systems researchers. It's also important to make sure that power distribution is not interrupted, and that problems can be identified and fixed quickly.

Currently, when lightening strikes a transmission line, an operator can gather certain information from the line, and can send a crew to the general location. The crew then must pinpoint the exact location. Evrenosoglu has developed a technique that is faster and more accurate than conventional fault location methods.

Using very high frequency traveling waves, his method captures the first traveling wave within the first microseconds of the fault, and works with wavelet transformations and support vector machines. According to Evrenosoglu, "wavelet transformation tells you if and when a frequency is introduced to a signal and when it disappears. It's much faster and more accurate than previous methods."

Evrenosoglu comes to Virginia Tech from the University of Nevada, Reno (UNR), where he served as an assistant professor in the Department of Electrical and Biomedical Engineering since 2008. Prior to joining UNR, he worked for Software & Information Systems group at Nexant, Inc. as a senior consultant for wholesale competitive electric energy markets for two years.

While at UNR, he founded and directed the Electrical Power and Renewable Energy Systems research laboratory, and created and taught two graduate level courses in power system operations. He received the Outstanding Teacher Award in 2009 from the University of Nevada IEEE student branch.

Evrenosoglu earned his B.S. and M.S. in Electrical Engineering from Istanbul Technical University in Turkey in 1998 and 2001, respectively, and his Ph.D. from Texas A&M University in 2006.

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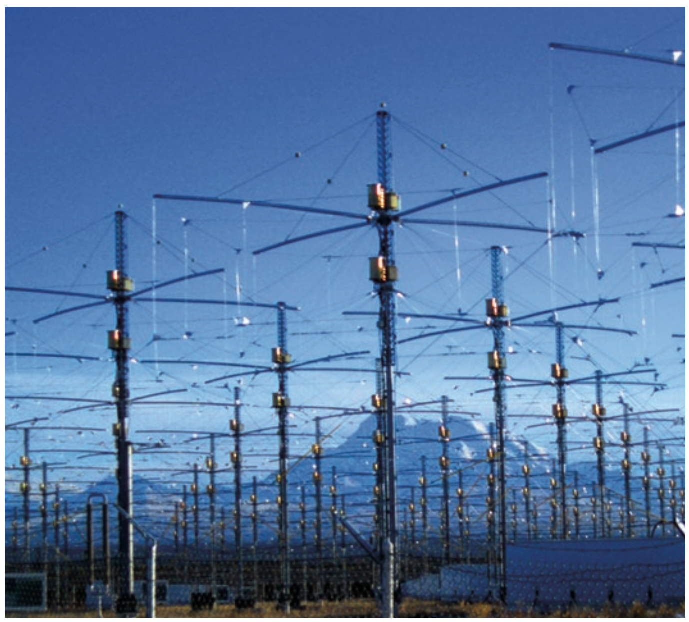
HAARP

From WUVT to the most powerful short-wave station on Earth

An interest in amateur radio and a passion for public broadcasting eventually led Steve Floyd (BSEET, ’80) to serve as chief RF engineer and designer for the highest-power, short-wave transmitting station in the world. This station, called the High Frequency Active Auroral Research Program (HAARP), can transmit up to 3,600 kilowatts via an array of 180 crossed dipole antennas on towers covering 42 acres in Alaska’s bush country.

HAARP is a research facility for studying plasma physics and radio science involving the Earth’s Ionosphere. Changes in the Ionosphere’s plasma in this near-space region are related to space weather, which generate the beautiful auroras. Space weather can also interfere with all forms of radio communications and navigation systems, or generate electromagnetic impulses that disrupt the power grid.



Floyd’s experience at WUVT sparked an interest for high power RF technology, eventually putting him in charge of the most powerful RF antenna in the world.

While passive radar stations around the world can measure the effects of space weather, HAARP and similar facilities — including ones in Peru, Puerto Rico, Russia, and Norway — can transmit a focused high-frequency (HF) electromagnetic radio beam into the ionosphere to study different effects (See page 20). The HAARP website describes the intensity of the HF signal in the ionosphere as less than 3 microwatts per cm^2 — tens of thousands of times less than the Sun’s natural electromagnetic radiation that reaches the earth. However, this is enough power to do ground breaking Ionospheric physics research.

It wasn’t a love of space science, however, that drove Floyd to his role with HAARP, but a passion for amateur radio and public broadcasting. Floyd had earned his ham radio license when he was 13 and spent the next few years building radio equipment and experimenting with wire antennas in his back yard. During that time, he also started listening to public radio. “One of my goals was not just to study EE,” he recalls, “but to find a way to get involved in the high power transmitter engineering side of radio broadcasting.”

When he visited Virginia Tech as a high school student and discovered the student-run WUVT radio station, he knew he had found a good fit. He returned home and promptly earned his FCC commercial broadcast licenses. “Back then, you had to have an FCC commercial radiotelephone license to be a radio station disc jockey.” Floyd earned his FCC First Class radiotelephone license, enabling him to serve officially as a radio station chief engineer. When he enrolled at Virginia Tech as a student, one of the first things he did was join WUVT. “Within a week of joining, I was on the air doing a radio show,” he says. Although he continued with ham radio, most of his extracurricular time was spent with the campus radio station, working as a disc jockey and station engineer.

During his senior year at Tech, the WUVT engineering team upgraded from a 770 W transmitter to a much larger and complex 3,000 W transmitter. “We received an old transmitter and lovingly rebuilt it, and redesigned the entire WUVT transmitter system including the installation of a new high power broadcast antenna on Lee Hall,” he says. “We did all the work ourselves, and we prided ourselves on being as professional as we possibly could.”

The new WUVT transmitter system was based on ceramic-metal tube RF amplifier technology for the power amplifier. “I really fell in love with that higher-powered RF technology,” he says.

After graduating in 1980, Floyd worked in the defense industry in the Washington, D.C. area, designing radio transmitters, receivers, and radar systems. While working for E-Systems (acquired by Raytheon), he earned his MSEE degree from The Johns Hopkins University in 1991. In 1995, he joined the HAARP team. “My past experience with the new transmitter for WUVT lit a fire of interest

PHOTOS COURTESY OF STEVE FLOYD

Background image: A silhouette of Steve Floyd standing with the 3,000 Watt WUVT transmitter in 1980.

HAARP can transmit up to 3,600 kilowatts via an array of 180 crossed dipole antennas on towers covering 42 acres in Alaska's bush country.

in me for that high power RF technology. I'd always been looking for an opportunity like HAARP," he says. HAARP employs 180 20 kW each custom designed transmitters using ceramic-metal tube RF amplifiers. "It's essentially a larger version of the WUVT system!" he says.

When Floyd joined HAARP, the initial 18-transmitter build-out was experiencing problems. "We were able to completely redesign the existing system, plus build 30 more modified transmitters and antennas. By 1998 we had 48 transmitters operating in a 60 MW phased-array system. "Everything was working well and we had some great science results from researchers using the facility." In 2004, the final build-out began and by 2007, HAARP was up and operating at the planned 180 transmitter/antenna system.

Designing and building a research facility of that size and complexity is not without problems. One of the early issues was defining the very technology required and creating it. "We had many debates as to whether to use the new solid-state or ceramic-metal tube transmitter technology," Floyd recalls. "I had experience with both and preferred to use tubes, due to the inherent ruggedness and simplicity of construction." HAARP is a planar phased antenna array of 12 columns by 15 rows, creating a highly interactive environment. "The transmitter interactions, or "mutual coupling," between the closely spaced antennas would generate widely varying load impedances across the array. A tube amplifier is by far the most rugged amplifier type that can withstand this harsh environment. It is also more sound architecturally and less costly to build."

Steve Floyd
HAARP Chief RF Engineer

A tube is by far the most rugged amplifier that can withstand this environment. It is also more sound architecturally and less costly to build.

Tubes are so rugged, that when operating under extreme conditions, all they do is get hot, he says. "We have lots of cooling air in Alaska."

The required operating mode flexibility of the HAARP system and a desire to minimize any possible interference to other radio users was also a challenge. Most high-power broadcast transmitters are designed for one modulation type or service, such as FM or AM. HAARP needed the flexibility of operating in AM, FM, CW, or pulsing with user defined shaped rise and fall times. "We needed to limit the transmitted signal occupied bandwidth on the dial," he says.

The team designed for a very pure output signal. "When other users of the radio spectrum saw the planned extreme high radiated power, they were concerned that our unintended radio harmonics and spurious emissions would be correspondingly large — that we'd interfere with them." So, one of the specifications was for the transmitters to be 100 times, or 20 dB, better in harmonic and spurious emissions than any other transmitters ever built. The tuned plate tank output circuit used in tube amplifiers inherently provides a low harmonic output in addition to rugged durability, according to Floyd. "The required signal purity output was a huge challenge and we met it."

In spite of its name, HAARP is not supposed to be musical. However, in 1998 when the facility first started at 48 transmitters, the maintenance staff would ask Floyd why they were hearing tones when we were transmitting. "They should not have been hearing anything. That meant there was arcing going on in the antenna system. We found there were missing wire connection welds from an antenna contractor." The team waited until the dark of night, then transmitted a 1,000 Hz amplitude modulated tone. Listeners would indicate where the tone was loudest in the antenna wiring. They would spot a blue flame and then repair each defective connection.

His experience at Virginia Tech gave him an uncommon background, Floyd says. "I developed a love of high-power transmitter design and RF engineering from the wonderful teaching of my EE professors at Tech. The enthusiasm in the EE department and at WUVT was infectious. Not only did I succeed well in defense electronics, but then I found HAARP."

It's rare these days to find an EE comfortable with designing and building high-power transmitters. "I was tailor-made for this job," Floyd says. ece

DIAGNOSING THE IONOSPHERE

Although many electrical engineers work with the ionosphere for communications, there is still much that's unknown about the ionosphere's physical behavior in different situations. Sometimes a signal passing through the ionosphere behaves as expected, and sometimes it doesn't. Space weather researchers are figuring out why.

While most electrical engineers are familiar with bouncing radio waves off the ionosphere for communications purposes, space weather researchers are using the practice to study and diagnose the ionosphere itself.

From left: Ph.D. students Hai Yang Fu and Alireza Samimi, with Wayne Scales, Steve Floyd ('80), and Ph.D. student Maitrayee Bordikar.

Last summer, Professor Wayne Scales and four Ph.D. students traveled to remote Gakone, Alaska to study the electromagnetic energy that is reradiated when a powerful, high-frequency transmitter aims at the ionosphere. The High Frequency Active Auroral Research Program (HAARP) facility can transmit powerful radio waves at frequencies between 2.8 and 10 MHz hundreds of miles into the ionosphere (see page 18).

"HAARP is the most powerful research facility of its kind," Scales says. "The facility can send up a very powerful radio wave, which heats a small section of the ionosphere," he explains. A small amount of the energy is reradiated back to the earth's surface. Researchers use this stimulated electromagnetic emission (SEE) to study the ionosphere.

To complicate matters, the reradiated energy returns at frequencies different from what HAARP transmits. "The HAARP transmission is strong enough that some nonlinear processes are stimulated," he explains.

By measuring and analyzing the reradiated energy, researchers hope to determine the types of ions at the time, what type of nonlinear processes are happening, what type of turbulence is there, and how electron temperatures can change, according to Scales. "However, you need theoretical models to develop that understanding. That's what my students are doing; they are developing some of the first theoretical models based on the frequency spectrum of the SEE data."

Maitrayee Bourdikar, Alireza Mahmoudian, Alireza Samimi, and Haiyang Fu all wrote short proposals to participate in the HAARP Summer Student Research Campaign. The program enables graduate students to do state-of-the art experiments while learning how to design experiments and how to use a premier scientific research facility. "The students get to work with premier scientists in the field. The program helps to train tomorrow's leaders in space science," Scale explains.

The Virginia Tech team collaborated with the Naval Research Laboratory and researchers at the University of Alaska. The team was using new receivers, positioned five miles away from the HAARP transmission facility. "We were fortunate, we got a great dataset," Scales says — in spite of being pestered by Alaska's infamous mosquitos.

The students even made some discoveries of frequencies that had not been observed in such experiments before. The phenomenon could be related to a geomagnetic substorm that dumped protons that normally would not be in the heated region, Scales says.

The team is taking the experimental measurements and developing theoretical models to understand what kind of diagnostic information they can get out of the space environment. "It was an extraordinarily successful experiment." ece

The Integrated Design Studio provides laboratory space and equipment for students enrolled in design based courses.

ROOM TO CREATE

ECE students have new dedicated space for design projects, with the opening of the department's Integrated Design Studio on the second floor of Whittemore Hall. The design studio complements the new integrated design courses being offered for upper-level students, particularly the new two-semester, project-based capstone design courses.

In the studio, students have access to equipment, work benches, project storage, meeting space, and advice from Dennis Sweeney, director of instructional laboratories. According to Sweeney, "it's hard for me to say no to the students."

Three of the four new integrated capstone design options currently use the space. Two are familiar competition teams: the underwater robotics team, advised by Dan Stilwell, with Craig Woolsey of AOE, and the IEEE robotics team, advised by Cameron Patterson and Jaime De La Ree.

The other capstone design course using the new space is a two-semester design sequence that focuses on radio frequency (RF) spectrum sensing and is taught by Steven Ellingson. The class is designing and building an RF spectrum sensing system. Soon, Sweeney expects students who are building CubeSats with Scott Bailey to begin using the space.

"The environment and culture of safety is something students have to learn."

Another project using the studio is managed by Sweeney and stemmed from Joseph Baker's class on exploration of the space environment. The class is designing a payload with two cameras along with sensors and a GPS tracking beacon. A high altitude balloon will take it 30 km (nearly 100,00 ft.) into the stratosphere. When the balloon bursts the payload will parachute down for recovery. The project is providing a base level of capability that future classes can use for actual space science data collection, according to Baker.

Engineering Fee funds were used for the renovation and initial equipment in the studio. Some of the materials in the studio are funded by grants from General Motors and Lockheed Martin. "These grants are critical: it's money we can spend on things like electronics components," Sweeney says.

The studio is available around the clock and students using the space are briefed on safety and protocol. "The environment and culture of safety is something students have to learn from the very start," says Sweeney. ece

BRAINS FOR A ROBOTIC CHAMPION

It's not just about walking. Humanoid robots also must think and react, and Bradley Fellow Mike Hopkins is working on this robotic brainpower.

Hopkins and other students from the Robotics and Mechanisms Laboratory (RoMeLa), guided by Dennis Hong of mechanical engineering, led Virginia Tech's humanoid robots to victory at the 2011 RoboCup, an international robotic soccer competition that was held in Istanbul, Turkey last summer. Winning five awards, including first place in both the Adult Size and Kid Size humanoid soccer leagues, the RoMeLa team has brought the Louis Vuitton Humanoid Cup to the United States for the first time. In previous years, the cup has been held by Japan and Germany.

Their adult-sized robot, Cognitive Humanoid Autonomous Robot with Learning Intelligence, known as CHARLI-2, competed in one-on-one soccer matches where it had to locate the ball behind him, dribble it to the other half, then kick it into a goal guarded by its opponent robot. It also had to be able to guard the goal when another robot was on offense. CHARLI-2 has also been named one of *Time* magazine's 50 Best Inventions of 2011.

Hopkins was the lead software developer for CHARLI-2. His first year with the RoMeLa team was the first year that RoboCup had an adult-sized humanoid robotic soccer competition, and RoMeLa brought CHARLI-L1 to the competition. CHARLI-2 was the victorious redesign.

"Most of the students on our team are mechanical engineers, but robotics is one of the most multidisciplinary fields in engineering," says Hopkins, who is advised by ECE's Lynn Abbott. "It includes mechanical design, electronics, software, controls and artificial intelligence."

There are two main challenges for any autonomous task, according to Hopkins. The first is state estimation (where is the robot on the field? where is the ball? what obstacles are in the way?). The second is decision-making. "Once the robot knows what state it's in, it can make the best decisions to score a goal."

"At the lowest level, you have the communication system which allows the robot to talk to its sensors and actuators," Hopkins explains. "You want the communication to be as fast as possible

Hopkins and the RoMeLa team, guided by Dennis Hong (front right), celebrate RoboCup victory.

THE **NEXT** ROBOT

The next RoMeLa project that Hopkins' is working on involves software development for a firefighting robot called SAFFiR. Another ECE student, Steve Ressler, is doing the embedded systems and electronics development. This robot will be able to walk in unstable environments: through obstacles, on uneven flooring, on a rocking ship.

Most robots, including the CHARLI and DARwIn models, use position control rigid walking. For this kind of movement, "you plan out the precise trajectory for the feet to keep the center of pressure within the support polygon of the foot. This requires the floor to be totally flat."

SAFFiR, however, will be using force control walking. Instead of planning a precise trajectory, they will apply torques at all the joints. "The legs will swing naturally using force control with custom series-elastic actuators. The actuators are attached to titanium beams which act like springs," says Hopkins. Only a few robots in the world are using this kind of walking. It will, however, allow SAFFiR to walk on uneven terrain.

in order to achieve robust control over the system. At the next level, you have the control system for motion tasks such as walking, kicking, tracking the ball with the head, etc. At the highest level, you have the perceptual and behavioral code for making decisions based on the current state of the world."

The RoMeLa team collaborates with the University of Pennsylvania for their software needs. Virginia Tech was in charge of the CHARLI-2 code, and the University of Pennsylvania was responsible for the code for DARwIn-OP: the kid-sized robot that won its division at RoboCup last summer. "There is a shared software framework between the two teams," Hopkins says.

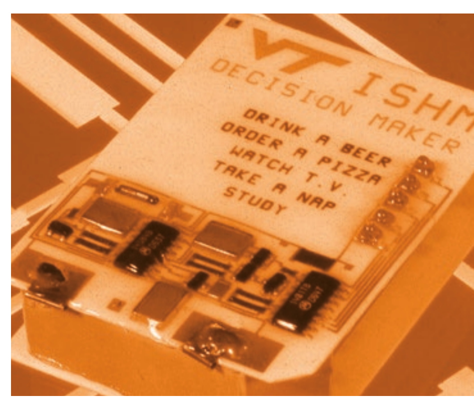
CHARLI-2 analyzes the state of the soccer field.

According to Hopkins, the great challenge is time: "getting all the components working together in the short amount of time that we have for these competitions. Both years, we've built the entire platform from scratch. A year before RoboCup 2011, there was no CHARLI-2 robot. There wasn't even a design." It took approximately nine months to design and build CHARLI-2, leaving only three months for the full development process. They had to make the robot walk, have vision, and play soccer.

One thing that makes all this possible is that the entire system is designed in the lab. "We have a really good environment for collaborating, and everyone in the lab is really close. Working closely with the mechanical designers makes software development easier." For CHARLI-2, Hopkins requested that the design of the neck joints be simpler so that the vision tasks would be easier.

Hopkins enjoys seeing his work in action. He explains that a lot of labs work on just one part of the system: for example, simulation, hardware, or code. "In our lab, we work on pretty much everything. We can create a whole robot and have the reward of seeing it play soccer," he says. ece

25 YEARS



1989: In a much earlier artificial intelligence project, the Decision Maker could advise a student to drink a beer, order a pizza, watch T.V., take a nap, or study. Hopkins uses more advanced algorithms for his artificial intelligence work.

ece RESEARCH BRIEFS

STRUCTURAL HEALTH IN HIGH TEMPERATURES

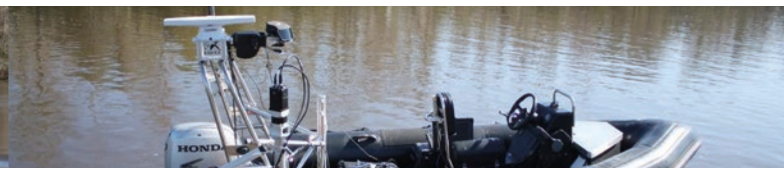
The technology exists to generate energy from fossil fuels with greater efficiency and lower CO_2 emissions than conventional power plants, but these systems operate at much higher temperatures and pressures, and have a greater risk for chemical corrosion. ECE's Center for Photonics Technology (CPT), directed by Professor Anbo Wang, has received a $1.2 million grant from the Department of Energy (DOE) for a three-year project to develop sensors that can monitor the situation to prevent equipment failure.

These fiber optic sensors will not require any electrical power at their location and will be able to operate in temperatures over 800°C, Wang explains. "The sensing concept is based on a pair of acoustic generating/detecting devices integrated in an optical fiber." The sensors will be able to gather information on temperature, strain, cracking, and corrosion. Monitoring the structural health of these systems will keep them running safely and smoothly.

"The technology also has the potential of multiplexing of a large number of integrated acoustic generator and detector pairs along a single fiber cable," says Wang. This would allow for distributed structural health monitoring across a long structure.

This new technology can not only help make more efficient power plants feasible, but can also help improve the operations at existing plants, Wang notes.

In another project, CPT is developing fiber sensors that are able to monitor real-time temperature in coal gasifiers. According to Wang, "coal gasifiers perhaps represent the best clean coal technology."

AUTONOMOUS RIVER MAPPING

In January, the Autonomous Systems and Controls Laboratory (ASCL), in collaboration with the Naval Postgraduate School, field tested its sensing and autonomy system for unmanned surface vehicles (USVs) on Mississippi's Pearl River. "We successfully demonstrated long-range missions by traveling up and down the Pearl in an area between Stennis Space Center and the Gulf of Mexico," says Dan Stilwell, director of the laboratory.

The effort focuses on very large tropical riverine systems and the Pearl River provided a good test field. "The USV senses objects above the water with a laser line-scanner and below the water with a forward-looking sonar," explains Stilwell. The team has also developed new methods for representing maps that allow them to plan and modify missions in real-time based on information from the sensors. "Surprisingly, even existing maps of the Pearl River have significant inaccuracies, so it was necessary for the USV to make sense of the environment as it went."

The ASCL team is developing a sensing and autonomy system that can be put on any boat, explains Stilwell, although the group developed its own USV for testing purposes.

The team also performed an initial evaluation of a helmsman assist system that takes information from the sensing and autonomy system and displays it on a screen for a human operator who steers a boat. This allows the boat to be operated at night and in all weather," says Stillwell.

Cooperation for better wireless networks

The wireless spectrum bands are already overcrowded, yet demand for wireless capacity continues to increase. This increase won't be sustainable indefinitely. In collaboration with researchers at the Centre for Wireless Communications at the University of Oulu in Finland, ECE professor Luiz DaSilva and associate professor Allen MacKenzie have received a $290,000 NSF grant to research ways to meet the significant demand for high data rate mobile connectivity brought about, at least in part, by the ubiquity of smart phones. MacKenzie and DaSilva are exploring technical solutions and economic incentives to enable seamless heterogeneous wireless networks managed by different operators.

Heterogeneous wireless networks involve multiple wireless services in a single network. The project involves developing models to show the benefit of cooperation between large- and small-scale operators, developing pricing models to study incentive structures for such cooperation, and studying the security threats that might threaten a heterogeneous network. According to MacKenzie, "this work will be immediately applicable to real networks."

MacKenzie and DaSilva have built the collaboration with the University of Oulu over the past few years, and have both traveled to Oulu multiple times. They have co-authored 10 journal and conference papers with their Finnish colleagues. "It has already been an extremely fruitful collaboration, and now it is nice to see this formalized," says DaSilva.

BUILDING A MAGNETOMETER CHAIN AT THE SOUTH POLE

For the past four years, a space weather team led by ECE professor Robert Clauer has sent researchers to the South Pole.

As part of a $2.39 million grant from the National Science Foundation (NSF), the team is deploying seven autonomous data collection stations in Antarctica. There are unique difficulties associated with the project, but also a unique payoff: these are measurements that no one has taken before.

Each system is autonomous and designed to operate unattended for at least five years on the east Antarctic plateau. Data are acquired at Virginia Tech in near real time using satellites.

When fully deployed, the chain of data platforms will help with studies of global phenomena from the solar wind/magnetosphere interaction. Specifically, researchers will be able to observe the changes in the electrodynamic circuit formed by the solar wind coupled to both polar ionospheres by magnetic field lines.

This year, ECE assistant professor Majid Manteghi was part of the team that traveled to the South Pole. The team installed three more stations at the South Pole Research Station for their year-long testing, and moved one station to a more permanent location in on the east Antarctic plateau 400 miles away. There are now two stations on the Antarctic 40-degree magnetic meridian chain and four more being tested at South Pole.

The 2012 Antarctica team — From left: Bob McPherron, Bob Clauer, Majid Manteghi, Joseph Macon, and Hyomin Kim.

This year's team also did testing with high frequency (HF) radios that they hope to use in future stations. Each station already has an Iridium radio, and they would like to add an HF radio also. The Iridium radio has been working well, but the HF radio would have a different benefit.

The Iridium radio requires initialization time before it can communicate, explains Manteghi, and sometimes they need immediate communication between stations. "For example, if an ionospheric storm hits one station, the others need to know to immediately begin collecting data." The HF radio performed well during testing, and the new stations will use both radios.

Bi-directional IGBTs for PV systems

Researchers at the Center for Power Electronics Systems (CPES) are on a team that is developing and commercializing photovoltaic (PV) technology that allows standard, grounded PV arrays to operate without a transformer. The new technology will reduce the size and cost of materials, cut manufacturing costs, and improve operating efficiency.

Ideal Power Converters (IPC) is the industry lead on the $2.5 million project, which is funded by the U.S. Department of Energy ARPA-E (Advanced Research Project Agency-Energy). CPES and a team from Rensselaer Polytechnic Institute are developing bi-directional silicon Insulated Gate Bipolar Transistor (IGBT) components to support IPC's converter topology.

The new bi-directional IGBT switches will more than double the power density and slash the per-Watt manufacturing costs in half compared to conventional IGBTs and diodes. Other applications for the new technology include bi-directional battery converters, bi-directional plug-in electric vehicle converters, wind turbines and variable frequency motor drives.

CONFINING DATA TO A PHYSICAL SPACE

A team of Virginia Tech researchers has created software to remotely put smart phones under lockdown. The phones are given permission to access sensitive data while in a particular room, but when the devices leave the room, the data is completely wiped.

"This level of complexity and security, nobody else has," says Jules White, ECE assistant professor. "There are commercial products that do limited versions of these things, but nothing that allows for automated wiping and complete control of settings and apps on smart phones and tablets."

A general, for example, could access secret information while visiting a secure government facility without fear that his or her smart phone or tablet computer might later be lost or stolen, White said. "This puts physical boundaries around information in cyberspace."

Medical caregivers could review patient information during a doctor visit, but — safeguarding patient privacy — doctors or nurses couldn't walk out of the examination room with the patient's records.

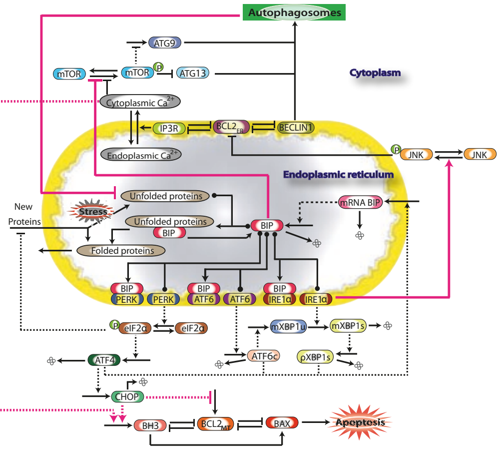
The software also enables central control of phone features such as preventing a smart phone's camera or email from working.

White and his team, in research underwritten by Virginia Tech Applied Research Corporation, modified Google's Android operating system to create the security features.

Graduate students working on the project are Paul N. Miranda, Danny Guymon, and Hamilton Turner. —*Steven Mackay*

Mathematical modeling to fight breast cancer

Virginia Tech researchers have developed a model that may eventually help explain and overcome drug resistance in breast cancer treatment. As part of the Georgetown Center for Cancer Systems Biology, ECE's William Baumann, Joseph Wang, and Jason Xuan, with John Tyson of Biology, have been using mathematical modeling and machine learning approaches to understand the causes of drug resistance in breast cancer treatment.



Recently, experimentalists at Georgetown found that a key chaperone protein known as BIP or GRP78, which helps fold newly synthesized proteins, was over-expressed in a resistant breast cancer cell line compared to a sensitive cancer cell line. Reducing the expression of BIP in the resistant cell line caused the cells to become sensitive to drugs, while enhancing its expression in the sensitive cell line caused the cells to become resistant to drugs.

Understanding this intriguing experimental result is complicated by the interaction of three complex cellular subsystems: the Unfolded Protein Response, autophagy (self-eating), and apoptosis (programmed death), Baumann explains.

Virginia Tech researchers mathematically modeled each of the three subsystems using nonlinear ordinary differential equations to capture their basic behavior, then combined the sytems as depicted in the figure. While much is unknown about some of the interactions, the model was able to recapitulate the experimental results. The model is being used to suggest new experiments to improve the model and understanding of drug resistance. Ultimately, the model can be used to find combinations of drugs to kill the resistant cancer cells.

The family history factor in breast cancer

While family history is an important factor in breast cancer risk, in many cases an increased risk of developing breast cancer is not due to genetic mutations that are passed down to future generations. Researchers at Georgetown University Medical Center have found that in rats, exposure of a pregnant mother to estrogenic compounds can result in increased risk of cancer in daughters, granddaughters, and even great granddaughters.

To understand how this increased risk is transmitted without genetic mutation, Joseph Wang used statistical machine-learning techniques to analyze changes in the methylation status of the DNA of descendants with increased risk. DNA methylation is a key process in normal development, allowing cells with the same genome to perform different functions by using methylation to turn some genes on and some genes off.

Wang's group found that the descendants with increased risk had several hundred common DNA regions that were methylated differently than a control group, providing a possible mechanism for how breast cancer risk can be transmitted without genetic mutations. Ultimately, it may be possible to undo this harmful methylation and decrease the risk of breast cancer.

Improving wireless networks

"A critical factor affecting the wide-scale deployment of wireless ad hoc networks is network capacity," asserted Thomas Hou, associate professor of ECE.

From left: Hanif Sherali, Thomas Hou, and Scott Midkiff.

A key technology to increase the capacity of wireless networks is called multiple-input-multiple-out (MIMO) — the use of multiple antennas at both the transmission and the receiving ends.

"Unfortunately, existing models for this technology are either too mathematically complex to be used or too simple to be accurate," Hou said. "As a result, research progress on multi-hop multiple-input-multiple-output ad hoc networks remains stagnant despite rapid advancements in this research at the physical layer."

In collaboration with Scott Midkiff and Hanif Sherali of Industrial and Systems Engineering, Hou has now received a little over $1 million from the National Science Foundation for two projects on wireless network research.

"We expect our research to be potentially transformative. With one of the two projects, we believe our work will serve a critical need in advancing multi-hop multiple-in-multiple-out network research by exploring new models beneath the network layer that are both tractable and accurate."

With the second project, they will be exploring cooperative communications where each node is only equipped with a single antenna and spatial diversity is achieved by exploiting the antennas on other nodes in a network. They will focus on designing network level algorithms based on cooperative relaying that can maximize throughput.

—*Lynn Nystrom*

WEAR-AND-FORGET HEALTH MONITORING

For patients with a variety of illnesses, diagnosis and treatment can be limited by the availability of accurate information regarding the patient's daily activities. Tom Martin and Mark Jones are working with researchers at the University of Minnesota's apparel program on a minimally-invasive way to gather this information using e-textile clothing for ambulatory monitoring. They have received a $306,000 NSF grant for the project.

"E-textiles are fabrics that have electronics and networks as an intrinsic part of the cloth," Martin explains.

According to Martin, it can be hard to assess a patient's state of health in a short visit with a clinician. It's also hard for patients to keep an accurate log of every daily activity, and many are unwilling to wear obvious monitoring devices. This makes the low-profile e-textile technology a valuable way to gather data without requiring active patient interaction.

Two specific applications for the project are blood-pressure monitoring and physical therapy garments. The blood-pressure garment will map blood-pressure measurements to different activities, while the physical therapy garment will allow physical therapists to "assess the activity levels, exercise compliance, and range of motion of a patient," says Martin.

The goal is to create what is called "wear-and-forget" monitoring. The garments will be able to classify the wearer's activity and the intensity of that activity, in addition to any physiological monitoring. The team is working on methods that adapt data collection characteristics during run-time. This would give the added capability for medical personnel to specify a set of conditions under which physiological data should be collected.

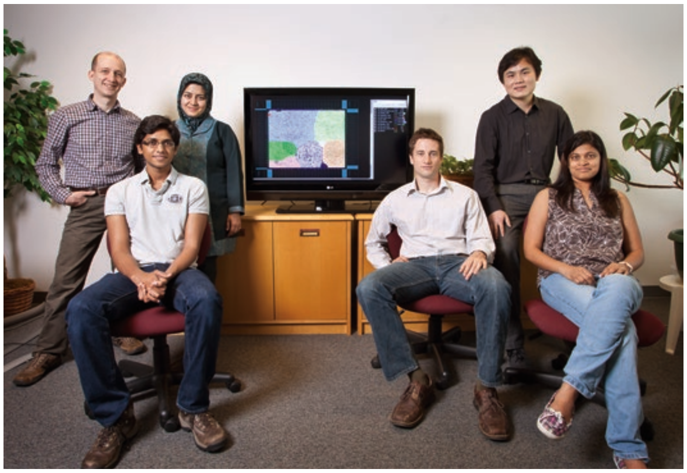
A large part of wear-and-forget is the clothing itself. Monitoring is easy with tightly fitting bodysuits, according to Martin. The real challenge, he says, is to design an architecture, including the algorithms, that can be successfully applied to the type of looser-fitting clothing that is worn by most people, where sensors will observe motion that is due to the garment's movement, not necessarily the body's. Developing garments that can be used by people with reduced mobility and that work accurately on the wide range of human size and activity levels is also a challenge, he says.

TESTING THE **CRYPTO STANDARD** IN **ASIC**

When checks go electronic, our signatures have to become electronic, too.

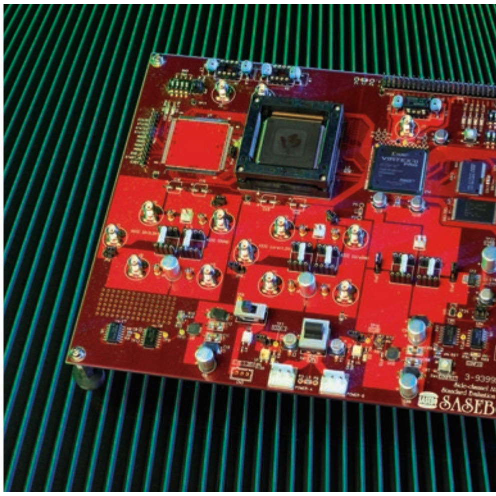
The need for standard signatures for widespread use makes the search for a new standard very difficult. "Think about what happens if suddenly all of the signatures you made in the past 10 years, as well as the next, can now be forged," says Associate Professor Patrick Schaumont, who, with Assistant Professor Leyla Nazhandali, is helping to test potential new encryption standards.

Their team is one of three university research groups being funded by the National Institute of Standards and Technology to test the next hashing standard, a key component in electronic signatures.



The SHA-3 ASIC team, from left: Patrick Schaumont, Dinesh Ganta, Leyla Nazhandali, Michael B. Henry, Xu Guo and Meeta Srivastav.

The most common hashing algorithm, which is also the dominant standard for Internet use, is Secure Hashing Algorithm 1 (SHA-1). SHA-2, a variation of SHA-1, is a slightly newer standard, and no one has found a problem with it so far. However, anyone who cracks SHA-1 will be close to cracking SHA-2, according to Schaumont.



The SHA-3 ASIC implementation.

In 2008, the National Institute for Standards and Technology (NIST) began a competition to determine a new SHA-3 standard that does not resemble SHA-1 and SHA-2.

The Virginia Tech team has fabricated all five finalists on a single chip, and is testing them in application specific integrated circuits (ASIC). Among other behaviors, they are testing power consumption and speed.

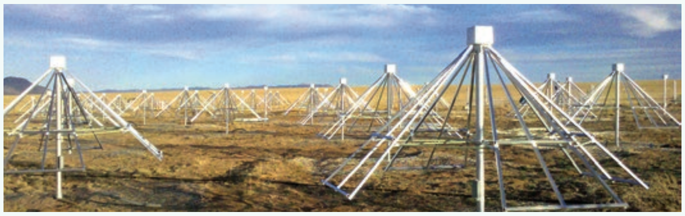
Virginia Tech teams with University of New Mexico
ON ARRAY RADIO TELESCOPE PROJECT

Virginia Tech's latest and largest array radio telescope project is located in the New Mexico desert. There, Virginia Tech researchers have teamed with counterparts from the University of New Mexico to operate 258 dual-polarized dipole antennas that combine to form a massive array radio telescope tasked with cracking the mysteries behind the universe's beginning.

Heading the Long Wavelength Array (LWA1) project for Virginia Tech is Steve Ellingson, associate professor of ECE. Chris Wolfe of Chesterfield, Va., a doctoral student in ECE, designed part of the telescope and is developing an upgrade as part of his dissertation.

The roughly $10 million LWA1 is located on the Plains of San Agustin, which is also home to the National Radio Astronomy Observatory's Very Large Array. "LWA1 is among the world's most powerful telescopes operating at frequencies between 10 megahertz and 88 megahertz," Ellingson said. The antennas are tent-shaped, with four wing-like sides attached to a vertical pole and a box on top that points skyward.

The telescope's digital beamforming mode allows simultaneous observation in four independent directions, making it possible for four astronomers to use the telescope at the same time. In addition, LWA1 simultaneously produces high-sensitivity images of the entire sky every five seconds, Ellingson said. "The all-sky mode is not the 'primary' mode of the instrument, but it is what we show most often because most people can immediately understand what it is," he added.



Astronomers and others will use LWA1 to study pulsars, Jupiter, the sun, and the earth's ionosphere.

Funding came from NASA, the Office of Naval Research and the National Science Foundation. In December 2011, the project was designated as a University Radio Observatory by the National Science Foundation for the years 2012 to 2015, bringing a $1.5 million grant to support research efforts. —*Steven Mackay*

ALLEVIATING POWER SYSTEM STRESS WITH SMART GRID

Virginia Tech Advanced Research Institute (ARI) is joining with Dominion Virginia Power and three small high technology businesses to develop smart grid technology, with a $600,000 National Science Foundation (NSF) Partnership for Innovation (PFI) grant. The collaboration's goal is to alleviate electrical power system stress conditions by offering customer choices for efficient use of electricity at all levels.

ECE's Saifur Rahman serves as principal investigator. The three businesses include Advanced Manufacturing Technology, Inc., Electronic Instrumentation and Technology, Innovative Wireless Technologies, and Dominion Virginia Power.

Together, these groups will create a platform that will "enable a diverse and smart demand response and energy conservation applications ranging from households to utility power grid," says Rahman. They will design hardware, including a smart power management system and sensor control devices for appliances, as well as optimization-control algorithms.

The platform will be tested on a set of homes and businesses in Arlington County, Virginia.

COMMERCIALIZING PHOTOVOLTAIC INVERTERS

The Future Energy Electronics Center (FEEC) has received a $148,000 grant from Virginia's Center for Innovative Technology to commercialize photovoltaic technology developed in its laboratory. Commercialization efforts will involve further technology development, intellectual property licensing, and setting up a pre-production facility.

Jason Lai's team developed the ultrahigh efficiency inverter technology with a $3.2 million grant from the Department of Energy (DOE). They plan to increase the efficiency from approximately 95 percent to more than 99 percent and decrease the cost from approximately $1 per Watt to $0.10 per Watt.

The efficiency will increase with the adoption of Virginia Tech's proprietary soft-switching techniques, Lai explains, while "the cost reduction will be achieved through highly integrated design and collaboration with the semiconductor industry."

The FEEC has already developed an inverter with 99.3 percent efficiency as well as "related power-conditioning systems [that] have built-in communication lines and digital computing capabilities that can be further developed into the 'brain' of an intelligent, controllable power grid," notes Lai.

The product will also be tested as part of the project, and once it is fully developed, the researchers will set up a pre-production facility and spin off a company to finish commercializing the inverters. According to Lai, "the ultimate goal is to create high-tech jobs with the PV inverter technology."

Better and cheaper photovoltaic inverters are on their way.

S^2ERC site established; Joins 2 other I/UCRCs

Virginia Tech, in cooperation with L-3 Communications, Northrop Grumman, General Dynamics Advanced Information Systems, and Verisign Labs, has received a five-year continuing grant to establish a National Science Foundation (NSF) Industry/University Cooperative Research Center (I/UCRC) site for cybersecurity. Since the I/UCRC site was established in August, four additional affiliates have joined, including Centripetal Networks, General Electric Information Technology Security Center, Lockheed Martin Information Systems & Global Solutions, SAIC Homeland and Civilian Solutions and the SI Organization.

Initial topics of research for the center include secure computing architectures, cloud computing security, visualization tools for cyber defense, securing critical infrastructure, wireless security, and malware detection and mitigation.

This new cybersecurity site joins the Security and Software Engineering Research Center (S^2ERC), which is led by Ball State University and includes a primary site at Iowa State University and now Virginia Tech. The NSF established S^2ERC 25 years ago as the only I/UCRC dedicated to software engineering and recently rechartered the center with an added focus on security.

Currently NSF sponsors 50 I/UCRCs to help connect industry with academic research at a pre-competitive stage. ECE is a member of two other centers, including the Center for High-Performance Reconfigurable Computing (CHREC) and Wireless Internet Center for Advanced Technology (WICAT).

CHREC was established in 2007 as the nation's first multidisciplinary research center in reconfigurable high-performance computing. Peter Athanas serves as the Virginia Tech lead and co-director of the Center. Current Virginia Tech CHREC projects include research in end-to-end tool flow for FPGA productivity and a $1.5 million project with the Virginia Bioinformatics Institute (VBI) that combines genomic data analysis, high-performance computing, and productivity. The project involves a nationwide competition for students.

WICAT's goal is to create flexible, efficient, and secure wireless networks, and includes teams from Polytechnic Institute of New York University, the University of Virginia, Columbia, and Auburn University, in addition to Virginia Tech. WICAT's mission is to create networks that satisfy the needs of businesses and of consumers. Virginia Tech's contributions to the center focus on cognitive radio-based wireless networks, with efforts in software defined radios (SDR), cognitive radios, cognitive network testbed implementation, theoretical foundations of wireless communications and wireless systems modeling and simulation. Tamal Bose serves as the Virginia Tech lead.

PATENTS AWARDED

"Dynamic Cellular Cognitive System," Y. Wang and C. Bostian.

"Method and Apparatus for Three-Dimensional Integration of Embedded Power Module," S. Wang and F. Lee.

"Method and Apparatus for Three-Dimensional Integration of Embedded Power Module," M. Lim, Z. Liang, and J. Daan van Wyk.

"Neural Network and Method for Estimating Regions of Motor Operation from Information Characterizing the Motor," C. Hudson, N. Lobo, and R. Krishnan.

"Wideband Compact Planar Inverted-F Antenna," W. Stutzman and M. Huynh.

"Detecting Software Attacks by Monitoring Electric Power Consumption Patterns," G. Jacoby, N. Davis, and R. Marchany.

"Electromagnetic Interference Noise Separator," S. Wang and F. Lee.

25 YEARS

CPES, called VPEC from 1983 until 2003, gained support from power electronics firms and establised the VPEC-Partnership Progam, which provided an opportunity for industry to profit from VPEC's research and for the Center to benefit through improved industrial interaction.

2010 2011 PH.D. DEGREES AWARDED

Ahmed, Sara Mohamed H.
Computer Modeling and Simulation of Power Electronics Systems for Stability Analysis
Committee Chair: Boroyevich, D.

Alfeeli, Bassam A.
Chemical Micro Preconcentrators Development for Micro Gas Chromatography Systems
Committee Chair: Agah, M.

Banga, Mainak
Testing and Verification Strategies for Enhancing Trust in Third Party IPs
Committee Chair: Hsiao, M. S.

Bian, Kaigui
Medium Access Control in Cognitive Radio Networks
Committee Chair: Park, J. M.

Burbey, Ingrid E.
Predicting Future Locations and Arrival Times of Individuals
Committee Chair: Martin, T. L.

Chandrasekar, Maheshwar
Search State Extensibility Based Learning Framework for Model Checking and Test Generation
Committee Chair: Hsiao, M. S.

Chen, Chien-Liang
Design, Implementation, and Analysis for an Improved Multiple Inverter Microgrid System
Committee Chair: Lai, J. S.

Chen, Li
Integrative Modeling and Analysis of High-Throughput Biological Data
Committee Chair: Xuan, J.

Feng, Yuanjian
Detection and Characterization of Multilevel Genomic Patterns
Committee Chair: Wang, Y. J.

Feng, Zhenhua
Cross-Layer Optimization and Distributed Algorithm Design for Frequency-Agile Radio Networks
Committee Chair: Yang, Y.

Gaeddert, Joseph Daniel
Facilitating Wireless Communications through Intelligent Resource Management on Software-Defined Radios in Dynamic Spectrum Environments
Committee Chair: Reed, J. H.

Hassan, Hoda Mamdouh
A Reference Model and Architecture for Future Computer Networks
Committee Chair: Eltoweissy, M. Y.

He, An
Power Consumption Optimization – A Cognitive Radio Approach
Committee Chair: Reed, J. H. & Tranter, W. H.

Huang, Fei
On Reducing Delays in P2P Live Streaming Systems
Committee Chair: Ravindran, B.

Jiang, Bo
Energy Efficient Target Tracking in Wireless Sensor Networks: Sleep Scheduling, Particle Filtering, and Constrained Flooding
Committee Chair: Ravindran, B.

Kong, Na
Low-Power Power Management Circuit Design for Small Scale Energy Harvesting Using Piezoelectric Cantilevers
Committee Chair: Ha, D.

Lee, Jeongheon
Physical Layer Security for Wireless Position Location in the Presence of Location Spoofing
Committee Chair: Buehrer, R. M.

Li, Xiaoxing
Registration of Images with Varying Topology Using Embedded Maps
Committee Chair: Wyatt, C. L.

Lobo, Nimal Savio
Doubly-Salient Permanent-Magnet Flux-Reversal-Free Switched Reluctance Machine
Committee Chair: Ramu, K.

Long, Xiaojing
Image Classification Using Pair-Wise Registration and Machine Learning with Applications to Neuroimaging
Committee Chair: Wyatt, C. L.

Macias, Nicholas J.
Self-Modifying Circuitry for Efficient, Defect-Tolerant Handling of Trillion-Element Reconfigurable Devices
Committee Chair: Athanas, P. M.

Pakdel, Zahra
Intelligent Instability Detection for Islanding Prediction
Committee Chair: Centeno, V. A.

Recio, Adolfo Leon
Spectrum-Aware Reconfigurable Orthogonal Frequency Division Multiplexing
Committee Chair: Athanas, P. M.

Rutishauser, David Kurt
Implementing Scientific Simulation Codes Tailored for Vector Architectures Using Custom Configurable Computing Machines
Committee Chair: Jones, M. T.

Shi, Yongsheng
Resource Allocation in Cellular Networks with Coexisting Femtocells and Macrocells
Committee Chair: MacKenzie, A. B.

Velez Cedeno, Francisco Gerardo
Multiple Swing Out-of-Step Relaying
Committee Chair: Centeno, V. A.

Vogler, Terry Richard
Analysis of the Radiation Mechanisms in and Design of Tightly-Coupled Antenna Arrays
Committee Chair: Davis, W. A.

Volos, Haris Ioannis
Cognitive Radio Engine Design for Link Adaptation
Committee Chair: Buehrer, R. M.

Wang, Jiajun
Sapphire Fiber Based Sensing Technologies for High Temperature Applications
Committee Chair: Wang, A.

Wang, Lei
Next Generation Frequency Disturbance Recorder Design and Timing Analysis
Committee Chair: Liu, Y.

Wilder, Frederick Durand
The Non-Linear Electrodynamic Coupling Between the Solar Wind, Magnetosphere and Ionosphere
Committee Chair: Clauer, C. R.

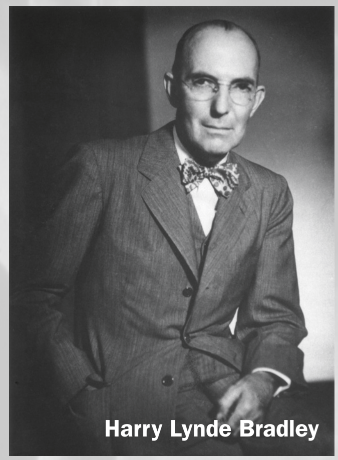
Yang, Nanying
Characterization and Modeling of Silicon and Silicon Carbide Power Devices
Committee Chair: Meehan, K.

Zhang, Yingchen
Electric/Magnetic Field Based Synchrophasor Measurement and a Noise Tolerant Frequency Estimation Algorithm
Committee Chair: Centeno, V. A. & Liu, Y.

Zhang, Yuji
Module-Based Analysis of Biological Data for Network Inference and Biomarker Discovery
Committee Chair: Xuan, J.

25 YEARS *of the* BRADLEY ENDOWMENT

Spring 1988: Dan Hodge and Bill Stevenson unveil the plaque proclaiming the ECE department's new name.



Harry Lynde Bradley

In spring 1987, the late Mrs. Marion Bradley Via established a $5 million endowment for the enhancement of the Department of Electrical Engineering. This endowment was in honor of Mrs. Via's late father, Harry Lynde Bradley. Mr. Bradley was a pioneer in the electric motor control industry and cofounder of the Allen-Bradley Company of Milwaukee. He was dedicated to quality in people, products, and community service. Another $5 million endowment was established for the benefit of the Department of Civil and Environmental Engineering (CEE) in honor of Mrs. Via's late husband, Charles E. Via, Jr. Mrs. Via died in 1993.

In recognition of this endowment, the department was renamed The Harry Lynde Bradley Department of Electrical Engineering. (In spring 1997, the ECE department was renamed The Bradley Department of Electrical and Computer Engineering.) The income from the endowment is used primarily to fund undergraduate scholarships, graduate and postdoctoral fellowships, and professorships in the continuing effort to improve the quality of the department's programs. To date, about 214 undergraduate and graduate students have had full scholarships funded by the endowment as Bradley Scholars and Bradley Fellows. These scholarships and fellowships are among the most competitive in the country and are awarded to the best students who study with the department. Since the endowment was created in 1987, more than $16 million in scholarships and fellowships has been awarded to ECE students.

2011 | 2012
BRADLEY HONORS

BRADLEY FELLOWS

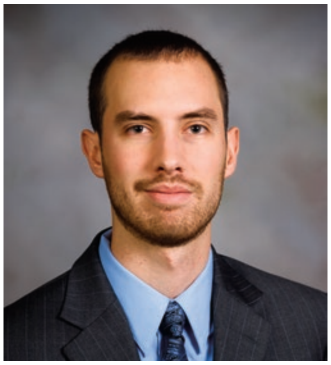
Uchenna Anyanwu
BSCPE '09
San Jose State University
Advisor: Allen MacKenzie
Research: Developing robust sense-based random access protocols for software defined radios (SDRs) by implementing flexible communications blocks on DSP and FPGA. Using a novel software/hardware abstraction layer, the blocks will work together to provide quick turn-around times for sensing protocols.

Michael Fraser
BSEE '09, Virginia Tech
Advisor: Anbo Wang
Research: Applying interdisciplinary research knowledge to design fiber optic sensors for various physical, chemical, and biological measurements.

Thaddeus Czauski
BSCPE '09
University of Pittsburgh
Advisor: Jules White
Research: Improve indoor localization techniques for location-based authentication and data protection for mobile devices. This will allow access to certain personal data only from defined locations inside a building. For example, a medical professional could access a patient's data only from their room.

Kelson Gent
BSECE '10
University of Texas at Austin
Advisor: Michael Hsiao
Research: Developing new algorithms for circuit abstraction and state justification. He is specifically working on new methods for reaching corner cases — those for which current ATPG tools cannot automatically generate test patterns.

Shaver Deyerle
BSEE '10, Virginia Tech
Advisor: Peter Athanas
Research: FPGA-based development platform for software-defined radios. By developing a block-based radio assembly tool that interfaces with GNU Radio, radio developers will be able to access significantly improved processing capabilities with a flow that is similar to that of software radio development.



Michael Hopkins
BSEE '09, Virginia Commonwealth University
Advisor: Lynn Abbott
Research: Investigating methods to allow humanoid robots to improve their walking gaits by learning through experience. He is currently developing the motion and communication framework for SAFFiR, the Shipboard Autonomous Fire-Fighting Robot.

BRADLEY SCHOLAR

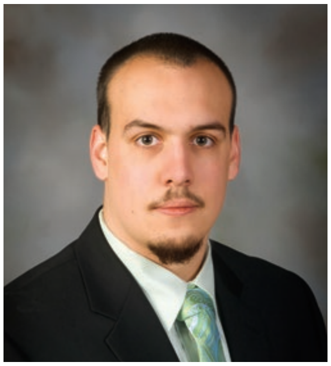
Callie Johnston
CPE ’14
Mentor, Ohio
Career goals: To work with biomedical robotics, specifically prosthetics.
Why ECE: “My internship at Rockwell Automation sparked my interest and inspired me to pursue a degree which can be applied in a variety of different ways.”

WEBBER FELLOW

Anne Martin
BSECE ’10, F.W.
Olin College of Engineering
Advisor: Michael Buehrer
Research: In communications, she is working on the secrecy capacity of MIMO systems, and how it can be approached in practice. In networking, she is looking at how the addition of femtocells can affect a cellular network.

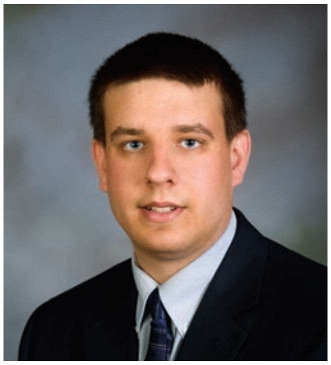
Kevin Jones
BSEE ’09, MSEE ’11
Virginia Tech
Advisor: James Thorp
Research: Development of three-phase linear tracking state estimator for implementation on Dominion Virginia Power’s EHV network. Development of algorithms for phasor-based dynamic state estimation and bad data detection.

Javier Schloemann
BSCPE ’04, MSEE ’07
Clemson University
Advisor: Michael Buehrer
Research: Applying Bayesian methods to develop a localization technique that encompasses traditional single-node static localization, single node tracking, static collaborative localization, and mobile collaborative localization.



Nicholas Kaminski
BSEE / BSCPE ’10
Virginia Tech
Advisor: Charles Bostian
Research: Foundational concepts for Cognitive Radio development, including principles to guide the design and development of Cognitive Radio (Based on Virginia Tech’s CSERE technology), cognitive component design, and the evaluation of cognitive systems.

David Uliana
BSCPE ’11, Virginia Tech
Advisor: Peter Athanas
Research: Piecing together an end-to-end development flow for FPGAs focused on providing extensive computing capabilities to those without hardware design expertise, specifically experts in the life and medical sciences. Much of the work is interdisciplinary in nature and involves collaboration with the Virginia Bioinformatics Institute.



David Mazur
BSEE ’11, Virginia Tech
Advisor: Jaime De La Ree
Research: Synchronized rotor angle measurements of synchronous machines, particularly developing a system that would directly measure the internal angle of a generator using a rotary encoder on the shaft of the machine.

Troy Willis
BSEE ’07, MSEE ’09
Baylor University
Advisor: Michael Hsiao
Research: Post-silicon diagnosis of sequential circuits using satisfiability, particularly techniques and heuristics to speed up the identification of possible fault candidates while minimizing the candidate pool.

DONORS to ece
DURING THE FISCAL YEAR 2011

ALUMNI

Glenn Michael Allen
& Rebecca S. Allen
David Eugene Ames
& Linda R. Ames
Brian Douglas Bailey
Andrew Beach
T. Wayne Belvin
& Colleen F. Belvin
Robert F. Bruce
& Connie E. Bruce
Shuo Chen
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& Jackie A. Crack
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& Lisa Cutler
Phillip A. Danner
George S. Davis
& Kathryn Y. Davis
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Warren Douglas Drumheller
& Peggy J. Drumheller
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Robert William Freund
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& Beth Gardner
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& Sandra C. Geabhart
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& Diana George
James Thomas Griffin
Paul S. Hamer
& Mary Hamer
Edgar D. Harras
& Danna J. Harras
Kurt Michael Hinds
John G. Hoecker
& Madonna E. Hoecker
Douglas C. Hopkins
& Linda J. Hopkins
Robert Bowman Howe, Jr.
& Jennie S. Howe
Kenneth Lee Johnson
Edward Andrew Jones
Ting-Pui Lai
William Kenneth Lamp
Maja Melton Lehnus
& David S. Lehnus
Fangxing Li
& Erin Q. Zhou
John K. Loftis, Jr.
& Pauline R. Loftis
Joseph R. Loring
& Sheila D. Johnston
Ronald Lewis Marsh
Joseph Walter Matzen, Jr.
Paul D. McFall
John Thomas McHenry
Charles Niedermayer, IV
Michael Lee Oatts
Stewart Lindsey Ocheltree, Jr.
& Sharon L. Ocheltree
Lowell Thomas Overby
& Carolyn Overby
David Harry Pearce
& Linda C. Pearce
Allan Brewer Pedin, III
& Anne L. Pedin
Billy Keech Peele
& Jeanne F. Peele
Maj. Gen. Milton A. Pilcher
Bindiganavele Ananthamara
Prasad & Sudha S. Prasad
Christopher Goodman Ranson
Gerald F. Ricciardi
David Wayne Roop
& Bonnie D. Roop
Daniel M. Sable
& Pamela Sable
James Franklin Schooler
& Nancy J. Schooler
Edith L. Schulz
Twana Banks Smith
& Robert R. Smith
Michael Elliot Sockell
Sharon A. Starowicz
William C. Strauss, III
Harvey Lee Sutton
Douglas Andrew Teeter
Paul Turner Thurneysen
Deborah Ruth Tillotson
& Daniel H. Tillotson
C. Hyde Tucker
Mark Daniel Walther
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Ann Powley Wingfield
& William A. Wingfield
Richard Fitzhugh Wrenn
Gregory A. Zumbrook

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ECE FRIENDS

Ahmed Adel Anbar
Erica Callaham
& Arthur A. Callaham
James A. Eder
& Kathleen M. Eder
Stanley Honda
Carol King
Ron W. Kirchenbauer
David M. Lofe
Scott F. Midkiff
& Sofia Z. Midkiff
Michael L. Miles
Mark A. Stach
Patricia B. Stach
F. William Stephenson

When you hear from The College Annual Fund this fall, make your gift to ECE.

Although every effort has been made to ensure the accuracy of this report, we acknowledge that errors may have occurred. If your name was omitted or listed incorrectly, please accept our sincere apologies and send corrections to the Office of University Development at (540) 231-2801, or contact: www.givingto.vt.edu/Contact/contact-form.

CORPORATE & INDUSTRIAL

AFFILIATES

WIRELESS @ VT

Affiliates

Applied Signal Technology, Inc.
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Motorola Solutions
Raytheon Company
Samsung Telecommunications America
Zeta Associates, Inc.

WICAT-VT

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Applied Signal Technology, Inc.
Center for Advanced Engineering and Research
Harris Corporation
Intel Corporation
L3 Communications
National Instruments
SRC, Inc.
U.S. Army CERDEC (Commun.-Elec. Res. Dev. Engr. Ctr.)
Zeta Associates, Inc.

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Orbital Sciences Corporation
VPT, Inc.

S2ERC

Affiliates

Centripetal Networks
General Dynamics – Advanced Information Systems
General Electric – Information Technology Security Center
L-3 Communications – STRATIS
Lockheed Martin – Information Systems & Global Solutions
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SAIC – Homeland and Civilian Solutions
The SI Organization
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CPES

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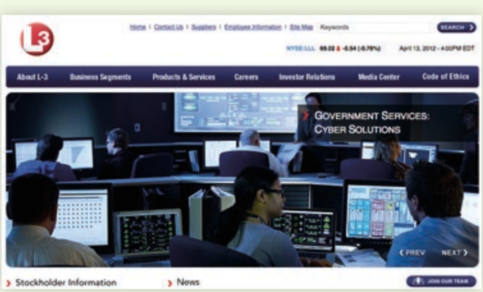
VPT, Inc.

L-3 AND VIRGINIA TECH

Partnership in Cybersecurity Research and Development



In 2011 L-3 donated one of the largest philanthropic gifts by a company ever given to Virginia Tech. The gift is to support cyber research and education. The gift supports a partnership between L-3 and Virginia Tech's Ted and Karyn Hume Center for National Security and Technology.

HONORS & ACHIEVEMENTS

HONORS & AWARDS

Fred C. Lee has been elected to the National Academy of Engineering. He was also named Honorary Li Kwoh-Ting Chair Professor, National Cheng Kung University.

Peter Athanas served as Virginia Tech's lead on the CHREC team that won the National Science Foundation 2012 Schwarzkopf Prize for Technological Innovation, for developing Novo-G, the world's most powerful reconfigurable supercomputer.

Tom Martin was selected for the university's Diggs teaching award. He was also selected to attend the NAE's Frontiers of Engineering Education Symposium in the fall of 2011.

Sedki Riad was honored with the Alumni Award for Excellence in International Education.

Jason Lai was named the James S. Tucker Professor.

Dushan Boroyevich has been elected President of IEEE Power Electronics Society (PELS).

T.-C. Poon was a plenary speaker at the 2011 Digital Holography and Three–Dimensional Imaging in Tokyo, Japan.

Gary Brown was named a National Associate of the National Research Council by the National Academy of Science.

Allen MacKenzie received the E.T.S. Walton Visitor Award from the Science Foundation of Ireland.

Joseph Tront was named director of education for the Hume Center for National Security and Technology.

Robert McGwier was named director of research for the Hume Center for National Security and Technology.

Amir Zaghloul was elected a Fellow of the Applied Computational Electromagnetics Society.

Michael Hsiao won the Best Paper Award at the 2010 IEEE Asian Test Symposium.

Tom Hou was awarded the Best Paper Award Runner-up at IEEE INFOCOM 2011.

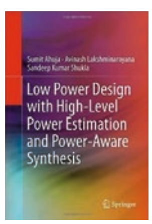
Tenure and Promotion

Patrick Schaumont was tenured and promoted to associate professor.

Yong Xu was tenured and promoted to associate professor.

JoAnn Paul was tenured as an associate professor.

Luiz DaSilva was promoted to professor.



BOOKS PUBLISHED

Sandeep Shukla co-authored *Low Power Design with High-Level Power Estimation and Power-Aware Synthesis*; Springer, 2012.

Peter Athanas co-authored *Reconfigurable Computing: Architectures, Tools and Applications* (Springer, 2012); *Embedded Systems Design with FPGAs* (Elsevier, 2010); and *A Management Paradigm for FPGA Design Flow Acceleration: Creating a framework for vendor independent representation of FPGA designs* (LAP LAMBERT Academic Publishing, 2011).

Michael Buehrer co-authored *Handbook of Position Locations: Theory, Practice and Advances* (IEEE Series of Digital & Mobile Communication.)

ECE student team wins grand prize at IEEE Future Energy Challenge

A team of Virginia Tech EE students won the grand prize and the best efficiency award at the 2011 IEEE International Future Energy Challenge for their low-cost lithium ion battery charger. The team achieved greater than 94 percent efficiency even when delivering as much as 4kW. More than 12 students worked on the project, mostly during the Spring 2011 semester.

Three students completed the battery charger over the summer and took it to competition. From left: Jason Dominic, Eric Faraci , and Thomas LaBella. Kathleen Meehan and Jason Lai served as faculty advisors.

EXCEPTIONAL NATIONAL SERVICE

Saifur Rahman is the chair of the NSF Advisory Committee for International Science and Engineering. He is also a member of the National Research Council panel on Partnerships for Enhanced Engagement in Research and a member of the Congressional Briefing Panel organized by NSF and *Discover Magazine.*

William Davis serves as the Chair of Commission A (Metrology), International Union of Radio Science (URSI).

Gary Brown serves as a National Academy of Science Panel Member reviewing the U.S. Army's Communication Research Program. He is also a reviewer of the University of Massachusetts CASA Engineering Research Center for the National Science Foundation (NSF).

Amir Zaghloul serves as Chair of Commission C (Communications and Signal Processing Systems) of the U.S. National Committee of the International Union of Radio Science (URSI).

CONFERENCE CHAIRS & SPEAKERS

Peter Athanas was co-chair for the 21st International Conference on Field Programmable Logic and Applications (FPL) Crete, Greece, September 2011. He co-chaired the International Conference on ReConFigurable Computing and FPGAs (ReConFig), Cancun, Mexico, December 2011. He co-chaired the 8th International Symposium on Applied Reconfigurable Computing (ARC), Hong Kong, March 2012.

Thomas Hou is serving as vice chair for IEEE INFOCOM's steering committee since 2011.

Saifur Rahman served as the general chair of Asia Pacific Power and Energy Engineering Conference, Shanghai, China, March 2012.

Sandeep Shukla was the technical program committee chair for IEEE HLDVT 2011 (IEEE Workshop on High Level Design Validation and Test), Napa Valley, California, November 2011; and ECSI ESLsyn 2011 (Electronics and System Design Initiative Symposium on ESL Synthesis), San Diego, California, June 2011.

Patrick Schaumont was the program chair for the 2011 International Symposium on Hardware Oriented Security and Trust (HOST 2011), San Diego, California, June 2011.

EDITORSHIPS

Michael Buehrer is associate editor for *IEEE Transactions on Communications* and *IEEE Wireless Communications Letters*.

Luiz DaSilva is associate editor for *IEEE Communications Letters* and *Journal of Communication and Information Systems*. He is also a member of the editorial board for *Computer Networks* and a guest editor for the *IEEE Communications Magazine's* feature topic of Game Theory for Wireless Communications.

Thomas Hou is the editor for *IEEE Journal on Selected Areas in Communications — Cognitive Radio Series; IEEE Transactions on Mobile Computing; Springer Wireless Networks*; and *Elsevier Ad Hoc Networks.* He is also the technical editor for *IEEE Wireless Communications* and the area editor for *IEEE Transactions on Wireless Communications.*

Michael Hsiao is associate editor for *IEEE Transactions on Computers* and serves on the editorial boards of *IEEE Design & Test of Computers and Journal of Electronic Testing: Theory and Applications.*

Allen MacKenzie is associate editor for *IEEE Transactions on Communications* and *IEEE Transactions on Mobile Computing.*

Paolo Mattavelli is the associate editor for the *IEEE Transactions on Power Electronics.*

T.-C. Poon is division editor for *Applied Optics* and lead feature editor of "Digital Holography and Three–Dimensional Imaging" for *Applied Optics.*

Saifur Rahman is editor-in-chief of *IEEE Transactions on Sustainable Energy.*

Patrick Schaumont is associate editor for *ACM Transactions on Design Automation of Electronic Systems* and the *Springer Journal on Cryptographic Engineering.*

Sandeep Shukla is associate editor for *IEEE Transactions on Computers; IEEE Embedded Systems Letters; Elsevier Journal on Nano-Networks;* and *Computer Society of India Journal of Computing.*

Joseph Wang is associate editor for *International Journal of Biomedical Imaging* and *EURASIP Journal on Bioinformatics and Systems Biology,* and a member of the editorial board for *Systems Biomedicine.*

INTERNATIONAL SERVICE

Luiz DaSilva holds a part-time appointment as the Stokes Professor in Telecommunications at Trinity College, Dublin.

T.-C. Poon was appointed a Distinguished Chair Professor of Feng Chia University, Taiwan. He was also awarded the Visiting Professorship for Senior International Scientist of the Chinese Academy of Sciences, China.

ece FACULTY

A. Lynn Abbott
Associate Professor
Illinois '89

Masoud Agah
Associate Professor
Michigan '05

Peter Athanas
Professor
Brown '92

Scott Bailey
Associate Professor
Colorado '95

Joseph Baker
Assistant Professor & Steven O. Lane Junior Faculty Fellow
Michigan '01

William T. Baumann
Associate Professor
Johns Hopkins '85

A. A. (Louis) Beex
Professor
Colorado State '79

Dushan Boroyevich
American Electric Power Professor
Virginia Tech '86

Tamal Bose
Professor
Southern Illinois '88

Robert P. Broadwater
Professor
Virginia Tech '77

Gary S. Brown
Bradley Distinguished Professor of Electromagnetics
Illinois '67

R. Michael Buehrer
Associate Professor
Virginia Tech '96

Virgilio Centeno
Associate Professor
Virginia Tech '95

Charles Clancy
Associate Professor
Maryland '06

C. Robert Clauer
Professor
UCLA '80

Claudio da Silva
Assistant Professor
UC San Diego '05

Luiz DaSilva
Professor
Kansas '98

William A. Davis
Professor
Illinois '74

Jaime De La Ree
Associate Professor & Assistant Department Head
Pittsburgh '84

Gregory Earle
Professor
Cornell '88

Steven Ellingson
Associate Professor
Ohio State '00

C. Yaman Evrenosoglu
Assistant Professor
Texas A&M '06

Louis Guido
Associate Professor
Illinois '89

Dong S. Ha
Professor
Iowa '86

Thomas Hou
Associate Professor
Polytechnic Univ. '98

Michael Hsiao
Professor
Illinois '97

Mantu Hudait
Associate Professor
Indian Institute of Science '99

Mark Jones
Professor
Duke '90

Kwang-Jin Koh
Assistant Professor
UC San Diego '08

Jason Lai
James S. Tucker Professor
Tennessee '89

Fred C. Lee
University Distinguished Professor
Duke '74

Douglas Lindner
Associate Professor
Illinois '82

G. Q. Lu
Professor
Harvard '90

Allen MacKenzie
Associate Professor
Cornell '03

Majid Manteghi
Assistant Professor
UCLA '05

Tom Martin
Associate Professor
Carnegie Mellon '99

Paolo Mattavelli
Professor
University of Padova '95

Kathleen Meehan
Associate Professor
Illinois '85

Scott F. Midkiff
Professor & Head
Duke '85

Lamine Mili
Professor
Liege '87

Leyla Nazhandali
Assistant Professor
Michigan '06

Khai D.T. Ngo
Professor
Caltech '84

Hardus Odendaal
Associate Professor
Rand Afrikaans '97

Marius Orlowski
Professor, VMEC Chair
Tuebingen '81

Jung-Min Park
Associate Professor
Purdue '03

Cameron Patterson
Associate Professor
Calgary '92

JoAnn Paul
Associate Professor
Pittsburgh '94

Paul Plassmann
Professor & Assistant Department Head
Cornell '90

T.–C. Poon
Professor
Iowa '82

Timothy Pratt
Professor
Birmingham '68

Saifur Rahman
Joseph Loring Professor
Virginia Tech '78

Sanjay Raman
Professor
Michigan '97

Binoy Ravindran
Associate Professor
UT Arlington '98

Jeffrey H. Reed
Willis G. Worcester Professor
UC Davis '87

Sedki Riad
Professor
Toledo '76

J. Michael Ruohoniemi
Associate Professor
Western Ontario '86

Ahmad Safaai-Jazi
Professor
McGill '78

Wayne Scales
Professor
Cornell '88

Patrick Schaumont
Associate Professor
UCLA '04

Sandeep Shukla
Associate Professor
SUNY Albany '97

Daniel Stilwell
Associate Professor
Johns Hopkins '99

Dennis Sweeney
Director of Instructional Labs
Virginia Tech '92

Kwa-Sur Tam
Associate Professor
Wisconsin '85

William H. Tranter
Bradley Professor
of Communications
Alabama '70

Joseph G. Tront
W.S. "Pete" White Professor
of Innovation in Engineering
Education
SUNY Buffalo '78

Anbo Wang
Clayton Ayre Professor
Dalian '89

Chao Wang
Assistant Professor
Colorado '04

Yue (Joseph) Wang
Grant A. Dove Professor
Maryland '95

C. Jules White
Assistant Professor
Vanderbilt '08

Chris Wyatt
Associate Professor
Wake Forest School
of Medicine '02

Yong Xu
Associate Professor
Caltech '01

Jason Xuan
Associate Professor
Maryland '97

Yaling Yang
Assistant Professor
Illinois '06

Instructors

Leslie K. Pendleton
Director of Student Services

Jason Thweatt
Instructor

Research Faculty

Antonio Barbalace
Postdoctoral Associate

Charles W. Bostian
Alumni Distinguished
Professor Emeritus
& Research Professor

Ingrid Burbey
Research Scientist

Xia Cai
Research Scientist

Kristie Cooper
Research Associate Professor

Ryan Davidson
Postdoctoral Associate

Yi Deng
Postdoctoral Associate

Carl B. Dietrich
Research Associate Professor

Bo Dong
Research Associate

Michael C. Fowler
Research Associate

Aditya S. Gadre
Research Associate

Joseph Gaeddert
Postdoctoral Associate

Mahmud Harun
Postdoctoral Associate

Hyomin Kim
Postdoctoral Associate

Robert W. McGwier
Research Professor & Director
of Research, Hume Center

Julien B. Ouy
Postdoctoral Associate

Arun G. Phadke
University Distinguished
Professor Emeritus
& Research Professor

James Pokorski
Research Associate

Apoorva Shende
Postdoctoral Associate

Shabnam Sodagari
Postdoctoral Associate

James S. Thorp
Hugh P. and Ethel C. Kelly
Professor Emeritus
& Research Professor

Brentha Thurairajah
Postdoctoral Associate

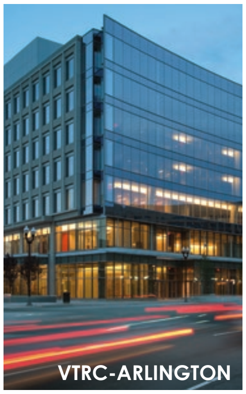
Haris I. Volos
Research Scientist

Dan Weimer
Research Professor

Wensong Yu
Research Assistant Professor

Baigang Zhang
Research Associate

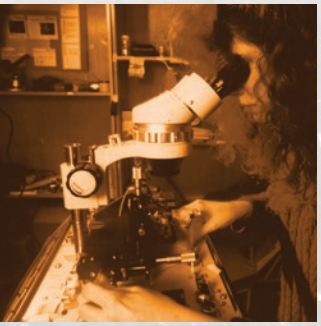
25 YEARS

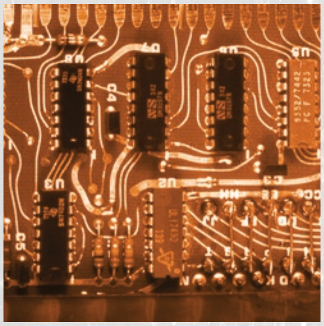


Twenty-five years ago, the faculty of the Electrical Engineering Department was 54 strong and fit in part of Whittemore Hall. Today, the Bradley Department of Electrical and Computer Engineering includes 73 full-time, tenure-track faculty members, two instructors, and 26 research faculty members. The department is housed in nine buildings around the state.

THE **BRADLEY DEPARTMENT**
of Electrical & Computer Engineering

Virginia Polytechnic Institute and State University
302 Whittemore Hall
Blacksburg, VA 24061

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