ECE 2010

The Bradley Department of Electrical and Computer Engineering

Virginia Tech
Invent the Future

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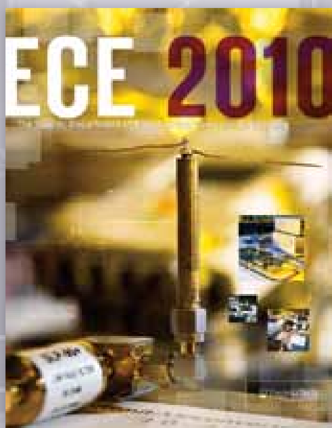

Cover photos
by John McCormick

Cover: Virginia Tech's RapidRadio framework can help a user build an FPGA radio in a short time, based on a set of characteristics extracted from an unknown signal. Researchers in the Configurable Computing Laboratory are building an Internet-controllable robot to impair the wireless channel for testing.

Produced by Uncork-it Communications

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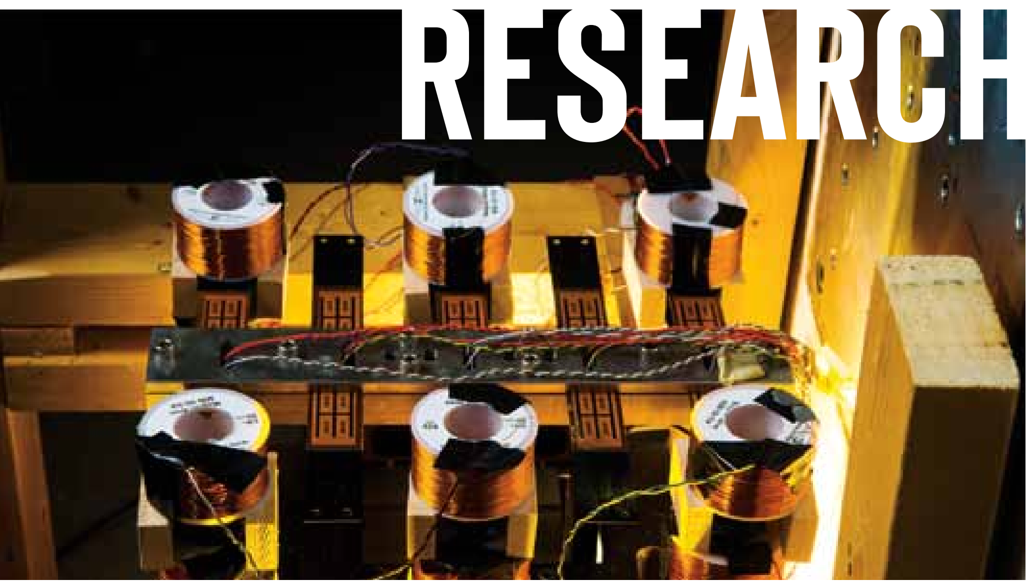


RESEARCH

ECE PEOPLE

Photography: Robert Dunay: p. 11; Kelsey Kradel: pp. 13, 21; John McCormick: pp. 2, 35, 36;
Dave Franusich: p. 24, 25; Christina O'Connor: pp. 1, 4-12, 17, 20, 21, 23, 25; Jim Stroup: p. 8, 10, 22, 23

PERSPECTIVES

from the Department Head

It is my great honor to now serve as department head of the Bradley Department of Electrical and Computer Engineering and to provide this introduction to our 2010 annual report. This report summarizes the many notable accomplishments of our students and faculty. Perhaps more importantly, it provides a glimpse into just a few of the innovations in research, education, and outreach that reflect the great potential of the department. It is this potential, the opportunity, and the challenges that we face that make my job exciting.

I look forward to serving the 70-plus faculty members, the approximately 1200 undergraduate and graduate students, and the thousands of alumni and friends of the department as we strive for even higher quality, even more significant impact, and even greater innovation.

Scott Midkiff
Department Head

While increased national rankings, research funding, and SAT and GRE scores for our applicants are important and necessary goals, we are driven by more pressing and more important challenges. I assert that electrical and computer engineering has never been more important than it is right now for both economic vitality and societal good. The National Academy of Engineering formed a committee to identify Grand Challenges for Engineering for the 21st Century. If you are not familiar with this list of 14 Engineering Grand Challenges, I urge you to visit the informative web site at *www.engineeringchallenges.org*. While one may argue that the list is incomplete or that there are other challenges that are more "grand," the list does illustrate the important and difficult challenges facing the world that require technically innovative solutions. Finding solutions to the grand challenges will require the expertise of multidisciplinary teams of engineers, scientists, and policy makers. But, to varying degrees, the talents and contributions of electrical and computer engineers are essential to new breakthroughs to solve these grand challenges.

I categorize the 14 Grand Challenges into five general domains:

1 **The domain of energy and the environment** is vital to a sustainable future. Virginia Tech's ECE department has world-class expertise in power electronics, power systems, and sensors for harsh environments that are necessary to solve challenges such as making solar energy economical.

2 **In the domain of critical infrastructures**, the department is making contributions in many areas, including power and energy systems, telecommunications and networking infrastructure, sensors and embedded systems for structural health monitoring, and rail transportation.

3 **The domain of healthcare and biotechnology** is clearly important as our population ages and healthcare dominates political discourse. ECE researchers, often in collaboration with researchers in other disciplines, are making important advances in medical imaging, synthetic biology, bio-MEMS, and computing infrastructure and methods that can help to solve challenges such as engineering better medicines or reverse engineering of the brain.

4 **The fourth general domain is safety and security**, with includes the grand challenge of securing cyberspace. ECE faculty and students are creating innovative hardware for the secure implementation of cryptographic algorithms, methods for locating wireless attackers, and programs for educating the next generation of engineers and scientist for the intelligence community.

5 We are striving to both transform and to be transformed by **innovations in education, research, and collaboration**, the fifth domain of the grand challenges. ECE technological developments promise to dramatically increase the performance and efficiency of cyberinfrastructure, which are the tools for scientific discovery, and advance personalized learning through the use of the Tablet PC and other educational technologies.

The challenge and the opportunity for the Bradley Department of Electrical and Computer Engineering is to make the fundamental discoveries, develop the transformational innovations, and ensure the well prepared future ECE workforce necessary to meet the Grand Challenges of Engineering and find solutions to other important problems to help ensure the prosperity of the nation and a sustainable future for the world.

The future of engineering is clearly multidisciplinary. ECE researchers are already working across disciplinary boundaries. Engineering will rely more and more on cyber systems, including high performance computing that is enabling new approaches to discovery and innovation, plus embedded systems that underlie new cyber-enabled engineered systems such as the smart grid and cogni-

The National Academy of Engineering's Committee on Engineering's Grand Challenges developed the following list of 14 key areas needing engineering solutions.

1 Make solar energy economical
2 Provide energy from fusion
3 Provide access to clean water
4 Reverse-engineer the brain
5 Advance personalized learning
6 Develop carbon sequestration methods
7 Engineer the tools of scientific discovery
8 Restore and improve urban infrastructure
9 Advance health informatics
10 Prevent nuclear terror
11 Engineer better medicines
12 Enhance virtual reality
13 Manage the nitrogen cycle
14 Secure cyberspace

Source: www.engineeringchallenges.org

tive wireless networks.

In the future, the nation will need more electrical and computer engineers with more advanced preparation, and exhibiting greater diversity. We must expand the ECE student pipeline from K-12 to college and from the undergraduate to the graduate level. To introduce undergraduates to advanced study, we offer undergraduate research experiences across the department, including an NSF-funded REU site in wireless. We seek to engage even more of our best undergraduates in research. And, we strive to better prepare our students to work in global, multidisciplinary teams and to creatively integrate knowledge to solve problems through "hand-on, minds-on" learning.

This annual report shows that ECE faculty and students are working very hard to seize the opportunities before us. It is also clear that more must be done. This is our challenge. Despite declining state support for higher education, we are not standing still. More and more, we control our own destiny. We are establishing creative partnerships with industry, government, and others in academia, as well as with our alumni and friends, to find the resources to move forward. And, we are using these resources efficiently to realize quality, impact, and innovation. We must, and we will, lead the way in ECE research, education, and outreach.

I would like to thank our many partners in this pursuit — the Bradley Endowment, our industry supporters, our sponsors, and, especially, our alumni and friends. The department is especially appreciative of our ECE Advisory Board, chaired by Gino Manzo, and the advisory boards for research groups and centers. The department is indebted to James Thorp, our previous department head, who left the ECE department both intellectually strong and fiscally sound. I am especially grateful to Jim for the wisdom and knowledge that he shared so generously before and after I became department head. I wish to thank the ECE faculty and staff, who do so much for the department, and Dean Benson and the the College team. All have been very helpful to me as I learn the ropes of the new job. And last, but certainly not least, I thank my wife, Sofia, and my children, Victoria and Erik, for their support in the move back to Blacksburg and for their understanding of the demands associated with my position.

We welcome two new members to our faculty, Mantu Hudait in microelectronics and Paolo Mattavelli in power electronics. Mantu and Paolo are introduced at right.

In closing, I note the passing of William A. Blackwell on March 12, 2010. Bill was department head from 1966 to 1981, during which time he led the transformation of the department into its modern form as an international leader in ECE education and research. Bill's life of service to the department, the profession, and the nation exemplifies *Ut Prosim* and serves as a model for us all.

NEW FACULTY

Mantu Hudait

Mantu Hudait joined ECE in September as an associate professor in the microelectronics area. An expert in materials science and microelectronics, Hudait is investigating new materials and device structures for energy-efficient nanoelectronics and alternative energy sources. He came to Virginia Tech after serving four years as a senior process engineer in the Advanced Transistor and Nanotechnology Group at Intel Corporation. Hudait received his Ph.D. in materials science and engineering from the Indian Institute of Science in 1999, and a master's degree in materials science and engineering from the Indian Institute of Technology in 1992.

Paolo Mattavelli

Paolo Mattavelli joined ECE in January as a professor in the electronics area. Mattavelli will be working with the Center for Power Electronics Systems (CPES). Mattavelli comes to ECE from the University of Padova in Vicenza, Italy, where he served as an associate professor of electronics since 2005. He has coordinated a number of research and industrial projects in power electronics, and received the Prize Paper Award in *IEEE Transactions on Power Electronics* in both 2005 and 2006. Mattavelli received his Ph.D. and Master's degrees in electrical engineering from the University of Padova in 1995 and 1992, respectively. He has served as an associate editor for *IEEE Transactions on Power Electronics* since 2003, and is the IPCC Paper Review Chair for *IEEE Transactions on Industry Applications*.

COMPET

LESSONS YOU CAN'T FIND IN A BOOK

Competitions build better engineers

A student zooms around the track in a hybrid car designed by a team of her peers. She steps out and removes her helmet as a crowd cheers and her teammates surround her. Great, right? But how much do these high-profile design competitions actually help students?

It's difficult to find hard data on the impact of competitions on engineering education, but easy to find advocates among students, professors, and employers. ECE's Dan Stilwell, who co-advises the autonomous underwater vehicle team sums up the advocates' position: "The undergraduate student competition teams are among the best educational experiences we can offer. I'm a huge fan."

Engineering competitions are fun: they motivate students through hands-on, real-world experiences. Students come away with renewed passion and enthusiasm for their coursework. Some students might even sign up for a discipline because of the competitions offered in the curriculum.

Employers love to see that a student has practical experience working with a budget, a timetable, and a group of other engineers — or even marketing or art students. Some competitions have even led to major technological innovations.

Competitions have become an increasingly popular tool for getting students enthusiastic about engineering. Students can choose from a smorgasbord of vehicle and robotic competitions tailored to specific technologies. They can build a hybrid car, a solar-powered car, a fully autonomous car and who knows how many boats, helicopters and other things that move. They can also build robots that play soccer, pick up and sort recyclables, or perform any number of other tasks.

Virginia Tech has a dedicated building, the Ware Lab, for student competitions. "Did you know that the Ware Lab has great machining and fiberglass facilities, but these can only be used by students on a competition team?" Stilwell asks. "This is a great rule.

TITIONS

The College of Engineering has made specific and useful investments in the student competition teams."

Many of the senior projects in Virginia Tech's department of mechanical engineering are based on competitions. In ECE, competitions are an increasingly important part of students' experience at Virginia Tech, with many students receiving course credit for their work. This year, ECE students have participated in the Solar Decathalon, the formula car, the Lunabotics team, the IEEE robot contest, and the autonomous underwater vehicle team, among others. Many of these teams first were sponsored by other departments, but as electrical and computer engineering technology has become critical to almost every field of endeavor, the teams are increasingly seeking ECE students to help out. During course sign-up week, undergraduate email inboxes are filled with announcements of dozens of interdisciplinary team opportunities.

Competitions have become an increasingly popular tool for getting students enthusiastic about engineering

Relationship to coursework

The competition-based learning model has grown with student claims that it complements and helps motivate their coursework with valuable hands-on experience.

Micah Boswell (CPE '11), captain of the AUVT team, said that students think that robotics competitions are "the coolest things they've done." A lot of topics students encounter in competitions are covered in class, and a lot aren't, he noted. "You can only teach so much in class and the competitions give you a chance to explore so many additional aspects."

The most fun, according to Boswell, was going to the competition. "We met with 29 teams from all over the world. Just seeing how those students attacked the same problem was a huge learning experience," he commented.

Graduate student Zack Zaremski, lead ECE on the Lumenhaus Solar Decathalon team agreed. One of the highlights was seeing all the other team's solutions and picking up ideas for the next version, he said.

Students learn from other teams, but also from older students on their own team. Kevin Green (CPE '10), captain of Virginia Tech's IEEE hardware team said that, because he was interacting with older students, he gained hands-on experience with technologies and techniques that usually aren't taught to new students. The experience was very useful in his senior-level embedded design course. "That class would've been a lot more difficult had I not been through this competition for two years prior to taking it. I was used to working with a group of people and I was comfortable using test equipment and the electronics side of things."

He speculated that without the competition experience, he may not have been a CPE. "I'm not your typical A/B student. I got frustrated and bored with our 'Intro to Engineering' courses. In those courses it could be difficult to see how the things we were learning would apply to our future work," he said. "The courses I do find interesting are the ones I can relate to the robotics projects we've done, and those are the subjects that I really do a great job on. So, selective effort here and there, but maybe I wouldn't be doing anything without the robotics competitions."

Although experience with a competition's particular technology may help students in their coursework and curriculum, they unanimously agree that competition experience helps them learn time management, group coordination and leadership, communications, and budgeting skills.

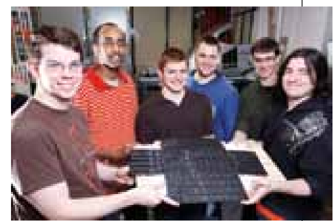
"One of the biggest challenges we had to overcome was communicating with the rest of the team and getting everyone in one place to make decisions," said Zaremski of the Lumenhaus project, which involved almost 100 students from different disciplines.

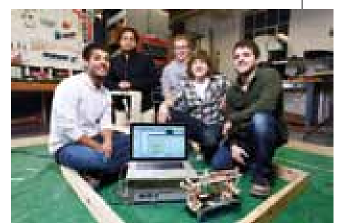
Although Green's team is smaller, he agreed that getting everyone together despite pressing course and personal obligations, especially during the semester, was one of his teams' biggest challenges.

Employers love competition experience

Employers love to see experience with competitions on an applicant's résumé. "Sometimes companies float these competitions to see who the best students are and then hire them later," said Harpreet Dhillon, a master's student who recently participated in a competition funded by Qualcomm; the first-place prize for this competition included preference for an internship position with Qualcomm.

In a discipline that has been criticized for producing talented individuals who find it difficult to communicate or work with others, the collaborative atmosphere of undergraduate engineering competitions is a welcome complement to coursework.





MORE LIGHT...

Team effort conquers low power

Competitions aren't just about building and testing systems, as Kevin Green (CPE '10), captain of Virginia Tech's IEEE hardware contest team, and his teammates have learned. Good management and advance work can be as important as overcoming technical challenges and developing working hardware and software.

For the 2010 IEEE SoutheastCon hardware contest, teams built a photovoltaic-powered vehicle that would navigate an obstacle course without the help of a human controller. To add to the challenge, no batteries were allowed, only capacitors, and the only power sources were four 250W Halogen work lamps. The vehicles could stand still and charge under the lights, but the competition was timed to ensure that the vehicles were always pressured to move forward and operate on very low power.

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Visit the IEEE Hardware Team website: *ieeehardware.ece.vt.edu*

The autonomous vehicles attempt to go under or over a height obstacle, through a width obstacle, and over a ramp. The Virginia Tech team found the ramp especially difficult, because of the vehicle's low power and the ramp's slick surface.

The team struggled with various options, including a set of very sticky wheels, which worked when perfectly clean but constantly picked up dirt from the artificial turf of the track. "We tried wiping down the ramp and cleaning the Astroturf, but no matter what we do, the wheels collect so much dirt that they slip," Green said. The team eventually opted for treads, which are a big energy drain.

For power, the team started with paper thin, inexpensive PV panels that crumbled with the slightest pressure. For a team that is always disassembling, reassembling, or transporting their device, these panels were not a viable option.

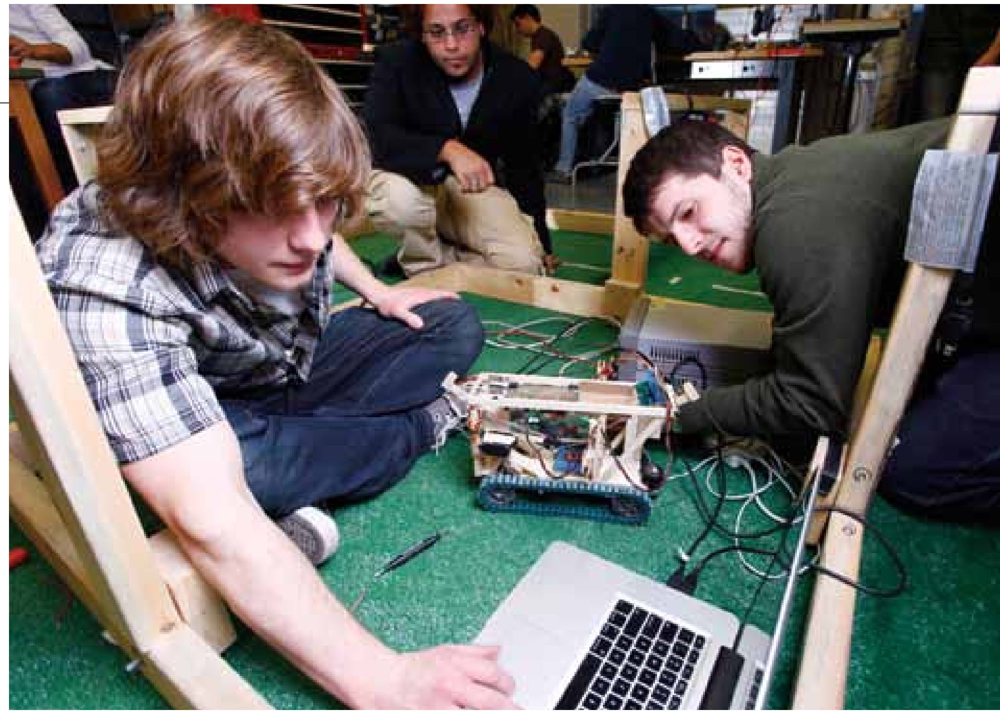
The students found sturdier panels, but at a high cost of $500. With a contribution from defense contractor Artis, they were able to purchase and install 160 of the small square solar panels on their vehicle.

A week before competition, the team had the power and locomotion systems operating, as well as working software. This was unusual for a project that typically hasn't had a working vehicle until days or even hours before competition. Green attributed this success to a larger team than normal and several decisions made early in the process.

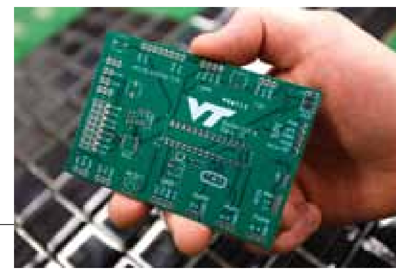
After several years of ultra-small teams, this year's team was 18 strong, including some mechanical engineering students. The students were able to break into several functional groups: hardware and chassis, and software. Each group had strong team leaders, which Green said made his job as captain much easier.

"This has been really great," he said. "These guys have been great to work with. They've taken over a lot of the work, which lets me focus on the funding, management, and other aspects of the contest like paperwork or buying pizza for everybody when they

“Most of the robots...just sat there without moving. It was a standoff – whoever could move first would win.”



Students on the IEEE hardware team built a solar-powered robot for the 2010 SouthEastCon competition. In the group photo on the opposing page: Back row from left: Fitwi Hailegiorgis, Philip Caspers, Kurt Brendley, Abdullah Asiri, Alex Goodman, Jacob Stultz, Nick Dodson, and Alfred Gonzalez. Front: Michael Francis, Kevin Green, Josh Avant, Chris Arnold, and Bobby Bowen.



have to stay late. I don’t know how previous captains did it without this structure.”

While the hardware team struggled with power and chassis issues, the software team was busy developing code and “war gaming among themselves.” When the chassis was ready, the software “just kind of worked,” Green said. “In the past, we’d have the chassis built, but zero software. This time, we had written tons of software.”

They have even had time to develop software techniques to improve processing of feedback and system integration. “Now if something goes wrong, it’s a lot easier for us to tell whether it was a minor technical glitch or a major problem with the system,” explained Green.

So, how did the robot perform at competition? The team had been very hopeful and when they got to the competition in March, they found they were the only team to use treads and their vehicle was the most sophisticated looking. “We looked like a robot, whereas other teams looked like a motor with solar panels.”

Then, a half hour before competition, disaster struck. “The robot was having electrical problems and we discovered that a wireless radio module was dead. We had used that module all year to debug and send back telemetry information. It turns out this awesome module had shorted and fried one of our power regulators.” They were in the first heat and had to forfeit while scrambling for a replacement part.

Lesson learned: redundancy is critical.

The robot was partially operational for the second heat, when the team found out that the competition power lights were different from the practice room. “Most of the robots – including ours – just sat there without moving. It was a standoff – whoever could move first would win,” Green said.

“Because we were robotic, we could reprogram our vehicle for the third heat, when other teams had to rewire theirs.” Lesson learned: advance preparation was a good thing.

The robot moved for the final heat and gained one point. “We were off zero, which put us in the middle of the 50 teams, but we were far from placing. One team got 30 point and the rest just sat. It was a slaughter!”

Lesson learned: “It was a good experience. We learned a lot about ourselves.”

Back in Blacksburg, the students are repairing and fixing up the robot as a departmental demonstration unit. The team is sponsored each year by Norfolk Southern and was advised this year by Jaime De La Ree.

TAKING THE COMPETITION

UNDER WATER

Top (from left): Joe Ball, Ben Guzzardi, Richard Stroop, and Bryant Ferguson. Bottom: Karli Brittain.

Many annual student competitions purposefully make the requirements not just different, but tougher each year — keeping success just beyond reach. With this strategy, organizers hope to both develop top-rate engineers and move the technology forward step by step.

The Autonomous Underwater Vehicle (AUV) Competition follows this strategy. One team completed the course in 2009, so the organizers have promised it will be more difficult this year, its 13th competition, according to Micah Boswell (CPE '11), leader of Virginia Tech's team.

The competition, sponsored by the Association for Unmanned Vehicle Systems International (AUVSI) and the Office of Naval Research (ONR), focuses on realistic missions underwater.

With vehicles no longer than 6 feet and less than 3 feet high or wide, teams seek to complete a number of underwater tasks. The AUVs must drive through a validation gate, follow an orange path, touch a red buoy, jump over bars, drop markers in bins, fire a torpedo, grab a PVC structure and surface in a specified octagon — all in 15 minutes or less.

It's hard enough to develop a land-based autonomous vehicle to complete such locomotion with visual and acoustic recognition tasks, but the underwater environment adds extra challenges, Boswell said. "ECEs generally don't have to operate underwater."

The electronics must be small and dense so the system is the same weight as water, which is surprisingly heavy, he noted. The team will add weights, if needed, so the AUV can submerge. Powering the system underwater is also tricky, he said. "We decided to use lithium polymer batteries, but they don't react well when combined with water. We need numerous failsafes so that if the system shorts, the battery is protected and doesn't blow up the vehicle."

During the July competition in San Diego, the teams will not

"It's hard enough to develop a land-based autonomous vehicle... but the underwater environment adds extra challenges."

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operate their own AUVs, but will put them in the hands of Navy divers. This means the operating system must be user-friendly. With that in mind, the ECE students make sure the other students can understand and operate the vehicle and are continuously improving the software so that all of the systems can interact well through a simple interface.

This is the second year Boswell has participated. In 2009, Virginia Tech floated its first AUV team in several years. "Last year none of us had any idea what to expect," he said. "Just the fact that we were able to get an AUV put together and score points… I think it's pretty amazing that we were able to do that given that we started with no idea of anything."

Virginia Tech's AUV

Last year's team was six strong, with three CPE students. This year, with many returning members, a much larger team, and sponsorship from Lockheed Martin, the team has dreams of greater success.

Some of the challenges the students face stem from the team's growth. This year's team has 22 members, with eight ECEs. The team is advised by ECE's Dan Stilwell and Craig Woolsey of aerospace and ocean engineering.

With the larger team, the students have been able to rebuild, modify and add systems for higher value tasks at the competition. One new system is passive sonar. The team had hoped to buy a functional system off the shelf, but balked at the almost-$20,000 price. Instead, the team identified a specialized sonar group that is working with Stilwell's laboratory to develop a cost-effective system.

Once a subsystem works independently, however, it must be integrated into the whole system, which can be a challenge. "We're dealing with more complexity integrating the work of a much larger group," explained Boswell.

The software is critical to the system integration. Mathworks, a sponsor of the Ware lab that houses the team, has provided software, including Simulink, which the students use for autonomous-level code. "We integrate that with our own C++ code," Boswell said. "Simulink gives us a graphical programming interface, which makes it easier for those who are not strong programmers to look at the code and understand how it works," he added. "This helped us develop the software very rapidly." Last year, the team hadn't started programming until about three weeks before the competition, he said.

Although the larger team helps with technology development, it makes it more difficult to ensure strong team interactions. Boswell described a recent underwater test. "It was the first time we had several different groups at the same event, and it was an interesting experience to have groups that have been working on the same project for weeks meet each other for the first time. As the team has grown, it has become harder and harder for everyone to know each other, and a challenging task for the overall coordinator (me) to keep track of everyone's work," he said. "I believe this experience is invaluable for anyone working on a large team, and should be an integral part of a good engineering education."

FROM THE GROUND UP

ECEs design and build Lumenhaus PV system

"The house can operate anywhere. It's been a very cool project with the sustainable energy component and backfeeding to the grid."

When a team of ECE students joined the multidisciplinary team building Lumenhaus, Virginia Tech's entry in the Solar Decathalon, they faced an age-old misunderstanding: they were expected to be electricians.

The project is the university's largest cross-college design competition, involving about 100 students from disciplines including architecture, marketing, communications, and engineering. "It's funny; the other students on the team just expect us to know everything about electricity," said Zack Zaremski, the lead student on the power system team.

The ECEs happily pitched in and learned wiring (one ECE, Damion Logan actually had worked as an electrician before coming to Tech). But, the ECEs' main interest was designing and building the solar power system and connecting it to the grid.

Lumenhaus is a pavilion-style home, with an open plan. The ECE team designed, specified, and built an 8 kW photovoltaic (PV) array that provides enough power for the energy-efficient building's needs and then some. The PV system can operate in almost any level of cloud cover, and does not fail when power generation spikes or dips, according to Zaremski.

The solar panels generate more power during the day than is needed by the house, which sells that power to the electric company at the high daytime price. At night, the house draws electricity from the grid at the much lower night cost. "The house can operate anywhere. It's been a very cool project with the sustainable energy component and backfeeding to the grid," Zaremski said.

In addition to energy-efficient appliances, the house "has a lot of lights, including fluorescent lights in the plenum that are covered by a stretched-fabric ceiling." The team installed a user-friendly Lutron interface that can control the lighting through an iPhone application. The system also turns off lights when a room is empty.

The U.S. Department of Energy competition in fall 2009 in Washington D.C. evaluated the teams in 10 areas; "construction and engineering," "solar system and hot water," and "energy balance" were the areas involving the ECE team.

A German team won the competition by covering every available surface with solar panels and using the maximum overall dimensions allowed. The German team won many points for

Zack Zaremski, Paul Gherardi, Kenny Johnson, Damion Logan, and Justin Reyes are on the ECE team that designed, spec'ed, and built the solar power system for Lumenhaus. Other ECEs who participated: Danny Slover, Roddy DeHart, Richard Gilker, John Shields, and Josh Schaefer. Virgilio Centeno serves as ECE faculty advisor.

generating excess electricity, and the Lumenhaus team is adding PV panels for its entry into the European Solar Decathlon, to be held in June, in Madrid, Spain.

The team, however, has reservations about producing too much energy. "Part of the evaluation is on marketability, which includes affordability," Zaremski said, "You don't want to generate a whole lot more than you need, because when you're offsetting your own cost it's about 12 cents a kilowatt hour. But when you sell it back to the grid, it's at wholesale price, which is about four cents. So it's actually cost effective to generate just under or right about what you need."

Other modifications to the power system that are under way include making all of the outlets tamper proof and fixing minor bugs in their code.

Zaremski is the only ECE graduate student involved. The other nine participated as part of their senior power design course. "This has been the best internship or design or team experience I've had," he said. Not only do the students learn, but "there's a lot of pride — not just school pride, but national pride. We'll be one of only two U.S. teams competing in Spain."

The fully functioning Lumenhaus as it was installed on the National Mall for the 2009 Solar Decathlon.

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Visit the Lumenhaus website: *www.solar.arch.vt.edu/about*

While undergraduate competitions typically highlight design and teamwork, competitions at the graduate and research level can often be more about ideas. This is the case with the spring 2010 Qualcomm Cognitive Radio Competition, which Qualcomm designed to identify new ways of detecting wireless microphone systems. Virginia Tech was one of only 14 universities invited to participate.

The challenge stems from the recent switch from analog to digital TV signals and the FCC allowing cognitive radios to use TV white space. Cognitive radios may not interfere with existing communications and so must identify the signals of licensed users. The cognitive radios must have spectrum-sensing technology capable of detecting and avoiding ATSC and NTSC (digital and analog television signals), as well as wireless microphones.

MINDING THE GAPS

Teaching smart radio to sense wireless microphone signals

Established techniques exist for sensing ATSC and NTSC, but detecting wireless microphones is more difficult. Wireless microphones can be found anywhere in the spectrum, have very low received signal strength and their transmitter format is not well defined. Moreover, multiple wireless microphones can coexist anywhere in the TV band, explained Harpreet Dhillon, a graduate student on the team. It was also required to detect the exact frequencies of all the wireless microphones present in the said frequency band.

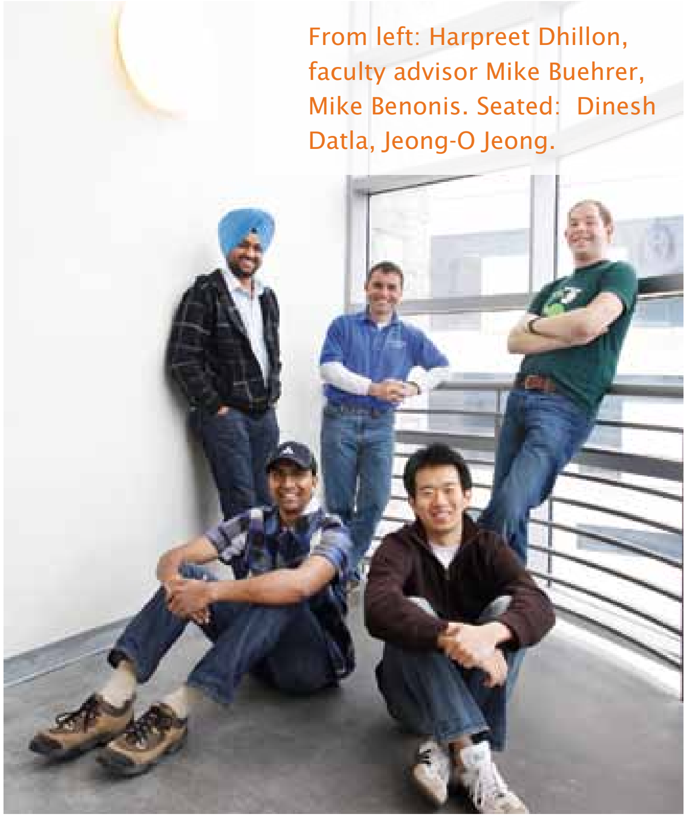
"That was the biggest motivation for Qualcomm to float this competition. They wanted to get different ideas, because this problem is not so straightforward to solve. If it was, of course, those guys would have solved it already," he said.

Dhillon and three other ECE graduate students competed for the $25,000 first prize. Michael Buehrer served as faculty advisor.

Dhillon had participated in design competitions as an undergraduate and found some differences in the experience. "Team spirit was absent in the initial phases of our efforts, because we are graduate students used to working independently on our own research. However, as our work progressed, we developed a unique spirit and sense of responsibility," he recalled.

The team came together serendipitously, with each member contributing a different strength: Jeong O-Jeong acquired the literature, Dhillon developed the algorithm, Dinesh Datla characterized the noise, and Mike Benonis obtained real signals to create an extra data set for the team to test its algorithm.

The students developed a fairly robust solution. They determined a baseline noise correlation matrix from a data set with no wireless microphone signals. To see if a signal is present in a new environment, they compare the new correlation matrix with the baseline matrix using singular value decomposition. If their algorithm determines there is a signal, it calculates the center frequency from the measured auto correlation of the signal.



From left: Harpreet Dhillon, faculty advisor Mike Buehrer, Mike Benonis. Seated: Dinesh Datla, Jeong-O Jeong.

With no deliverables or hardware, the competition did not gather the teams together. The teams were given two data sets: a training set and a test set. When they were ready, they used their algorithm on the test set, which randomized the wireless microphone signals, and sent their results and algorithm to Qualcomm for evaluation. They expect to hear the results of the competition in April.

"It would have been nice to meet the other students," Dhillon said. "When you delve so deeply into an issue, it's always nice to meet other people and see how they dealt with the challenges. But in this case, people don't always want to share their results. They may want to get IP or publish."

Although different from his undergraduate experiences, Dhillon enjoyed the contest. "We had a good team and we appreciated how each person could contribute different skills," he said. He also enjoyed a competition so related to his research. "In school, we develop the strong fundamental concepts. This was an eye-opener that helped me see the industrial applications of our work."

INTERDISCIPLINARY DESIGN

Eclectic projects boost ECEs' adaptability

In a single day, Tom Martin, an associate professor of ECE, might be involved with a laptop orchestra, a fashion show curtain, and an intelligent jump suit. In all these efforts, he's engaging undergraduate ECE students in a world far from engineering.

"The most interesting ideas come alive at the margins between disciplines," he says — and as a pervasive computing expert, much of his work is at those margins.

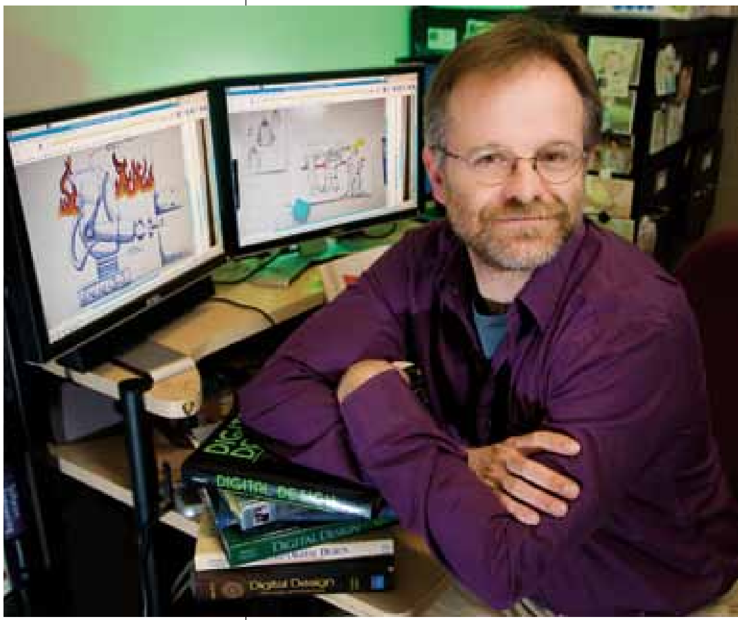
Pervasive computing involves integrating intelligent or "smart" functions into everyday objects and activities. He believes that for ECEs to be successful in pervasive computing, they must break through the cultural mindset of engineering and understand how professionals in business, design, and other fields operate. At the same time, students in other disciplines must be exposed to the engineering processes.

To encourage such cultural breakthroughs, he has a long-standing collaboration with faculty members across the university, from marketing, industrial design, and engineering education, to music and architecture. Each year, he is involved in at least one interdisciplinary design project with industrial design and marketing, plus additional ad hoc teams.

The faculty collaborations with industrial design and marketing first came together on a project in 2006 for a student design contest sponsored by Procter & Gamble (P&G). In 10 weeks, the students were tasked with designing an intelligent product that P&G could sell to elderly customers. The Virginia Tech team was one of four selected by the firm out of 50 submissions.

The team developed a set of products related to pet care. "Studies show that the elderly do better with pets around, but they are at a time in life when caring for pets may be more difficult," Martin says. The students developed the Pet Care Awareness System (PAwS) that would help the elderly remember tasks and assist with some routine aspects.

In the end, P&G did not name a winner from the four teams, but Virginia Tech did well, Martin recalls. "We had people crying at one point during a video the students made showing the elderly with their pets. People were wiping their eyes."



Tom Martin advises a variety of interdisciplinary student design projects. One lesson students learn: how design differs across disciplines.

The P&G team involved 12 students from five departments, including ECE, industrial and systems engineering, marketing, industrial design, and art. A faculty advisor from each department and an advisor from the veterinary school served as mentors.

Working with others from such diverse backgrounds requires bridging cultures, Martin says. "We take these students from different disciplines and they use the same words, but they don't understand what each other is saying. It's like moving to a different country and learning a new language." *(continued on next page)*

(continued from previous page)

He and Edward Dorsa and Ronald Kemnitzer of industrial design decided to coordinate another design project the following year, involving just computer engineers and industrial design students. "We thought that perhaps the P&G experience had too many different types of students and too many cultural gaps to bridge," Martin explains.

The project was part of a special studies course in which 11 CPEs and 10 industrial design students explored pervasive computing for improving safety on construction sites.

"Communications is often more important than the technical aspects."

The laptop orchestra involved embedding six speakers and three amplifiers into a former IKEA salad bowl. The project goal was to get the cost to $700 or below.

For fall 2008, the faculty team wanted to add a business perspective and worked with Eloise Coupey from marketing, who had also worked on the P&G project. We needed marketing, Martin says. He uses the iPod as an analogy for the situation. There were MP3 players before the iPod, and one could argue that they looked cool. The real kicker in the iPod success wasn't the technology, but the business model. Apple's iTunes store, which enabled people to buy a song for 99¢ is a major part of what made the iPod successful, he maintains.

For the 2008 project, seven ECE students, seven industrial design students and seven marketing students developed concepts for making dorm rooms more intelligent for students with disabilities.

"It was important to us to have equal numbers of students from each discipline," Martin says. "That way, the team wasn't dominated by one group or the other. That semester went very well."

The fall 2008 project was also a more formal experience; the team had enlisted the help of Lisa McNair of engineering education to help study and improve the learning experience. McNair found the team some dedicated space, incorporated team-building experiences early on and helped strengthen the communications links between the students from different backgrounds. "For interdisciplinary teams like these, communications is often as important as the technical aspects," Martin explains.

This past fall, 2009, the faculty team tried a different strategy.

CULTURAL DIFFERENCES

Working across disciplines like computer engineering and art is not easy, according to Martin, and the faculty mentors have learned much with each successive project.

"We're trying to break through cultural barriers that get established in the different disciplines," he says. "If we want engineers to be innovators and to help solve society's needs, we need to give students true interdisciplinary experiences."

One of the basic cultural differences between engineering and liberal arts students is the comfort level with unstructured exploration in "wide-open problem spaces," he says. "Ours is a very unstructured process. We start out saying, 'here's the problem area, what are the opportunities to make a new product?'" In his experience, the industrial design students are very comfortable in that situation and the computer engineers much less so. The computer engineers have not had to deal with such a high level of uncertainty before in their classes. "A lot of team building happens during this exploration phase," and getting all the students involved is critical to success, he says.

In most engineering courses, the students are given a specification for a design and told to build something that meets the spec, he says. "We also find that the engineers want to drill down almost instantly and say, 'here's the widget,' when we don't even know yet if that's the right widget to build."

Even the experience of evaluation presents differences, he notes. "The engineers have an expectation of how their grade will be calculated and that grade is important. The firms that recruit engineers have certain GPA expectations and the students want to meet that. Whereas, the industrial design students are building a portfolio and grades are not as important."

The faculty advisors have learned that even the space where the team works is important to a team's success — and that dedicated, unstructured space works best, so team members can leave materials in one place, move around between groups. The faculty team discovered that being in a neutral place was also important, so that one set of students isn't intimidated while the other is comfortably at home.

The first year, during the P&G competition, the team worked in space at the College of Arcitecture and Urban Studies that none of the students had experienced before. The next year, the team

Instead of providing the students with a wide-open space to explore, “we wanted them to redesign the firefighter helmet and bring it into the 21^{st} century. We presented a similar situation to having a customer come in with a specific problem.” The project did not go as well as expected, but the faculty team is reviewing the project to make adjustments for future projects.

The team recently received a $396,000 grant from the National Science Foundation to study and develop improved pedagogical methods for teaching students how to collaborate in interdisciplinary environments. “We started this collaboration because we were interested in working across disciplines,” Martin says. “It’s important for engineers to be well prepared for this kind of work and we’re trying to improve how we teach them these skills.”

In addition to the ongoing annual projects, Martin helps mentor ad hoc interdisciplinary teams. Last summer, he teamed with Ivica Ico Bukvic of the Department of Music, Eric Standley of the School of Visual Arts, and a group of students to develop a laptop orchestra based on Linux. The orchestra, called L^{2}Ork, debuted in December 2009.

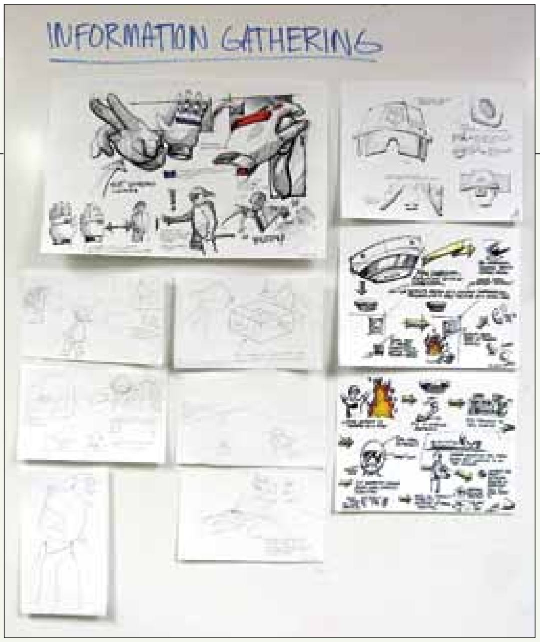
“There are other laptop orchestras around,” Martin says, “but they are goldplated. Our goal was to get the cost at or below $700.” The team used inexpensive notebook computers and IKEA salad bowls that serve as omnidirectional sound sources — each sporting six speakers. The notebooks are networked and the operators use Wiimotes and nunchuks to control loudness, pitch, sound color and more.

Building the speakers was a feat, Martin acknowledges. “Normal amplifiers drive two speakers at a time and we needed to physically fit three amp boards in each salad bowl.” The students formed a production line to build 18 of the speakers and each student learned to solder and desolder in the process.

In another project, for spring 2010, Martin and Paola Zellner Bassett from the School of Architecture and Design are mentoring a team of students who are developing a curtain for a fashion show that will feature lights that track the models on both sides. “The students are using inexpensive strands of LED lights sewn on the curtain fabric,” he explains.

“We still aren’t sure the control system will work,” he says, adding that the faculty advisors get used to not knowing if projects will come together at the end. “We’re as much interested in the process as the result,” he says. “The students still went through a process and if they made progress working across disciplines, then we succeeded.”

started the semester in a classroom with desks. “That really wasn’t working,” Martin says. So in the middle of the semester the team moved to the industrial design studio space in Burchard Hall. “Although it was more open and dedicated, the non-architecture and design students felt less like they owned the space.” The most recent teams have worked in “somewhat dedicated” space provided by engineering education, and although it’s engineering, it’s not the student’s disciplinary home and is serving well as neutral space.



The faculty team has an NSF grant to study and improve how to teach students interdisciplinary collaboration.

It’s not just the students who learn through the team efforts; the faculty advisors also struggle at times with the gaps. “It’s hard as a faculty member. I’m going to walk in each time and have no idea what I’ll be asked or what I’ll be called to contribute.”

It’s also hard to cross disciplines organizationally, he says. “The one time we ran the project as a special studies course instead of independent studies, we decided it was too difficult to develop a single course description that could satisfy both colleges.”

There is a language barrier at the faculty level as well, he notes. “If you really want to watch a fun argument, tell somebody in industrial design that engineers do design,” Martin suggests. “We had to dig way down to reach an understanding on this. The industrial designers are certainly more focused on people than the designers in ECE. But I believe there are good designers in both camps; that good designers have an appreciation for elegance and know how to use just the right amount and not too much. Good designers know that you never get anything for free and they appreciate the right balance of elements to meet a set of design constraints.”

PROMISING POWER

BUILDING AN ENERGY LAB WITH SPARE PARTS AND CREATIVITY

ECE students [and professors] are creating their own outdoor laboratory to study alternative energy issues. With funding from the engineering fee, students in ECE 4304 Design in Power Engineering are pouring concrete to support their equipment, building their systems, and repurposing old technology. A visit to the laboratory reveals a couple of highly reflective parabolas — former satellite dishes that have been converted into solar collectors.

"Students want to do hands-on work with alternative energy," says Virgilio Centeno, an associate professor of ECE and the course supervisor. "We're now giving them the chance."

For several years, student design teams had tried working with solar panels installed at various locations on campus, but had to stop due to safety and access concerns, according to Centeno. This past year, the ECE department was able to allocate some dedicated outdoor space just off campus, with some shared interior space for equipment and other needs.

The first major effort involved renovating and installing an abandoned 3-meter satellite dish for use as a solar collector. A local resident donated the dish, but the students dug it up and installed it themselves. Although the white dish could collect enough energy to boil water, the students installed a reflective film (later upgraded to polished steel) to increase its solar gain.

Professor Tim Pratt, an old hand with using the dishes for communications research, guided the team as it created a system to allow the dish/solar collector to track the sun. The mechanism that moves the dish is powered by solar panels that were donated by the College of Architecture and Urban Studies, so the entire operation uses only alternative energy sources. With the last minutes of sun each day, the dish moves itself back to reset for the next day.

The students have been very enthusiastic about the repurposed dishes, according to Centeno. "There are a lot of abandoned satellite dishes, if we can find a cheap way to reuse them, that's wonderful."

The course enrolls about 20 students each fall and about 30 each spring. The semester-long projects are limited, but many teams choose to build on efforts from prior semesters, or to establish new systems for future classes.

For spring 2010, three senior ECE students are assembling two solar systems. One is a 500W (in midday sun in June) photovoltaic system that charges a battery. Mentored by Pratt, the students are measuring how much energy can be collected by a typical, commercially available photovoltaic system and comparing the cost to electricity bought from American Electric Power (AEP). According to Pratt, "it's usually cheaper to buy from AEP."

The second system is a hot water generator that uses heating tubes and a heat exchanger. Such systems can be used to preheat

Yigit Can Ozen, Michael Brennan, Mark Saunders, and Messeret F. Gebre

Power design students have converted an abandoned satellite dish into a thermal collector that tracks the sun each day. The controller is powered by a solar panel nearby.

water for household use or to heat swimming pools. The hot water can be used to store solar energy for use at night.

Another group of students is studying some of the problems with the solar panels. Dirt and pollen building up on the panels significantly affect their ability to capture energy. One possible way to take care of this is to run water constantly over the solar panels, but the running water also takes energy and needs to be supplied by the panels. This group will soon know if it's worth it.

A third group is working on a solar tower, which operates like a greenhouse to heat the inside air, which then rises through a central chimney to power turbines. Only three of these towers are in use in the world today: one in Spain, one in Australia, and one in Texas.

A fourth project, mentored by Jaime De La Ree, associate professor and assistant department head of ECE, explores the question of whether solar energy needs to be converted into electricity at all. "There is a lot of waste in converting solar energy into electricity and if the end use is something other than electricity, that conversion is wasted," says De La Ree. The students are exploring using the reflective dishes directly for heating and air conditioning, which represent major uses of electricity around the world.

"Converting solar energy into heat is much more efficient than converting it to electricity, which is then converted again to heat," he says. Cooling is a bit trickier. The students are investigating the use of an ammonia-cycle chiller used in off-grid refrigeration systems. When water and ammonia are mixed, heat is absorbed. If the reaction takes place inside a vessel, the outside gets colder and air moving across it gets cooled. For continuous cooling, however, the cycle needs to be repeated.

"We're trying to build a closed system, so we need to boil the mixture to separate it into water and ammonia again." The students are calculating the energy needed for the flame, and seeking ways to increase the temperature without boiling, because of pressure concerns in a closed system. They also are measuring the amount of energy lost as heat on the dish itself. If there is a significant amount, that heat can also be captured and used.

About these projects, De La Ree says, "If it works, great! If not, all our students will still know more about control systems, alternative energy, and thermal power."

AN ARCTIC BLAST

One adventurous ECE Ph.D. student is studying space weather at the world's northern-most university

Above: Nathaniel Frissell in Svalbard. Below: The University Center in Svalbard has about 350 students.

SNAP IT

Get the free app for your phone at http://gettag.mobi

Visit Frissell's blog: *sd-software.ece.vt.edu/svalblog*

Nathaniel Frissell is studying at The University Centre in Svalbard (UNIS), which is located on the Svalbard archipelago, well north of the Arctic Circle.

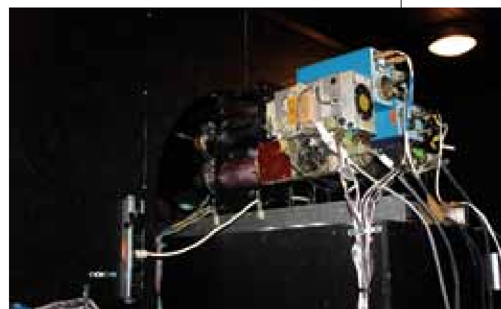
Svalbard is separated from mainland Europe by several hundred miles of the Barents Sea. It is a land of few inhabitants and no trees — but an incredible view of auroras and night-shining (noctilucent) clouds that are the visible effects of space weather.

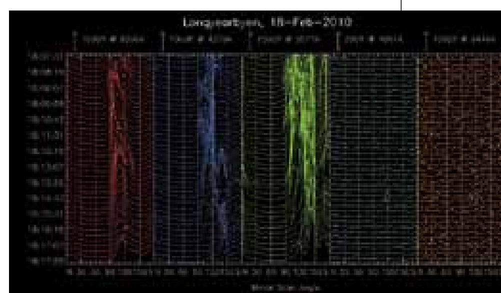
Space weather is the interaction between the solar wind and Earth's magnetic field and upper atmosphere. Scientists and engineers are studying space weather because it can interfere with communications and GPS systems, generate electromagnetic impulses that disrupt the power grids, increase atmospheric drag on spacecraft and radiation damage to spacecraft electronics and increase radiation doses on transpolar airline flights.

The Center for Space Science and Engineering Research (Space@VT) uses satellites, rockets, magnetometers, and radar to study the various aspects of space weather, including the deposition of auroral energy, the motion and redistribution of ionospheric plasma, the formation of irregularities, and other disturbance effects. Tech is the lead U.S. institution on a series of radars that look toward the poles from auroral latitudes.

The Super Dual Auroral Radar Network (SuperDARN) high-frequency coherent scatter radars is an international collaboration that continually maps plasma convection. The specialized facilities at Svalbard include high-power incoherent scatter radar, auroral imagers, an ionospheric heater, and a rocket range. In addition, two SuperDARN radars located in Finland and Iceland have fields-of-view that overlook Svalbard. These tools are necessary to gain a global-scale view of

Left: Skiing during the first week the sun was visible. Top right: Aurora as seen by Frissen. Middle right: The Meridian Scanning Photometer observes the intensity of various colors at different points in the sky. Bottom right: A snøscooteren excursion.





upper atmospheric processes — and Frissell has been sent to Svalbard to learn more. His is the first of what his advisors Joseph Baker and Mike Ruohoniemi hope will be many student exchanges between UNIS and Virginia Tech.

Taking two courses and conducting research with Svalbard's facilities, Frissell is gaining expertise not available anywhere else. Before he could begin his studies, however, he had to complete required arctic survival training that included avalanche rescue and polar bear safety. Roughly 3,000 polar bears live in Svalbard, and one or two enter the town limits of Longyearbyen each year, at which point, writes Frissell in his blog "they often become offerings on the menus of local restaurants. Safety regulations require that no one leaves the city without the protection of a big-game rifle."

In Svalbard, Frissell is working with UNIS Professor Kjellmar Oksavik, investigating pulsations in the electromagnetic field associated with the onset of magnetospheric substorms. "A magnetospheric substorm is the process that causes the explosive brightening of the aurora," he explains. The team uses data from SuperDARN, satellites, and magnetometers located around the world.

"The research is...exciting because you develop a much deeper understanding of an extremely beautiful and exotic natural phenomenon (the aurora), as well as the fact that this work could have a direct impact on life on Earth. The processes and phenomena we are studying affect the operation of communications and GPS satellites, as well as the safety of transpolar flights."

Frissell is taking two courses: one on Radar Diagnostics of Space Plasma and another on the Upper Polar Atmosphere. Instead of being taught by a single professor, a new guest lecturer arrives every couple weeks, allowing students to learn from some of the foremost experts in the field.

As part of his coursework, Frissell spent a week doing fieldwork at the Kjell Henriksen Observatory (KHO). The KHO is more than 1500 ft above sea level and is usually accessible only by belt wagon (a large snow vehicle). "The KHO is home to many different instruments, almost all of which can be thought of as very specialized cameras," writes Frissell. The class helped calibrate three of the instruments. Splitting into two teams, plus a third for a polar bear watch, the students were fortunate to have a night with no moon and little aurora, which would negatively affect the calibration measurements. It was a tricky operation that took nine hours — from 6 p.m. to 3 a.m. Even the simple task of putting a power supply inside one of the instrument huts was unexpectedly difficult: the door lock had frozen shut and the ice had to be melted with a heat gun.

Frissell reports that the cold weather makes life easier in Svalbard. "The weather finally decided to turn cold again today; the temperature is currently -14°C [6.8°F] and the sky is clear," he says one day in his blog. "This makes people much happier, for no one likes warm weather around here. Warm weather means lots of sliding around, difficulty walking, rain, wetness, avalanches, and very limited outdoor activity. With the cold weather, people will return to skiing, snow scootering and the like."

As Frissell says, Svalbard is "the only place on earth that is reasonable for habitation and allows you to observe dayside aurora optically," making it an important research destination for engineers and scientists from all over the world. He writes that the globally diverse group at UNIS "made watching the Olympics a great deal of fun...it was the first time I have ever watched the games with people from so many different countries."

Svalbard is the only place on earth that is reasonable for habitation and allows you to observe dayside aurora optically.

PHOTOS COURTESY OF NATHANIEL FRISSELL

the NEW SOLAR

Making solar energy affordable, efficient & user-friendly

Shocked by the low efficiency and high cost of solar-energy systems, many potential buyers decide to wait till new materials or photovoltaic (PV) technology improve the affordability. Consumers don't realize that with a better power conditioning system, even today's technology can be more affordable, according to Jason Lai, director of ECE's Future Energy Electronics Center (FEEC).

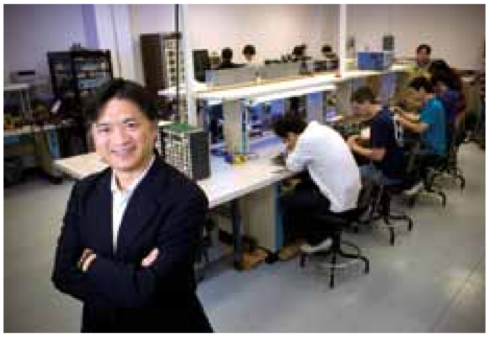
"You buy your panel and power electronics separately," Lai explains. The panels typically run $2 per watt, so the manufacturers try to sell the cheapest control system, typically between 50 cents and $1 per watt. These systems are not designed for efficiency and create much of the operating problems with solar PV systems, he says.

The problems can be significant. Currently, most commercial PV cells are connected in series to get the necessary voltage. So if one cell shuts down, the entire panel shuts off. Shade, clouds, and even bird droppings covering any part of a PV cell can turn off an entire array.

"If power generation suddenly spiked or dropped, because, for example, a cloud passed overhead, it could disrupt some of the existing systems," explains graduate student Chris Hutchens, who works in the FEEC. "You'd be out on a beautiful sunny day and the whole thing would be down. It's as if you flipped on the light switch at your house and caused a blackout in your town," he says.

Opposite page: The FEEC solar shed sits outside the laboratory, serving as a testbed for system designs.
Above: A sunny day finds Chris Hutchens in the solar shed testing the PV conditioning system.
Top right: The prototype FEEC power conditioning system for PV panels.

Lai and his team at the FEEC are trying to solve these problems and capture more energy for the same panel cost — by improving the power electronics system. He and Kathleen Meehan, an associate professor of ECE, were recently awarded a $3.2 million grant from the U.S. Department of Energy's High Penetration Solar Deployment effort. The program's goal is to increase widespread commercialization of grid-tied solar PV systems. The grant is part of the Green Jobs initiative and aims not just at commercializing solar technology, but also at creating domestic jobs.



Nearly two dozen students are involved in the Future Energy Electronics Center, according to Jason Lai (foreground). "Students are very excited about this work," he says.

In order to connect to the 240V grid, a PV system must produce 400V peak. Single solar panels typically produce an average of 20V. Conventional lower-cost systems today stack a number of 20V panels in series to reach the 400V maximum, then use a dc-ac inverter to match the electrical grid. A number of companies are solving this problem by using micro-inverters on each panel to convert from 20V dc to 240V ac, and connecting them in parallel. "These systems solve a lot of the problems," Lai says, "but at a higher cost." He estimates the cost at more than $1 per watt.

The FEEC solution is to install dc-dc converters directly on each 20V panel and then connect the outputs in parallel to a 400V dc bus. Then, just one high-power dc-ac inverter is needed for the entire house to connect to the grid. The result is efficient system operation at a currently estimated cost of 20 cents per watt. "My goal, however, is 10 cents per watt," Lai says.

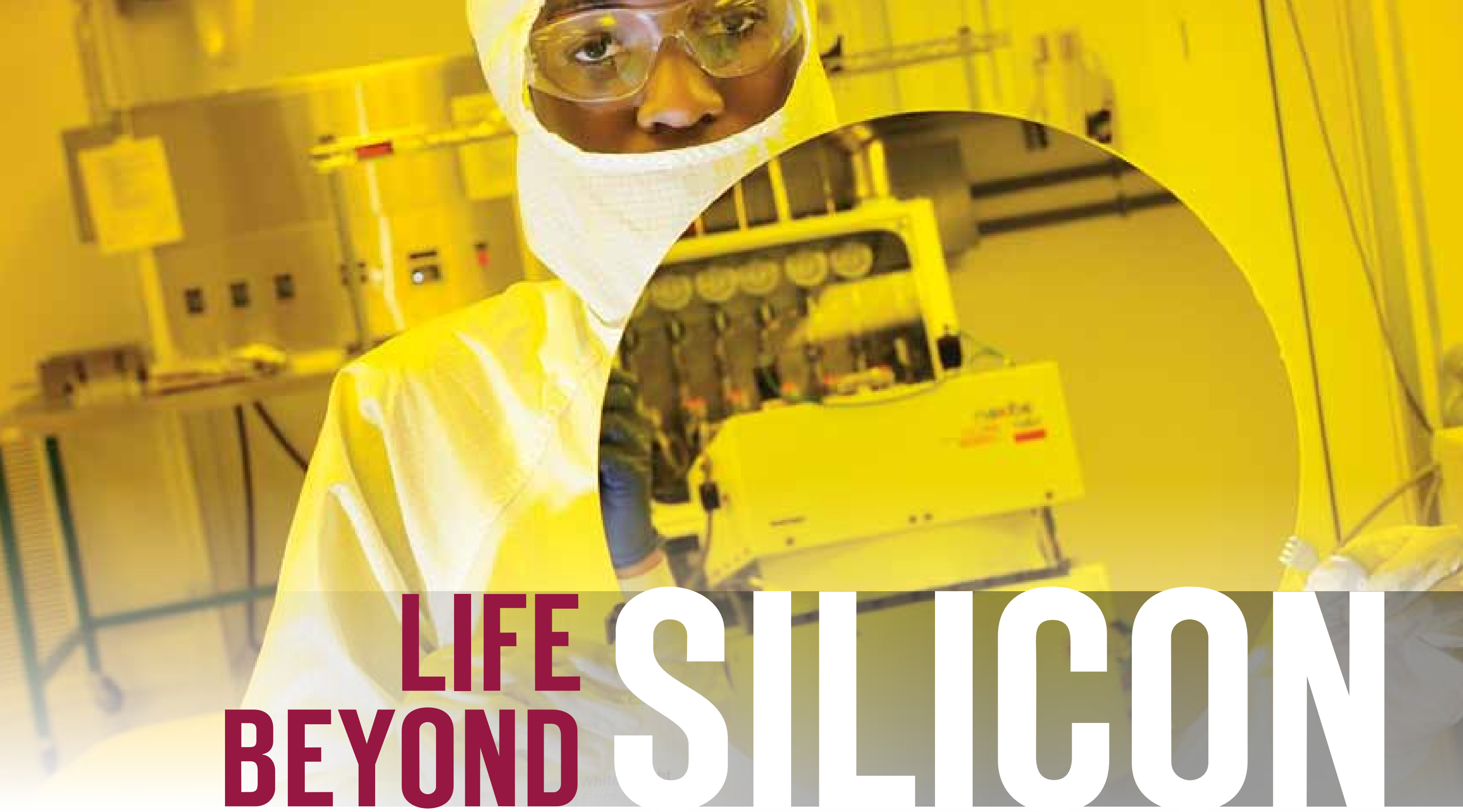
A high switching frequency enables Lai's group to integrate PV panels with a small module that eliminates the need for electrolytic capacitors. Electronics used with commercial solar panels today use electrolytic capacitors for smoothing the dc power. The capacitors, however, are short lived and require expensive maintenance.

The Virginia Tech team is not only lowering purchasing and operating costs, but also providing a solar system for the future. "There is no need to convert to ac at all for most modern appliances," Lai says. "With each conversion, you waste energy." His system will give the option for modern homes to access dc power directly. He predicts that "ac will be obsolete in 100 years," but expects that the first step will be buildings with both ac and dc options.

The team will demonstrate a proof-of-concept in 2011 and is working on IC design and low-cost production. They are also making systems that are consumer-friendly. "We had another project a while back where we told a corporate partner that our system worked," recalls Hutchens. "They came over, switched the power switch on and off really fast for a few minutes and it exploded." Now the FEEC designs everything to withstand significant abuse to make it absolutely hassle-free.

"You should be able to install it in your car or house and it will work for 20 years without any fuel costs and very low maintenance," says Hutchens.

That's good news for consumers.



LIFE BEYOND SILICON

Top: Graduate Student Coumba Ndoye holds a 12-inch silicon wafer being used as a substrate to grow compound materials that could help improve the next generation of semiconductor technology. Above: Mantu Hudait (left) and Marius Orlowski.

The increasing density and speed of today's semiconductor devices has hit the limits of silicon's capability — and a Virginia Tech microelectronics team is developing a technology to not just continue semiconductor miniaturization for logic and memory chips, but also to colocate photonics applications with silicon-based circuitry, including light generation by lasers and more efficient solar-cells. The team's technology vision may open new possibilities of integrating optical and logic functions.

"The half-a-century-old silicon semiconductor technology is running out of steam," comments Marius Orlowski, the Virginia Microelectronics Consortium (VMEC) professor of ECE. "The current industry's trajectory demands to continue the transistor miniaturization to render chips denser and faster. However, currently there is no consensus of how to accomplish this."

Mantu Hudait, who joined ECE in 2009 after serving in Intel's Advanced Transistor and Nanotechnology Group, agrees. "I don't think anyone really knows how we will continue Moore's Law [doubling the number of transistors on a chip every two years] in the foreseeable future where the device dimensions are 15nm or below. Therefore, it is an excellent opportunity to explore new materials and device architectures, innovation for low-power and high-speed logic, memory, photonics and interconnects, all monolithically integrated onto silicon substrate."

Orlowski, Hudait, and Louis Guido are seeking to meet this challenge by synthesizing compound semiconductor materials on a silicon substrate that would take advantage of established silicon technology base as well as of the superior photo-electronic properties of other materials. "Silicon technology has 50 years under its belt and commands an immense infrastructure," Orlowski says. "Circuit design methodology, manufacturing-and-material know-how — the whole industry is geared for silicon… Although we cannot claim we know all the properties of silicon, we know a whole lot about this element. It is probably the best researched element in the periodic table."

To take advantage of silicon technology infrastructure, but add new functions, the team is growing crystals of other so-called III-V compound semiconductors — such as gallium arsenide — on a silicon substrate. Using a process called heterogeneous epitaxy, they are forcing the III-V material to grow in single-crystalline structure on large-area, low-cost silicon wafers.

The challenges of heterogeneous epitaxy involve defects, processes that need to be controlled on an atomic scale, co-integration of heterogeneous technology, and demonstration of manufacturing viability.

Materials are controlled with single atomic layer precision. A key enabling tool for deposition of subnanometer dielectric layers is the so-called Atomic Layer Deposition chamber seen in the forefront.

The crystalline defects arise mainly from mismatch between different crystal lattices and their thermal mismatch, according to Orlowski. When a material is forced onto the crystal template of another, "you are changing the natural distance between atoms, trying to squeeze or stretch a material's structure into different atomic distances," he explains. This puts the new material under compressive or tensile stress and allows this stress energy to accumulate. "The more layers you grow, the more stress energy will be accumulated. In seeking equilibrium configuration, the composite material tries to release this energy in the form of defects. The question then becomes how to confine defects to certain areas and not let them propagate to the area where we want to form transistors that require highly defect-free crystals."

Another difficulty is coming up with an optimal process flow for creating devices with these new materials — the process flow for creating devices in silicon can't be transferred unaltered to this new world. "Our knowledge of these III-V semiconductors must yet catch up with our knowledge of silicon in the next five to 10 years," says Orlowski.

Synthesizing compound semiconductor materials on silicon substrates is a big challenge, he says. "However, if this can succeed, then it opens wonderful new opportunities, such as allowing integration of silicon-based electronics with optical devices." One major limitation of silicon is that it does not convert light well on its own. But with two or more materials on the same substrate, many new applications are possible, such as on-chip lasers for sensors and even efficient solar cells.

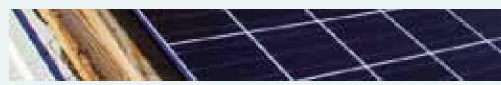
The team is well poised for success, according to Orlowski. "My experience is in the silicon world; Hudait is a specialist in growing III-V compound semiconductors and device structures heterogeneiously onto Si And Ge substrates, and Guido is a specialist in compound semiconductor-based laser and optoelectronic devices. It will take the three of us to realize this vision of bringing the two worlds together. Together we have all the expertise we need to meet this challenge."

LOWER-COST SOLAR CELLS

Success in integrating III-V compounds on silicon substrates can lead to affordable (cost-efficient) photovoltaic (PV) and thermophotovoltaic (TPV) systems, says Mantu Hudait.

"The biggest challenge for PV is drastically reducing the cost per watt to deliver solar electricity." While power electronics researchers at Tech are enhancing conversion efficiency, Hudait is pursuing lowering the cost of highly efficient solar cells.

PV cells are usually made of a stack of up to 10 different materials of which the composition has to be minutely controlled — each being optimal at converting a different part of the solar light spectrum into electricity, he explains. Each layer of a cell, however, adds materials and processing cost as well as manufacturing time. Moreover, any single layer cannot exceed 30-percent efficiency according to the laws of physics as defined by the Shockley-Queisser limit. "Even a hypothetical cell with an infinite number of light-converting layers would have a conversion efficiency just under 70 percent," he says.



"The real question is," Hudait says, "if you want to buy energy, what is its cost per watt?" His solution is to use the compound III-V technology on silicon and to make the layers thinner, and use fewer layers to reduce the cost. "A 10 micron thickness has been demonstrated in the literature to achieve 41 percent efficiency. I propose we build a 5-micron thick active layer and accept 30-percent efficiency. We give up some efficiency for a much lower cost such that solar PV systems can become more acceptable."

Miniature dc-dc converter shrinks 51%

Qiang Li, a CPES Ph.D. student, is working on creating miniature, higher-current dc-dc converters that are suitable for applications such as laptops. Today's dc converters offer a choice of only one out of two options: high power density (W/in^3) or high current (20A or higher).

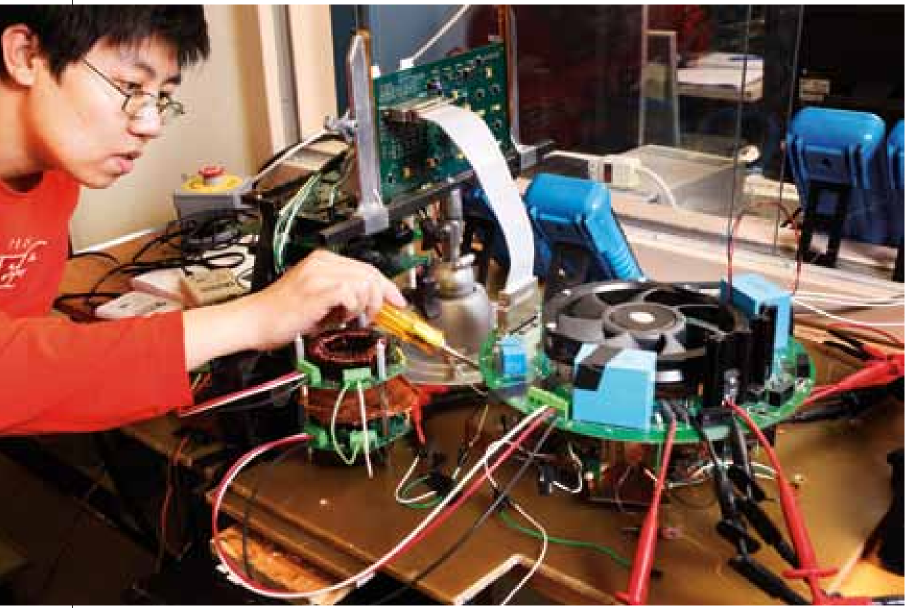
To create a small converter able to handle high currents, Li is adapting the 3-D integration technology currently used in low power converters and the converter is integrated onto a single chip, saving space and increasing power density.

Graduate student Qiang Li with a miniature dc-dc converter

The new converter is embedded as a bare die on ceramic using a "stacked power" packaging technology that offers six times greater thermal conductivity than a traditional printed circuit board. The improved thermal performance of the ceramic leads to an even distribution of temperature, preventing hotspots.

The converter pictured here represents a 51 percent reduction in size from the first prototype developed at CPES in 2006 and a seven-times improvement over industry state-of-the-art. The two-phase, four MOSFET converter produces converts 40A from 5V to 1.2V, coupling together the 20A capacity of each phase. Even at this higher current, the power density is about 500 W/in^3.

SiC switch handles heat 100° higher than silicon



In collaboration with Boeing, CPES researchers have been working on a silicon carbide (SiC) high power density motor drive (HDMC) designed to regulate and control the speed and torque of a motor. It takes in 230V, variable frequency, three-phase ac power, converts it to 650V dc internally, and then outputs up to 10kW three-phase ac to the high density permanent magnet synchronous motor developed in collaboration with the University of Wisconsin-Madison. The team has achieved a very good power-to-weight ratio, exceeding 2kW per pound.

The use of SiC enables the switch to handle temperatures of up to 250°C, 100°C higher than comparable silicon-based technology. The higher maximum temperature means that less space and weight needs to be devoted to heat management, increasing power density and improving the power-to-weight ratio.

Graduate student Puqi Ning

Building a single-phase converter for airplanes

In cooperation with Rolls Royce, the Center for Power Electronics Systems (CPES) has developed a new single-phase ac-dc converter technology with a high-power density suitable for use in airplanes. Although most conventional high-power ac-dc converters are three-phase, airplanes sometimes use multiple single phase converters to enable redundant operation if one should fail. However, standard single-phase converters have a large bulk capacitor to smooth out the natural waveform of single-phase ac power.

To reduce the bulk capacitor size, CPES has added an addition to the converter's output that alternately absorbs and boosts the output energy complementary to the input power pulsation. This active method of ripple power management greatly reduced the total size of the converter, boosting power density.

Graduate student Ruxi Wang

Concentrating gases at the micro scale

Chromatography, the separation of a mixture into its components, is getting small and portable. Masoud Agah's team at the MEMS Laboratory is working with microelectromechanical systems (MEMS) and nano-technologies to implement a vapor preconcentrator. The preconcentrator would become part of a system for micro gas chromatography that has applications in environmental monitoring and homeland security.

In collaboration with Convergent Engineering, Inc., the group is working to develop preconcentrator chips that will enable the production of portable, low-power systems to detect gases using gas chromatography and mass spectrometry. Convergent Engineering intends to use the technology to build a monitoring system to analyze breath to determine the amount of propofol, a common anesthetic, in a person's blood.

CONTROLS

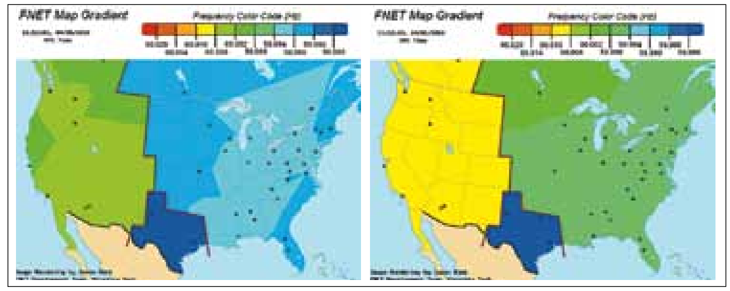
Limited communication and too much noise

How much communication does a task force of vehicles really need to autonomously complete a given mission? The answer is surprisingly small. Dan Stilwell and his students in the Autonomous Systems and Controls Laboratory (ASCL) are developing a new class of algorithms that not only enable teams of autonomous vehicles to cooperate, but do so with as little communication as possible between vehicles.

The researchers are not just developing algorithms, but also testing and perfecting them using Virginia Tech's own fleet of Autonomous Underwater Vehicles (AUVs). The group recently field tested data fusion and motion control algorithms using two Virginia Tech 475 AUVs. Each AUV towed a custom hydrophone array built by Virginia Tech students that measures the relative bearing to a source of acoustic noise. The AUVs maneuvered themselves into the best positions to cooperatively identify the location of an acoustic source. During the entire mission, the AUVs exchanged only a total of seven one-way data packets.

The lab has also developed a new class of extended/iterated Kalman filters that correctly account for state-dependent sensor noise and show significant performance improvement over more typical Kalman filters. These filters are useful for many applications, but were developed to help with the hydrophone array towed by the lab's AUVs. The noise of the sensor depends on the state of the system and this violates the requirements of a typical Kalman filter. "We are very excited that we have actually implemented these ideas on real vehicle systems," Stilwell said. "It is rare and very exciting for new theoretical developments such as ours to be demonstrated in the field, and to have the field trials so convincingly demonstrate the utility of the new theory!"

Using frequency measurements from grid **to analyze audio**



Data from Virginia Tech's frequency monitoring network (FNET), which monitors the entire U.S. power grid, may help improve the analysis and verification of audio recordings.

With the advent of digital recording, forensic methods of examining audio recordings for editing and authenticity need to be updated, according to Richard Conners, an associate professor emeritus and research associate professor. Traditional methods of analyzing analog audiotapes depend on mechanical and physical interactions with the hardware. One of the most promising new methods was first proposed in Europe a few years ago and suggests that the electric network frequency (ENF) can be used to identify location and time, he says.

"It turns out there is a hum that can be detected in recordings," Conners explains, "and it matches the frequency of the grid." The ENF signal is embedded into the audio in recorders that are plugged directly into the wall, as well as in battery-operated devices that pick up the signals from nearby power lines or unshielded electronic devices. Like the frequency of the grid, the ENF signal is a random pattern that varies within a 59.5-60.5 Hz range.

Conners is principal investigator on a $864,000, three-year grant from the National Institutes of Justice to investigate this method. He is working with Yilu Liu of the University of Tennessee-Knoxville, who developed the FNET system while on Virginia Tech's faculty. FNET is a system of 60 frequency disturbance recorders (FDRs) spread across all three U.S. power grids, that uses GPS timing to synchronize data. The FDRs are plugged into standard 120V outlets at universities and offices across the country. Since the units do not need to be installed at substations, FNET provides an independent observation system of the U.S. power grids.

Conners says the team is doing "basic, not applied research: we're figuring out questions such as, can you match patterns, and if so, how long do they have to be?" The team will look into the best methods for extracting the ENF from the surrounding background noise and voice patterns of a recording. Right now, Conners says, every known method exhibits a "tragic flaw" under certain conditions.

The team will identify best practices, in order to show how different techniques might be combined or used depending on the recording's nature and place of origin. Ultimately, the goal is to create a body of evidence, supported by good, peer-reviewed science, that a prosecutor or defense attorney could call upon in a court of law to uphold or disprove the authenticity of recorded audio as evidence. The key focus of the research, Conners remarks, will be improving the "accuracy, reliability, and validity" of the signal processing and analysis procedures.

VT developing smart grid clearinghouse

Virginia Tech has been awarded a $1.25 million five-year contract by the Department of Energy (DOE) to develop, manage, and maintain a public Smart Grid Information Clearinghouse (SGIC) web portal that encourages use of electricity in an environmentally responsible way. Project partners IEEE and the EnerNex Corporation will assist with content, which includes demonstration projects, use cases, standards, legislation, policy and regulation, lessons learned and best practices, and advanced topics dealing with research and development. The award, is part of $47 million in funding under the American Recovery and Reinvestment Act for eight projects to further smart grid demonstration efforts in seven states.

Saifur Rahman, director of the Advanced Research Institute (ARI) in the National Capital Region, is serving as principal investigator (PI) for the SGIC portal.

The SGIC portal is designed to serve as a repository for public smart grid information and to direct its users to other pertinent sources or databases for additional data, case studies, etc. It will facilitate direct sharing and dissemination of smart grid information among various stakeholders on knowledge gained, lessons learned, and best practices. The portal will also serve as a decision support tool for both state and federal regulators in their deliberations for rule-making and evaluating the impact of their investments in the smart grid technologies and software.

"We envision the portal as the essential gateway that connects a smart grid community to the relevant sources of information that are currently scattered and distributed on the worldwide web," said Rahman.

—Barbara Micale

Team seeks MRI-quality grid monitoring

An ECE team led by Arun Phadke is working with Dominion Virginia Power to push power grid monitoring from "X-ray quality to MRI-quality." The $1.5 million project, funded by the DoE, involves synchrophasor technology first built at Virginia Tech.

The research project also involves Quanta Technology of Raleigh, N.C.

"If you characterize the current state of technology for monitoring the power system as an X-ray image, synchrophasor technology will provide MRI-quality data," said Phadke. "Dominion's system is a unique and good proving ground for application of these techniques."

Phadke's work with synchrophasor technology, which provides precise, real-time data on transmission system conditions, began nearly 27 years ago. He invented the key building block of this technology — the phasor measurement unit — and credits the 2003 blackout of the northeast United States for initiating the emergence of this technology.

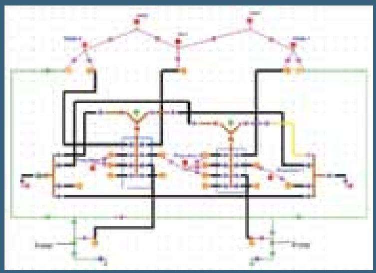
"A smarter, more efficient and reliable electric grid means better service for customers, benefits for the environment and lower costs in the long run," said Dominion Virginia Power Chief Executive Officer Paul Koonce. "What is particularly appealing about this technology is that it can be applied to our existing transmission network, not just new projects."

The new technology provides grid operators with the ability to better foresee, prevent and manage potential overloads on the grid, and route power more efficiently. This enables maximum efficiency and reliability for Dominion's transmission grid.

Graph trace analysis for power system design

Robert Broadwater and his students are adding capabilities to a power distribution system design program called Graph Trace Analysis (GTA). Modeling power grid systems in Graph Trace Analysis (GTA) to determine priorities in electrical failure, Ph.D. student David Kleppinger is developed a new notation to write algorithms in GTA that are independent of the systems being analyzed.

Ph.D. student Lynn Feinauer developed an object-oriented framework for GTA such that the object is the engineering algorithm. These new capabilities extend the use of GTA and are applicable for many applications.



Synchrophasors monitoring grid, preventing blackouts

ECE researchers garnered two of only four stimulus grants from the Department of Energy (DOE) to modernize the power grid. The awards, totaling $2.6 million are headed by James Thorp and Arun Phadke.

Collaborators for decades, Thorp and Phadke have developed a number of advances that strengthen the electric utility industry's ability to prevent power grid blackouts, or to make them less intense and easier to recover from. According to the DOE, Phadke and Thorp's newly funded work will now advance technologies that rely on the exchange of synchrophasor data among electric utility companies and other electricity entities.

Synchrophasors are high-speed, real-time synchronized measurement devices used to diagnose the health of the electricity grid. With synchrophasor data, electric utilities can use existing power more efficiently and push more power through the grid while reducing the likelihood of power disruptions like blackouts.

This new research will build upon a recently completed three-year project funded by the California Energy Commission through the Public Interest Energy. Its findings indicated the use of wide area synchrophasor measurements in electrical power systems can be of significant value to power companies. These measurements can reduce the likelihood of false trips by protection systems and lessen the likelihood of contributing to a cascading effect.

Thorp's team will develop and demonstrate tools using synchrophasor measurements to reduce the likelihood of false and inappropriate triggers of transmission system circuit breakers that protectively shut down electrical flow and contribute to cascading blackouts.

Members of the team include colleagues from Pacific Gas and Electric Co., Oakland, Ca., Southern California Edison, Rosemead, Ca., San Diego Gas and Electric Co., San Diego, Ca., Mississippi State University, the California Energy Commission, Sacramento, Ca., and Quanta Technology, Raleigh, N.C.

Phadke's team will develop analytic tools and calibration techniques for measurement devices to implement an innovative synchrophasor-based tracking system to monitor the state of the electric grid. The techniques will better diagnose the sources of network unbalances and identify actions needed to remedy them.

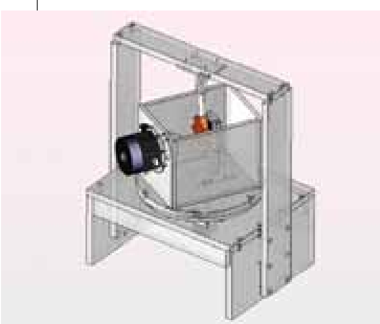
His project team includes researchers from Dominion Virginia Power, Richmond, Va., and Quanta Technology, Raleigh, N.C.

Virgilio Centeno is working on both projects.

–Lynn Nystrom

New ultrasound technology shows promise

Ultrasound imaging has become one of the most widely used medical imaging technologies for diagnostics and guiding images for surgical intervention because of its high portability, non-ionization, non-invasiveness and low cost. Standard ultrasound systems (B-scan) use the reflection of sound waves to produce images of what lies beneath the surface of an object. However, due to constructive and destructive interference of echo signals, significant speckle patterns have been the limiting factor on the image quality and broader use of conventional ultrasound.



Projection ultrasound system design

Chu Chuan Liu and his advisor, Yue (Joseph) Wang, are using a novel, two-dimensional, ultrasound sensor from Imperium, Inc. to investigate a projection ultrasound system (C-scan).

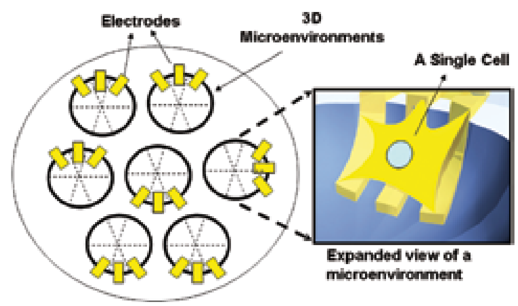
C-scan operates much like a conventional X-ray system in which a source transmits signals through the object that are recorded by a sensor on the opposite side. This configuration eliminates the speckle problem of B-scan systems and enables the use of computed tomography (CT) algorithms for generating three-dimensional images as in an X-ray CAT scan. Medical applications in biopsy monitoring, foreign object detection, real-time imaging and mammography have been explored with the experimental system, yet with promising results.

Catching cancer cells — on a chip

For many forms of cancer, including breast cancer, the cancer cells have spread throughout the body before a primary tumor can be detected. Detecting it early, therefore, is vital for high survival rates.

Masoud Agah is leading a project to make this possible with an NSF interdisciplinary research (IDR) grant — the first at Virginia Tech. The grant is for groups requiring specialized knowledge in multiple areas, and the NSF hopes that the IDR grants will pave the way to new fields of research.

Using breast cancer as their model, Virginia Tech's group is developing a microchip that detects the presence of even a single cancer or precancerous cell among a population of primarily healthy cells. Agah explains that the chip will "exploit changes in the biomechanics and bioel-ectrical properties that occur in cells as a result of progression to a cancer state….[it] combines the information from two different domains (mechanical and electrical) to diagnose a cancer or precancerous state."



The chip works by allowing cells to adhere to the surfaces of the chip. Healthy cells will adhere mostly to the flat surfaces, and cancer cells will adhere to the microengineered portions. Because it operates under static conditions, the chip does not require extra devices such as pumps or valves.

ECE imaging researcher Chris Wyatt has collaborated with Dr. Ge Wang in the School of Biomedical Engineering and Sciences to build the new SBES Multi-scale Advanced CT (SAM-CT) facility, located at the Nano Characterization and Fabrication Laboratory in the Corporate Research Center. The facility brings together various state-of-the-art CT scanners under one roof, allowing the user to acquire CT scans at various spatial resolutions — ranging from mm to 50nm. This unique combination of equipment allows the development of multi-scale methods in biological phenotyping, material characterization, and geological applications.

ECE team part of new systems biology cancer center

ECE faculty members are part of a new $7.5 million Center for Cancer Systems Biology that is investigating the development and treatment of breast cancer, with a specific focus on the estrogen receptor in breast cells.

This protein determines which women will develop the most common kind of breast cancer and how they will fare during their treatment. The ultimate goal of the center, which is funded by the National Cancer Institute (NCI), is to develop more advanced and better-targeted treatments for the disease.

The new center is part of NCI's Integrative Cancer Biology Program, which is the NCI's primary effort in cancer systems biology, a field that is rapidly seen as an essential component in the future of cancer research. The center is lead by researchers at the Lombardi Comprehensive Cancer Center at Georgetown University Medical Center, who are providing the experimental expertise. ECE's Yue (Joseph) Wang and Jason Xuan of the Advanced Research Institute in Arlington, are providing the bioinformatic analysis of the data; and ECE's Bill Baumann and John Tyson of biology will build the mathematical models. Guided by the experimental findings and the predictions of the mathematical models, researchers at Fox Chase Cancer Center of Philadelphia will test what happens when specific genes and proteins are knocked out.

Burning cancer with fiberoptic microneedles

ECE assistant professor Yong Xu is on a team that is working on an minimally invasive technology for laser-based photothermal therapy. Currently, laser therapies are limited by the difficulty of getting high doses of light into deep tumor tissue while avoiding injury to nearby healthy tissue. Xu and his team have invented a fiberoptic microneedle device (FMD), which enables what Xu calls "a new regime of minimally-invasive therapeutic procedures." The FMD is comprised of one or more optically transparent glass fibers guided into a patient's tissue by a novel elastomeric support ferrule," explains Xu. Each fiber is tapered to a needle point and is only 40 microns in diameter. This allows the needles to penetrate the skin painlessly, "similar to the dynamics of a mosquito bite."

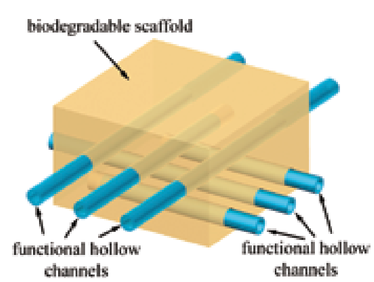
Microneedle penetration of ex vivo porcine skin.

The team also envisions several additional applications of the device. By using hollow fiber tubes, nanomaterials or drugs can be inserted to a target site. It will be possible to deliver chemotherapy directly to a tumor, rather than run the risk of introducing it into the patient's whole system. Before treatment, the microneedle device also can be used to detect and identify cancer. Xu is working with Chris Rylander and Nichole Rylander of SBES on the project, which is funded by the NSF.

'Holey scaffolds' under development for in-situ imaging, drug delivery

An ECE/School of Biomedical Engineering Sciences (SBES) team is building a first-of-its-kind engineered platform to perform real-time imaging of tissue regeneration at the cellular and molecular levels. Called "holey scaffolds," the environments are based on a novel combination of fiber optics and tissue regeneration technology.

"Despite their complex 3-D structures, tissues and organs are primarily studied using highly invasive 2-D in vitro techniques, such as biopsy and histology that can only provide limited information at a few discrete time points," says ECE's Yong Xu, who is principal investigator on the effort. In contrast, the holey scaffold technology will provide real-time, 3-D information on the complex biological processes involved in regenerative medicine. Holey scaffolds will initially be tested for bone-regeneration, but have wide-ranging potential in the medical field. The project is funded by Virginia Tech's Institute for Critical Technologies and Applied Science (ICTAS). SBES faculty members on the team include Ge Wang, Joseph Freeman, Nichole Rylander, and Chris Rylander.



Optically monitoring fumes from steel welding

The Center for Photonics Technology (CPT) is developing fiber-optic-based technology to monitor welding fumes in real time.

Welding fumes are one of the major health hazards for construction workers, according to the National Occupational Research Agenda. Prolonged exposure to welding fumes may lead to respiratory illness and increase the risk of lung cancer. With current technology, detecting dangerous levels of these fumes is time-consuming, and requires first collecting a sample and then analyzing it.

Yong Xu and Anbo Wang are working with Zhiwen Liu of Penn State to develop a system to continuously monitor sites for harmful levels of fumes. Using a novel combination of fiber technology, optical spectroscopy, and signal processing, the team plans to capture the optical signatures of welding fumes, allowing them to develop cost-effective systems for monitoring these fumes on-site.

The project is funded by the National Institute for Occupational Safety and Health.

Propagation model may help police quiet zone

while boosting access to wireless services

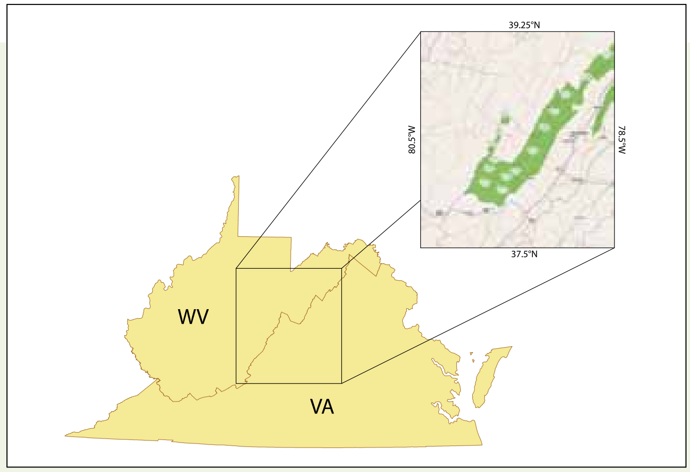
An ECE propagation model that incorporates variations of terrain may provide the precision needed to improve both the protection of the National Radio Quiet Zone (NRQZ) and residents' access to wireless services.

The NRQZ spans a region in West Virginia and Virginia that surrounds the Green Bank National Radio Astronomy Observatory (NRAO). Radio signals that could cause interference to the radio telescopes are considered illegal — including wireless Internet networks that leak outdoors and even cellular phone service to a ski resort.

Improved propagation models would enable better predictions of interference, possibly leading to some relaxation of limits in specified locations, according to Gary Brown, director of the ElectroMagnetics Interactions Laboratory (EMIL). "With more accurate models, those policing the quiet zone may be able to allow more powerful signals in certain situations." The EMIL team recently developed a computationally efficient method to model how terrain affects communications signals and other electromagnetic waves and is working with NRAO engineers to validate and improve the model.

The EMIL models integrate along the whole path instead of just working with certain data points, as done in commercially available models. The data is still only taken at certain locations, but generating a set of random curves to connect those points introduces error from which they can generate a standard deviation.

"We've got the topographical modeling down, now we're working on incorporating the electrical conductivity of the soil," he says. "It turns out that the earth is not a perfect conductor, which must also be taken into account for predicting the behavior of radio waves."

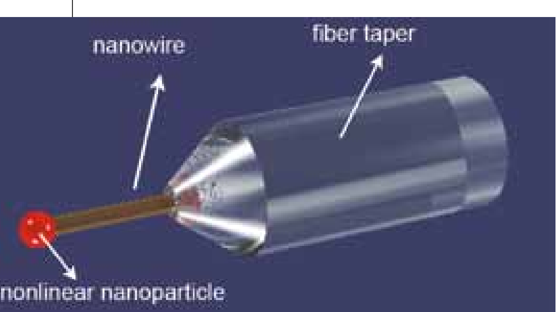


The National Radio Quiet Zone, established in 1958, covers approximately 13,000 square miles of land spanning the border between Virginia and West Virginia.

Brown and his team have been taking measurements at Green Bank and in the surrounding area to validate their model. "We aren't trying to fit the existing data," he explains, "but see how the new models compare to the old. We want to be able to accurately predict a signal from point A to point B."

Policing the quiet zone isn't the only application of the new propagation research. Naval vessels moving in the littoral zone, where the land meets ocean would also benefit from knowing how signals are traveling across land, he says. Another application would be for cognitive and smart radios; if they could predict the necessary signal level, they could conserve power.

The effort is funded by the Naval Surface Warfare Center, the NRAO, and the Army Research Office.



Measuring the nanoscale characteristics of ultrafast optical pulses

Ultrafast optical technology, which involves the generation of optical pulses measured in femtoseconds, has emerged as the natural complement to nanotechnology. There's only one hold-up in integrating the technologies: the nanoscale characteristics of ultrafast optical pulses can't be fully measured.

Although optical imaging can attain resolution on the scale of 50 to 100 nanometers, and characterization tools can characterize ultrashort optical pulses as short as a few femtoseconds, no way exists to observe all three dimensions of an ultrafast optical pulse at the nano scale without disturbing the pulse's operation.

Yong Xu is working with Zhiwen Liu of Penn State to develop a nanoprobe to solve the problem. The probe, which consists of a nanoparticle attached to a silica fiber by a nanowire, will be able to sense both the temporal and spatial characteristics of an ultrashort optical pulse. Because the sensor itself is at the nanoscale, it produces a minimal amount of optical scattering and does not disturb what it observes.

The research is funded by a $300,000, 3-year NSF grant.

Space@VT building chain of instrument stations in Antarctica

Members of the Space@VT research group are receiving a $2 million grant from the NSF to build a chain of space weather instrument stations in Antarctica. Space weather affects a variety of everyday consumer technologies including global positioning systems GPS, satellites for television reception, and cellular phones. Also, the understanding of space weather is critical to space programs.

The northern hemisphere is already well instrumented as a number of stations currently exist in the Arctic, including an array in Greenland. But due primarily to the "extreme Antarctic climate and lack of manned facilities with the necessary infrastructure to support facilities, the southern polar region is not," said Robert Clauer, who is leading the effort. Data from the southern magnetic field is weaker than the northern magnetic polar field because its "magnetic dipole is offset from the center of the earth and tilted," he explained.

The research team also includes Joseph Baker, Tamal Bose, Majeid Manteghi , and Brent Ledvina of Coherent Navigation.

—*Lynn Nystrom*

Modeling how geomagnetic storms heat the ionosphere, create satellite drag

Geomagnetic storms generate a changing heat pattern in the upper atmosphere, which creates a drag on low-orbit satellites and debris. ECE's Dan Weimer wants to better predict this drag through improved models and has been awarded a three-year, $375,000 grant from NASA to support the effort.

The interaction of solar wind with the Interplanetary Magnetic Field (IMF) causes significant energy transfer to the ionosphere at high latitudes. "This leads to added heat in the upper atmosphere and thermosphere, the same interaction that is associated with the aurora," he explains. In major geomagnetic storms, this heating causes low-altitude satellites to experience a higher drag force, which results in problems with their tracking, he says.

Weimer is comparing the heat flowing into the thermosphere from different sources. He is focusing particularly on the change in the global temperature of the thermosphere during geomagnetic storms. He also will be improving the empirical models that calculate the ionospheric electric fields and currents. The thermosphere is the part of the upper atmosphere above 90 km (56 miles) where the temperature rapidly increases from -170°F to more than 1200°F, due to heating by solar ultra-violet radiation.

Long Wavelength Array

A large radio telescope that is expected to eventually span a 400-kilometer region of New Mexico is under construction to study interstellar and intergalactic events as well as turbulence in Earth's ionosphere.

ECE's Steve Ellingson, Cameron Patterson and Majid Manteghi are working with researchers from the University of New Mexico, the U.S. Naval Research Laboratory, and NASA's Jet Propulsion Laboratory to build a number of array stations distributed across New Mexico. Each station will consist of 256 pairs of dipole-like antennas that operate over the frequency range 10-88 MHz.

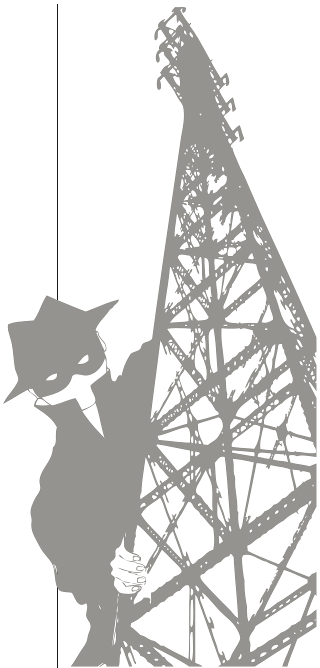
The outputs will be sent to a central location where they will be correlated to form images using aperture synthesis techniques. With an estimated image sensitivity of a few millijanskys (1 millijansky equals 10^{-29} watts per square meter per hertz), the angular resolution and sensitivity of the LWA should be comparable to existing instruments operating at shorter wavelengths.

Existing arrays built on previous technology are very narrowband, whereas LWA is very broadband, Ellingson noted. "That's enabled by a better antenna design combined with better analog electronics," he added.

The team's goal is to build 53 array stations, but to date, two stations have been funded and funding is projected for two more. Virginia Tech's team, which built and operated a similar, but smaller, telescope near Asheville, N.C., is focusing on the LWA's calibration, data recording, transient detection, and monitoring and control systems.

COURTESY OF J. CRAIG, UNIVERSITY OF NEW MEXICO

For more information, please visit:
lwa.unm.edu



Wireless network fingerprints technique helps identify location spoofers

Pervasive wireless networking, while convenient for users, presents an ever-increasing attack surface for hostile hackers. Attackers may try to misrepresent or hide their own location, or modify, forge, hide, or steal the location information of legitimate users.

Although much research has gone into improving location systems for legitimate use, relatively little has been done on detecting and countering attackers, according to Jeong Lee, who, with his advisor, Michael Buehrer, has developed new detection and positioning techniques.

Lee's work focuses on detecting and localizing spoofing attacks — those who disguise the source of their signal and thus their position in the network. Lee described two possible methods of forging an attack location: signal strength attacks, in which the attacker falsifies information about his transmit signal strength; and beamforming attacks in which attacker's antenna radiation pattern and strength are controlled as desired to one or more specific receivers.

Standard localization methods assume that network clients are truthful in the information that they provide about original signal strength and other location parameters, and so are unable to counter such attacks effectively. Other techniques have been proposed to detect and localize an attacker using signal strength only, but they rely on expensive or time-consuming research into an area's radio map or other pre-established statistical information. Moreover, the previous methods cannot deal with beamforming attacks and mobile attackers.

Lee's and Buehrer's solution is based on examining relative location error, rather than its absolute value. It relies on a set of new statistical and pattern matching algorithms based on normative signal strength data. Called "topological residual fingerprint matching," the technique is able to successfully identify attacks in progress, without any specific location or map information necessary. They also suggested a novel technique for tracing the forged signals back to their real location against both signal strength and beamforming attacks.

The work is funded by a $231,000 NSF grant, with Yaling Yang as principal investigator and Buehrer and Jung-Min Park as co-investigators.

Undergraduates experience **wireless research in REU program**

Each summer, 10 undergraduate students from Virginia Tech and elsewhere have the opportunity to work in Wireless@VT laboratories and engage in cognitive communications research. The opportunity is part of the NSF Research Experience for Undergraduates (REU) program.

Helping faculty members with ongoing research projects, the students spend 10 weeks receiving instruction on and researching the various aspects of cognitive communications, including software defined radios, cognitive radios, wireless networks, wireless communication circuits, and human factors engineering in communications.

The researchers are mentored by Tamal Bose and other faculty members of Wireless@VT. They will have weekly individual and group meetings in which they will report on their research and plans, and present short papers on the aspects of the research they find most interesting.

Students gain hands-on experience in the field and develop research and teamwork skills. Most importantly, students will play an active role in furthering meaningful research in cognitive communications.

Signal propagation in deep foliage

Haris Volos (left) from Wireless@Virginia Tech and Chris Anderson of the Wireless Measurements Group at the U.S. Naval Academy are working on characterizing the signal propagation of Ultra Wide-Band (UWB) signals in forest environments. The results from these measurements are expected to enable the development of UWB devices for applications such as: environmental monitoring, wildlife tracking, position location, and search-and-rescue operations.

VT cognitive radio technology to help improve railway communications,safety

A Wireless@VT research team is adapting Virginia Tech cognitive radio technology to improve safety and operations of the nation's railways.

The effort is funded through the Federal Railway Administration's Office of Research and Development and dovetails with the Positive Train Control (PTC) technology being implemented under the U.S. Rail Safety Improvement Act of 2008. PTC is expected to be implemented by 2015 and to include wireless communication and GPS navigation throughout the rail system.

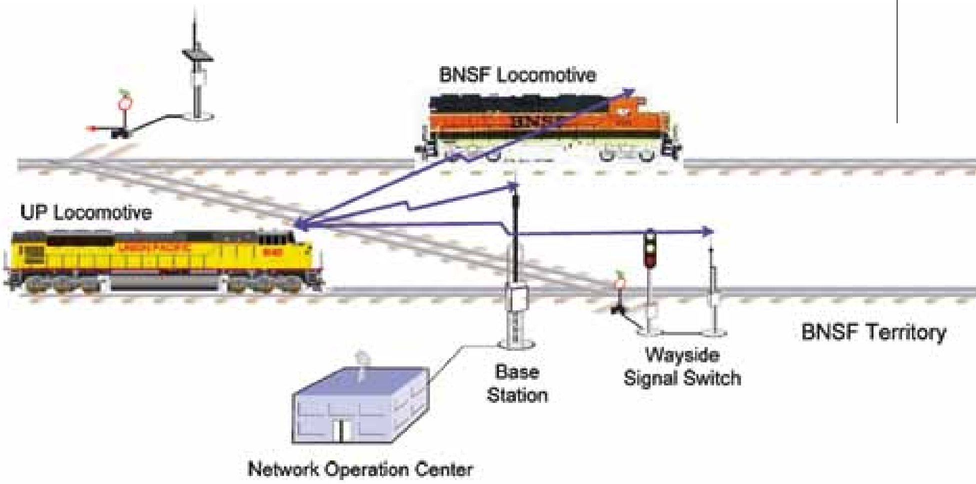
Under a PTC system, trains are expected to communicate with a base station and control center when they enter a rail yard. Using the highest bandwith available, a train would download the data regarding up-to-the-minute status in the yard. While traveling, trains will communicate with wayside wireless stations — delivering information about their location, speed, and direction, while acquiring information about the situation ahead and where they are allowed to travel.

Wireless communication with trains can be challenging, acknowledges Ashwin Amanna, a senior research associate and the project's principal investigator. Not only is the train's situation constantly changing, but so is the communications environment, with changing noise, multiple sources of interference, potential for multiple users contending for limited spectrum, and unpredictable usage by the users, he says.

"The railway industry is starting to use software defined radios (SDRs) that have a reconfigurable platform capable of condensing multiple radios into a single unit," he notes. "A railroad-specific cognitive radio (Rail-CR), however, would incorporate additional adaptation to mitigate crowded spectrum, intentional jamming or learn from past experiences."

The ECE team is developing a cognitive engine that uses AI tools such as case-based reasoning and optimization algorithms. The cognitive engine will also incorporate a policy engine that would prevent the radio from operating outside the policies of the area. "This is particularly important when a train runs along the border of another state or country," Amanna explains.

The resulting cognitive engine will be provided open source for easy integration with any software defined radio. Amanna is working with Manik Gadhiok, Matthew Price, and co-principal investigator Jeffrey Reed on the Rail-CR effort. The research team is integrating the software-based cognitive engine with a private partner's railway specific SDR.



Center for Intelligence Community

An ECE team is partnering with Howard University to establish an Intelligence Community Center for Academic Excellence. The initial award is $1 million, with an optional extension. Jeff Reed heads the effort and Tamal Bose and Ashwin Amanna are on the leadership team. This is one of the few such centers with an engineering thrust.

While engineering oriented, the program strives for cross-disciplinary involvement, and students from all majors who have an interest in pursuing national security careers can reap benefits.

The Intelligence Community sponsors the creation of these centers at academic institutions to promote the alignment of curricula (for example, scientific and technical programs of study, international relations, foreign language/cultural immersion) in "an effort to carry out America's national security imperatives over the long term," according to its call for proposals from universities.

The initial award is for $1 million over two years with an optional three-year extension for a total of $2.5 million over five years. Virginia Tech and Howard will split the resources.

Reed credited the coordinated efforts of Wireless@VT, the largest wireless communications/networks research center in the nation, as appealing to the IC community. "We have encompassing expertise in critical IC focus areas such as wireless communications, computer networks, antenna design, microelectronics, system integration, spectrum policy/economy, and very large integrated circuitry," Reed said.

–Lynn Nystrom

Orchestrating the end of manual network design

Yaling Yang, Michael Hsiao, and Luiz DaSilva are building a new open architecture to revolutionize the way network engineers design, test, and create protocols for routing traffic over a network. The new architecture, Orchestra, will be able to automatically assemble and test a great variety of routing designs.

Traditional routing systems have been designed manually by network engineers, based on complex collections of objectives, policies, principles and past experiences. Due to limited human experience and capability, this design process severely impedes the evaluation and dissemination of routing research results, Yan says.

In contrast, Orchestra will store a large set of reusable "genes." Each gene is a small piece of code that implements a particular design for a small component of a routing system. The correctness of the "genes" and their mutual compatibility are automatically verified. Orchestra assembles various routing systems from verified "genes" and then tests them, first in a simulation, then in a real network. Based on the performance of the assembled protocols, Orchestra uses evolutionary algorithms to switch and tune designs of routing components to eventually identify the best design for a network setting.

"Orchestra will greatly ease a network engineer's burden of implementing and evaluating an entire routing system, since it can efficiently explore a much larger design space for routing systems than any single network engineer, " Yang says. Orchestra will offer the potential to explore new territory and create routing designs that no human has ever considered. The large collection of component designs in Orchestra will also provide a common platform for comparing and evaluating different design choices.

ECE's undergraduate curriculum will also benefit from the project. The faculty members plan to develop a new networking lab course in which students design, implement, and test real network testbeds.

Orchestra is funded by a $150,000 grant through the NSF NeTS program. Yang is the principal investigator, and Hsiao and DaSilva are serving as co-principal investigators.

FINS to accelerate deployment of seamless mobile networks

Virginia Tech ECEs are developing a framework that is expected to bring closer the day when iPhones, Blackberries, laptops and other mobile devices can talk to each other effortlessly, anywhere in the world.

This communications ability will involve mobile devices sending data through each other, without relying on fixed transmission points like cell towers, according to Allen MacKenzie.

Unfortunately for mobile, ad hoc network (MANET) technology, existing network frameworks are based on the assumption that there will be stable routes and established nodes, like cell towers. "Mobile networks invalidate this assumption and throw traditional routing techniques into disarray," MacKenzie explains.

One of the biggest hassles for researchers is making major modifications to networking software: the software protocols controlling networking (the "stack") are layered deep within computer operating systems. Even tinkering with a single setting can require a complete rebuild of the computer's master program – the kernel. At present, no replacement for the traditional, fixed network stack is available, according to MacKenzie.

MacKenzie and Luiz DaSilva have been awarded a $350,000 NeTS grant from the National Science Foundation (NSF) to develop a framework for modular, extensible, experimental network technology.

Their Flexible Internetwork Stack (FINS) Framework will leverage existing protocols, and give researchers real-time control and easy access to data.

FINS will be implemented on hand-held devices, which have the advantage of longer battery life. The team is building the improved hand-held communications technology based on their experiences in deploying large, laptop-based MANETs as part of the MANIAC Challenge.

DaSilva and MacKenzie organized the MANIAC Challenge under a prior NSF NeTS grant. In MANIAC, teams formed an ad-hoc network with each team representing a node in a MANET. Organizers generated data packets destined for each team. Teams were judged according to how many of the packets destined for them they received. To receive a packet, they had to balance selfish interests with cooperation and get other teams to forward their packets from node to node by offering to forward other packets in return.

For the competition, organizers had to modify routing behavior in the networking stack to allow participants to view packet headers and data and to make per-packet forwarding decisions based on their strategy. It was difficult to obtain even partial data without access to all the network layers.

FINS will resolve these issues. DaSilva and MacKenzie plan to spur adoption of the framework by organizing a new design competition using FINS. They will also release networking course modules based on the FINS Framework.

The FINS framework will be openly shared, allowing researchers throughout the world to expand their experimental work and build more robust network models.

FINS will also be understandable to researchers with less experience in the field. This will dramatically improve the ability of undergraduate students, novice graduate students and students enrolled in networking courses to "play" with the network stack. "We want undergraduates to be able to play with the technology: play is critical for developing understanding and innovation," MacKenzie says.

Custom radio on demand

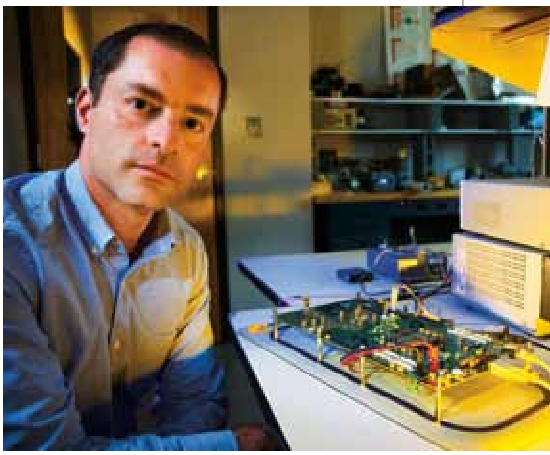
Researchers in ECE's Configurable Computing Laboratory have developed a RapidRadio framework that helps a user configure a radio receiver on the fly, based on a set of signal characteristics. The framework has potential for applications that must classify transmitters with unknown modulation types, such as cognitive radios trying to avoid interference, or signal intelligence users attempting to become silent third-party "listeners."

RapidRadio divides the radio creation into two phases: the analysis phase and the synthesis phase, according to Adolfo Recio, a Ph.D. student who developed the system with Jorge Suris (Ph.D. '09) and Peter Athanas. "The framework guides the user through the process of determining the modulation type of an unknown signal, and then builds an FPGA-based receiver capable of demodulating that signal," he explained. "The user needs only to be concerned with some of the signal analysis activities, and the framework will automatically identify the parameters of the physical link layer and build a receiver for it in a short time."

The system, Recio emphasized, allows a "human in the loop." The operator reviews the framework's decisions and "if the user sees something obviously wrong, he or she can override that decision and have the framework do something else, or augment the modulation scheme database," he said.

FPGAs are excellent candidates for receivers, but because of their complexity, designers have traditionally used them to implement only what is absolutely necessary and resorted to high-end processors for important parts of the signal processing, he said. "Off-loading the signal processing tasks from the processor permits a better workload distribution and enhances the overall performance."

RapidRadio can abstract away most of the system architecture because of its radio component database and the use of a platform-independent XML-based radio description file. "A goal of the RapidRadio framework is to reduce the amount of FPGA knowledge necessary to create a system." Preliminary tests were successful, transmitting and receiving signals using the BPSK, QPSK, 16QAM, and 32QAM modulation schemes, which encode 1, 2, 4, and 5 bits of data into a single radio symbol.



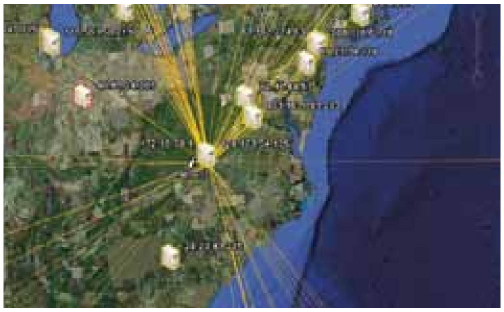
Adolfo Recio and the RapidRadio framework.

The framework successfully validated the signal constellation, reprogrammed the FPGAs appropriately, and properly resynchronized and received the transmitted symbols.

The team is building an Internet-controllable LEGO robot that carries an electromagnetically reflective foil shield to test the system's ability to deal with channel attenuation and multipath. The project was supported by Harris Corp. and earned a Best Paper Award at the 2009 International Conference on ReConFigurable Computing and FPGAs.

Coping with information overload

Information overload is the number one issue facing analysts who must monitor large amounts of data, according to ECE's Joe Tront, who is working on a team to create a visualization system for data management. "Most people simply discard portions of the information until it reaches a manageable level, but this means that vital information may be discarded — leading to incorrect conclusions," he said.



A real-time visualization of computers probing or attacking the Virginia Tech computer network.

Tront is working with Virginia Tech's Information Security Laboratory to develop the Converged Security Visualization Tool (Cover-VT). Cover-VT is a web-based application that shows a visual representation of the big picture for a set of data, letting the analyst see trends in the data. The analyst can then zoom in on any area to see more details — as much detail as is contained in the raw data. There are also filtering tools to help sift through the data.

Cover-VT is designed for analyzing many kinds of data, but the initial application is network security. Using an instance of Google Earth, Cover-VT can map the IP addresses responsible for attacks on a network to their geographic locations.

Other possible applications for Cover-VT include law enforcement and analysis of social networking. In a hostage situation, Tront explained, identifying the mobile networked devices in a locked down facility could suggest how many hostages are being held.

Energy harvesting for self-powered sensors

Embedded systems researchers are working with mechanical engineers from the Center for Intelligent Material Systems and Structures (CIMSS) to develop energy harvesting technology for embedded devices. Their goal, according to Dong Ha, is to develop self-powered sensors for hard-to-reach places, such as bridges and helicopter turbine engines.

The group is exploring a variety of techniques for harvesting energy from the environment — including miniature windmills, mechanical vibrations, thermal, and solar power. The big challenge, Ha says, is that "our circuit should adapt to the changing environment to harvest the maximum amount of energy. A simple example is sunlight, which changes in intensity and direction." This maximum power point tracking presents its own challenge: if the circuit expends too much energy improving its own efficiency, it may consume more than it gains. "We're dealing with milliwatts here," Ha says. "We have to not just make our circuit efficient at transferring power, but also make sure it doesn't use too much itself."

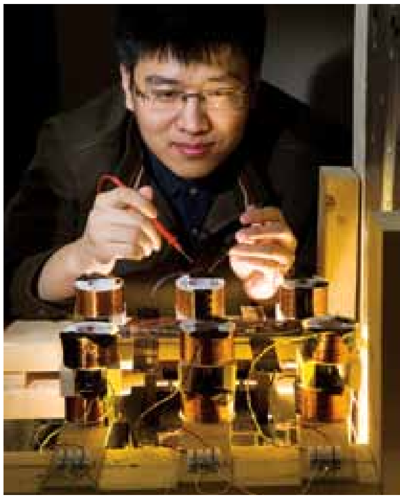
Bridge sensor nodes

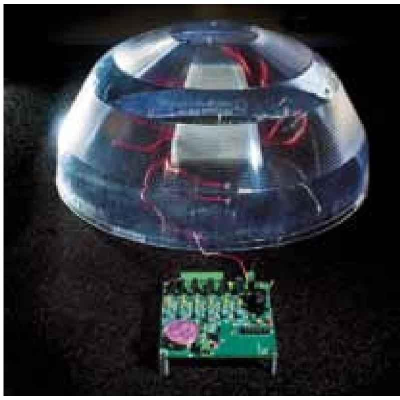
Ha's team is partnering with Dan Inman, director of CIMSS to develop embedded bridge sensor nodes as part of a $14 million grant from the National Institute of Standards and Technology (NIST). Physical Acoustic Corp. is developing the nodes, which will combine power from miniature windmills and mechanical vibrations. The miniature windmills produce low-voltage dc power, which must be stepped up to 7.5V dc yielding only about 60mW after conversion, explains Ha. The vibration is harnessed via both piezoelectric patches and electromagnetic coils. Piezoelectric patches generate 20-40V ac, which must be converted to 7.4V dc to charge the battery.

Helicopter engine sensors

Energy harvesting may also prove useful in the close confines of helicopter turboshaft engines. The ECE/CIMSS team is collaborating with Prime Research and Pratt & Whitney to develop wireless engine sensors that will power themselves through airflow, thermoelectric, and vibration energy harvesting.

High engine temperature plays both good and bad roles. The good part is that it provides an energy source. CIMSS experiments demonstrated the ability to harvest up to 40mW when a thermal harvester is placed on a 200°C surface and passively cooled with a heat sink. The high temperature inside the jet engine severely degrades the performance of circuits, posing a design challenge. Bulk CMOS technologies fail at temperatures greater than 200°C, so the group plans to employ silicon-on-insulator technology and use various compensation schemes to mitigate adverse effects of high temperature.





Infrastructure sensing

Ha's team is also designing a power management system that will produce about 200 mW, on average, regulated power under California sunlight from combined solar and thermal sources. Ha is working with Accellent Technologies, which is developing a structural health monitoring sensor node for infrastructure, and the power management system will provide 18.5V dc to power the sensor node.

The ECE team is investigating all aspects of the power management system including design of a thermal harvester possibly with active cooling, a battery charging circuit, and voltage boosters and regulators.

On-chip fingerprints

Patrick Schaumont and Leyla Nazhandali are working with Inyoung Kim of statistics to create trustworthy electronic hardware fingerprints based on random variations that occur during chip manufacturing. These random variations between and within chips of the same model have potential application in pervasive authentication mechanisms. Such physical unclonable functions (PUFs) can be neither reproduced or tampered with and could serve as unique, reliable, and uniform fingerprints, regardless of environmental conditions such as age, temperature, and electrical variance. However, the issues of scalability, cost, stability, and threats of reverse engineering have not been fully investigated, according to Schaumont. The ECE professors are working with Kim to develop a comprehensive approach that combines the latest techniques in statistics, architecture design, and circuit design. The team will validate their statistical models by implementing prototype on-chip fingerprints on both FPGAs and ASICs. Ultimately, they hope to create cost-effective physical unclonable functions that are unaffected by environmental factors like aging, noise, and voltage.

Standardizing crypto evaluations, benchmarks

When evaluating cryptographic algorithms, security is paramount, but speed is also important. A fast, secure algorithm is better than a slow, and equally secure one.

The problem in evaluating the performance of cryptographic hardware and software is a lack of consistent benchmarks, according to Patrick Schaumont, director of the secure embedded systems laboratory.

Schaumont and Leyla Nazhandali have received a three-year, $544,257 grant from the National Institute of Standards and Technology (NIST) to provide a consistent system for evaluating cryptographic algorithms in both hardware and software. They are members of a multi-university team that includes George Mason University and the University of Illinois at Chicago.

"Typically cryptographic algorithms have been standardized after an open competition overseen by a government agency," explained Schaumont. The benchmarks focus on software performance on personal computers and are not sufficient to predict speed and power usage on DSPs or FPGAs, or even custom-design ASICs, he added.

The Virginia Tech team will lead the benchmarking methods for performance of cryptography when implemented as an ASIC. Schaumont will also advise the team at the University of Illinois that will work on cryptographic software performance on small microprocessors and computers.

The resulting evaluation process will allow users to profile their hardware designs in a comprehensive process that covers FPGA as well as ASIC. An important driver application for this project on the short term is the ongoing competition organized by NIST to define SHA-3, the next-generation hash standard.

Unlocking the secrets of the Spartan boards

Researchers in the Secure Embedded Systems Laboratory are capitalizing on the Spartan 3E development kits used by all ECE undergraduates to make a groundbreaking study of how variances and the submicron level can affect computations.

The Spartan boards have an FPGA chip that varies slightly when compared to the same model chip on another board. Manufacturers have been aware of such die-to-die variations for more than a decade, and designers have been investigating techniques that take such variations into account during the design process, according to Patrick Schaumont, who leads an effort to investigate circuit variability from die-to-die, as well as within each chip.

As semiconductor process technology reaches ever smaller feature sizes, the impact of within-die variations has become significant, and that has begun to attract research attention, he says.

Schaumont's team is studying the population of more than 250 Spartan boards owned by ECE students. Previous research has studied at most 36 FPGAs, limiting the precision and detail needed to accurately characterize a large population of deployed chips. The team also hopes to show that it is feasible to recognize each individual chip from the entire population, which has important applications in secure hardware design.

To encourage students to bring in their Spartan boards for testing, the research team is running a contest to give away a game console for every 50 students who come in. The group recently awarded a Nintendo Wii to the first winner, CPE student Jingyao Zhang. The next winner will receive a Sony Playstation 3.

The project is funded by a $110,000 NSF grant, and will run until 2012. Schaumont is spending one year designing and implementing experiments to measure die-to-die variability, the second year creating experiments to measure variability within the die, and the final grant year on improving the experimental method and analyzing the collected data. The anonymized, collected data will be made available to the research community for further investigation of process manufacturing variations.

Shedding Sunshine on sensor network hardware design

Yaling Yang and Patrick Schaumont are leading a project to develop a hardware/software codesign tool to remove a critical roadblock to the success of sensor networks. Sunshine (Sensor Unified analyzer for Software and Hardware In Networked Environments) is expected to enable specialized FPGA hardware implementations of sensor networks for increased performance and energy savings.

"A major roadblock to the success of sensor networks has been the prohibitively slow and power-hungry software implementations of many applications," says Yang. "Yet, specialized hardware implementations can outperform equivalent software implementations by orders of magnitude," she adds.

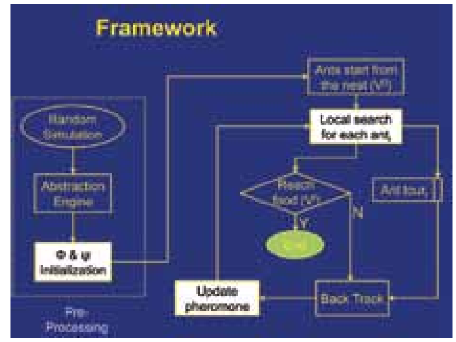
Sunshine will support joint software-and-hardware design, which is a relatively unexplored approach, she said.

Sunshine will be able to accurately simulate behaviors (with cycle-level accuracy) and performance of sensor hardware and software in a networked environment. Beyond simulation, the software simulation code used in Sunshine simulation can run over real sensor platforms and the hardware simulation code can be directly used to program real FPGA chips. The cross-domain design environment will enable the creation and testing of novel hardware architecture and platforms that are unexplored in current designs.

"Sunshine may fundamentally transform the relationship between the sensor network hardware and software communities," Yang said. "They will have an easy way to efficiently exchange mutual requirements and spread the latest technology advances in each other's areas of expertise." Such evolutionary change will greatly improve the state-of-the-art in sensor network technology, she said.

Yang and Schaumont have a three-year, $256,000 grant from the NSF to support the project.

Simulated ants
get to the hard-to-reach corner states



One of the hardest problems in validating designs is getting the system to reach all the possible states it will experience during use. Michael Hsiao's team has developed a new semi-formal validation technique that gets to those corner cases by drawing inspiration from nature. The Ant-Colony-Optimization-based state justification is based on how a swarm of ants searches for the best pathway to and from a food source. An individual ant uses its own senses to search for the best route, but it also lays down a pheromone track to lead other ants along a good route when found. As the swarm continues to search, the best route grows thick with pheromone tracks, while the tracks along poorer routes evaporate over time. Eventually, the pheromone-guided ants follow only the best path.

The algorithm simulates this same behavior with a swarm of simulated ants. The amount of pheromone left by the ants is directly proportional to the quality of the search. In addition, the intelligence based on the collective behavior is capable of avoiding critical dead-end states as well as fast convergence to the target state. Other researchers have proposed algorithms using random input or a genetic algorithm, but Hsiao's team tested their ant-colony-optimization-based algorithm over a variety of state justification benchmarks, and found it faster in almost every case. "For many circuits, our technique is very effective in reaching hard-to-reach states where previous methods either fail or require more time," Hsiao said.

Souping up hardware sim speed

Sandeep Shukla has led a team to improve the simulation performance of hardware models created in a language called SystemC. The team's new infrastructure, SCGPSim, has garnered a best paper award at the 15th Asia and South Pacific Design Automation Conference (ASP-DAC) in Taiwan.

Shukla and his collaborators said that they were able to demonstrate how to speed up the simulation performance of certain SystemC-based hardware models "by exploiting the high degree of parallelism afforded by today's general purpose graphic processor units (GPGPU)." These units have multiple core processors capable of very high computation and data throughput. When parallelism is applied, it means that the processor units can run various parts of the simulations simultaneously, and not just as a single sequence of computations. Their experiments were carried out on an NVIDIA Tesla 870 with 256 processing cores donated to the lab by NVIDIA.

In the past, Shukla said, "significant effort was aimed at improving the performance of SystemC simulations, but little had been directed at making them operate in parallel. And none of the attempts were ever targeted at a massively parallel platform such as a general purpose graphic processor unit." Shukla said their preliminary experiments showed they were able to speed up SystemC based simulation by factors of 30 to 100 times that of previous performances.

Another aspect of their work was the use of a specific programming model called Compute Unified Device Architecture (CUDA). It is an extension to the C software language that "exploits the processing power of graphic processor units to solve complex compute-intensive problems efficiently," Shukla explained. "High performance is achieved by launching a number of threads and making each thread execute a part of the application in parallel."

The Air Force Office of Scientific Research and the National Science Foundation helped support this research.

— Lynn Nystrom

Researchers quantify fingerprint images

Lynn Abbott and Michael Hsiao are part of an interdisciplinary team investigating fingerprint analysis. Fingerprint analysis and matching is a critical tool for law-enforcement, especially for partial (or latent) prints left at crime scenes. "Our work is probably different from most others because of our emphasis on latent fingerprints," explains Abbott, "latent [partial] prints are often smeared or otherwise distorted."

Fingerprint analysis is based on the recognition of minutia points, which are small portions of a fingerprint that, when combined, can lead to a unique identification. Ph.D. student Nathan Short has implemented software that can detect minutia points, which is the first step in the research. Graduate student Supratik Misra is also on the project.

The ECE machine vision effort is part of a two-year, $854,907 grant from the National Institute of Justice.

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Ball, Arthur Hugues
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Committee Chair: Lee, F. C.

Buennemeyer, Timothy Keith
Battery-Sensing Intrusion Protection System (B-SIPS)
Committee Chair: Tront, J. G.

Dong, Jingyuan
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Committee Chair: Martin, T. L.

Komali, Ramakant S.
Game-Theoretic Analysis of Topology Control
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Wang, Joshua Kevin
Identification, Analysis, and Control of Power System Events Using Wide-Area Frequency Measurements
Committee Chair: Liu, Yilu

Xu, Jing
Technology for Planar Power Semiconductor Devices Package with Improved Voltage Rating
Committee Chair: Ngo, K. D.

Zhou, Ming
Advanced System Monitoring with Phasor Measurement
Committee Chair: Centeno, V. A.

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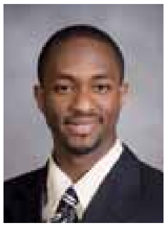
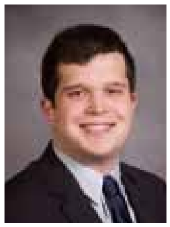
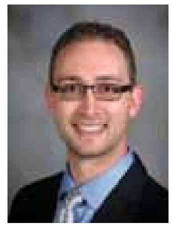


Uchenna Anyanwu
BSEE '09, San Jose State University
Advisor: Allen MacKenzie
Research: He is exploring wireless communication and reconfigurable devices to develop inexpensive, flexible software-defined radios. High-speed random access data networking is the ultimate goal.
Career aspirations: To collaborate on developing novel solutions as a professor at a research university.



Matthew Bailey
BSEE/BSCPE/ Math '09, Virginia Tech
Advisor: Dan Stilwell
Research: Maximizing the surfacing interval of autonomous underwater vehicles by finding an analytic cost function. He is a member of the Autonomous Systems & Controls Laboratory (AASCL).



Matthew Carter
BSCPE '09, University of California, San Diego
Advisor: Christopher Wyatt
Research: Medical imaging, with a current focus on localizing brain activity sources measured through magnetoencephalography (MEG) experiments. The hope is to combine the research with fMRI experiments to learn more about connectivity between regions of the brain.

Michael Fraser
BSEE '09, Virginia Tech
Advisor: Anbo Wang
Research: Photonic sensors. The current project involves building a harsh environment, high-temperature sensor able to withstand the heat of gas-turbine jet engines, to improve fuel efficiency and precision control. Success could lead to the development of clean natural gas technologies.

BRADLEY ALUMNI

JoAnn M. Adams (BSEE '94)
Co-owner, Big Fish Design
Centreville, Va.

Robert J. Adams
(BS '93, MS '95, Ph.D. '98)
Associate Professor, ECE
University of Kentucky
Lexington, Ky.

J. Shawn Addington
(BSEE '90, MSEE '92, Ph.D. '96)
Department Head, ECE
Virginia Military Institute
Lexington, Va.

Sarah S. Airey (BSCPE '01)

Christopher R. Anderson
(BSEE '99, MSEE '02, Ph.D '06)
Assistant Professor, ECE
United States Naval Academy
Annapolis, Md.

Matthew Anderson (BSCPE '04)

Nathaniel August
(BSCPE '98, MSEE '01, Ph.D. '05)
Mixed Signal Design Engineer
Advanced Design Group, Intel
Portland, Ore.
Various projects from pre-silicon validation, to silicon debug, to mixed-signal design. The current project is an all-digital PLL.

Carrie Ellen Aust (BSCPE '98)

William Barnhart
(BSEE '00, MSEE '02)
Raytheon
Denver, Colo.

Mark W. Baldwin
(BSEE '93, MSEE '05, Ph.D. '08)
Engineer, Dominion
Glen Allen, Va.
Working in control and protection of power generation equipment.

Benjamin Beasley (BSEE '09)
Associate
Zeta Associates
M.S.E.E. in progress at Virginia Tech (Northern Va.)

Brian L. Berg (Ph.D. '01)
Director of Engineering and Product Development
DTS
Agoura Hills, Calif.

Ray A. Bittner, Jr.
(BSCPE '91, MSEE '93 Ph.D. '97)
Microsoft Research
Redmond, Wash.

Kirsten Brown (BSEE '94)
Chief of Staff to the CEO
MicroStrategy Inc.
Alexandria, Va.

Steve Bucca
(BSEE '87, MSEE '90)

Mark Bucciero
(BSCPE '01, MSCPE '04)

R. Michael Buehrer (Ph.D. '96)
Associate Professor
Virginia Tech

Charles F. Bunting (Ph.D. '94)
Associate Professor
Oklahoma State University

Carey Buxton (Ph.D. '01)
Electronics Engineer
FBI ERF
Quantico, Va.

Scott C. Cappiello
(BSCPE '94)
Senior Director of Program Management
MicroStrategy, Inc.
Carlsbad, Calif.
He is involved in product definition in the R&D department.

J. Matthew Carson (BSEE '98)
Engineer, Engine Dept.
Joe Gibbs Racing
Huntersville, N.C.
His team successfully completed a transition to Toyota engines.

Ricky T. Castles (BSCPE '03, MSCPE '06, MSISE '08)
Ph.D student, Virginia Tech

Eric Caswell (Ph.D. '02)

Ross Clay (BSCPE '09)
M.S. student
North Carolina State Univ.
Focus on green cloud computing

Kevin Cooley (BSEE '02)
Industrial Automation Specialists
Hampton, Va.

Cas Dalton (BSCPE '03)

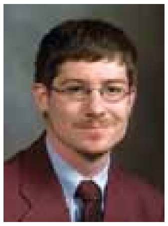
Phillip Danner (BSCPE '91)

Bradley A. Davis (Ph.D. '01)

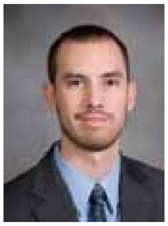
Daniel Davis (BSEE '03)

Scott Davis (BSCPE '00)
Senior Software Engineer
Kollmorgen
Works with the firmware group on servo drive development.

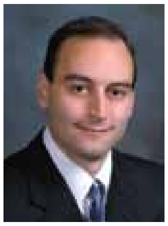
Brian M. Donlan (MSEE '05)



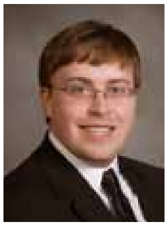
William C. Headley
BSEE ’06,
MSEE ’09,
Virginia Tech
Advisor:
Claudio
da Silva
Research: Signal classification and parameter estimation. Currently developing distributed detection and classification systems for the new femtocell phone networks being deployed by wireless providers.
Experience: Interned with the MIT Lincoln Lab in summer 2009.



Michael Hopkins
BSEE ’09,
Virginia Commonwealth University
Advisors:
Lynn Abbott, Dennis Hong (ME)
Research: Computer vision and machine perception methods for multi-robot systems. The goal is real-time cooperative search and surveillance capabilties. Currently developing technology for the Virginia Tech entries into the MAGIC 2010 and RoboCup 2010 competitions.



Ryan Irwin
BSCPE ’07,
Virginia Tech
Advisors:
Luiz DaSilva,
Allen
MacKenzie
Research:
Investigating distributed multichannel adaptation schemes for network topologies that will efficiently serve the demands of changing traffic conditions by sharing data between network layers that were traditionally independent.



Kevin Jones
BSEE ’09,
Virginia Tech
Advisor:
Virgilio
Centeno
Research:
Working on a power system synchrophasor-based tracking three-phase state estimator based on VIrginia Tech’s PMU technology. The goal is to estimate system state many times per second, rather than the several minutes required by traditional methods and use measurements from all three phases instead of today’s single-phase techniques.

Joel A. Donohue (MSEE ’94)
President
Janlee Services, Inc.
Professional engineering services for homeowner, legal, and academic sectors. Served as advisor on Tech’s Lumenhaus project.

Thomas Drayer (Ph.D. ’97)

Bradley D. Duncan (Ph.D. ’91)
Professor, ECE
University of Dayton, Ohio

Gregory D. Durgin
(BSEE ’96, MSEE ’98, Ph.D. ’00)
Associate Professor
Georgia Tech

W. Ashley Eanes (BSEE ’95)

Richard B. Ertel (Ph.D. ’00)

Brian F. Flanagan
(BSEE ’97, MSEE ’98)

Kevin P. Flanagan
(BSCPE ’00, MSCPE ’01)
Design Engineer
Micron
Folsom, Calif.

Todd Fleming
(BSEE ’94, MSEE ’96)

Ryan J. Fong
(BSCPE ’01, MSCPE ’04)
Senior Firmware Engineer
ITT
Elkridge, Md.

Jayda B. Freibert (BSEE ’98)

Daniel Friend
(BSEE, MSEE ’98, Ph.D. ’09)
Communication Systems Engineer
Northrop Grumman

Bradley H. Gale (BSEE ’97)

Robert M. Gardner
(BSEE ’03, MSEE ’05, Ph.D. ’08)
Electric transmission planner
Dominion Virginia Power
Richmond, Va.

Daniel J. Gillespie (BSCPE ’95)

Brian Gold
(BSEE/Math ’01, MSCPE ’03)
Senior Staff Engineer
Sun Labs; Redwood City, Calif.
Research focus is computer architecture for enterprise computing.

Jonathan Graf
(BSCPE ’02, MSCPE ’04)
Director of Trust Technologies
Luna Innovations
Roanoke, Va.
Graf works on computer security technology for the U.S. DoD.

Timothy Gredler (BSCPE ’03)
Senior Design and Development Engineer
Lutron Electronics
Coopersburg, Pa.
Currently in charge of the software development team for the EcoSystem lighting product line.

Christopher R. Griger
(BSCPE ’02)

Daniel Michael Hager (CPE ’08)

Alex Hanisch (BSCPE/Math ’03)

Abigail Harrison (BSCPE ’04)

Jennifer J. Hastings (BSEE ’96)

Dwayne A. Hawbaker (MSEE ’91)
Senior Staff Engineer
Johns Hopkins Applied Physics Lab

Matt C. Helton (BSEE ’01)

Benjamin E. Henty (MSEE ’01)

Jason Hess (BSEE ’97, MSEE ’99)
Manager, HW Engineering
Cisco Systems
Austin, Texas

H. Erik Hia (BSCPE ’99, MSCPE ’01)

James Hicks (Ph.D. ’03)

Hugh E. Hockett (BSCPE ’03)

Janie Hodges (BSCPE ’01)

Spencer Hoke (BSCPE ’03)
Software Engineering Team Leader
Garmin International
Kansas City, Kan.

Russell T. Holbrook (BSCPE ’03)

Andrew Hollingsworth (BSCPE ’02)

Ryan Hurrell (BSEE ’03)

John Todd Hutson (BSEE ’93)

Madiha Jafri (BSCPE ’03)

Daniel A. Johnson (MSEE ’01)

Adam Kania (BSEE ’01)

David A. Kapp (Ph.D. ’96)

Dimosthenis C. Katsis
(BSEE ’95, MSEE ’97, Ph.D. ’03)
President, Athena Energy Corp.
Bowie, Md.
Developing new products for the alternative energy market and consulting on defense-oriented power supply designs.

David Kleppinger (BSCPE ’04)

Paul A. Kline (Ph.D. ’97)

Gregory Kozick (BSCPE ’03)

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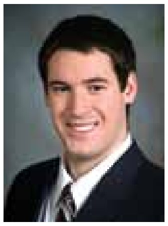
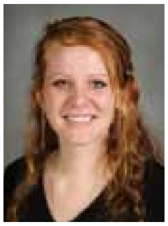
Continued

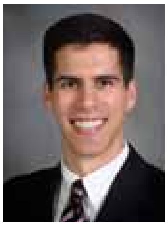


Nathan Kees
BSEE '08, Virginia Tech
Advisor: Hardus Odendaal
Research: Developing methods to recover the energy that is lost during the exit phase of a railgun projectile, improving efficiency and safety. The project is funded by the Naval Surface Warfare Center.



Amy Malady
BSEE '09, Virginia Tech
Advisor: Louis Beex
Research: Classifying signals by cyclostationarity statistical methods. Current focus is on how robust her method for classifying continuous phase modulation (CPM) signals is to varying burst modulation combinations and lengths, in order to improve its application for signals intelligence and cognitive radio.

David Reusch
BSEE '04, MSEE '06, Virginia Tech
Advisor: Fred C. Lee
Research: Investigating alternative power electronics topologies and designs to improve efficiency and power density. Currently working on a matrix transformer to reduce loss in high-frequency dc-dc power converters for telecom and computer microprocessors.



Benton Thompson
BSEE '05, University of Tennessee-Knoxville
Advisor: Michael Buehrer
Research: Practical noise modeling in wireless collaborative localization networks. In such networks, nodes work together to share information such as the GPS coordinates of select nodes, in order to provide localization information more cost-effectively.

BRADLEY ALUMNI
Continued

William B. Kuhn
(BSEE '79, Ph.D. '96)
Professor, EECE
Kansas State University

Zachary La Celle (BSEE '09)
Junior Engineer
Robotic Research
Rockville, Md.

Jeffery D. Laster
(BSEE '79, Ph.D. '97)
Principal Technical Manager
Mentor Graphics, Addison, Texas
Responsible for technical programs with Raytheon

Mark A. Lehne (Ph.D. '08)

Charles Lepple
(BSEE '00, MSEE '04)
Senior Research Engineer
Johns Hopkins University APL
Laurel, Md.

Jason Lewis (BSEE '99)

Joseph C. Liberti (Ph.D. '95)

Zion Lo (BSEE '94)
Sr. Software Engineer/Architect
IQNavigator, Denver, Colo.

Daniel L. Lough
(BSCPE '94, MSEE '97, Ph.D. '01)

Andrew Love
Graduate student, Virginia Tech

Cheryl Duty Martin (BSEE '95)
Research Scientist
Applied Research Laboratories
University of Texas at Austin

Stephanie Martin (BSEE '04)
Associate Professional Staff
Johns Hopkins University APL;
Columbia, Md.
Provides electronic warfare support to the U.S. military.

Michael Mattern (BSEE '02)

Christopher Maxey (BSCPE '02)

Eric J. Mayfield (BSEE '97)

Patrick McDougle (BSEE '03)

Brian J. McGiverin (BSCPE '96)

John T. McHenry
(BSEE '98, MSEE '90, Ph.D. '93)
Senior Electrical Engineer
U.S. Department of Defense

David McKinstry (MSEE '03)

Garrett Mears (BSCPE '00)
Chief Software Architect
Open Vantage Ltd.
London, U.K.
Leading software development for new mobile entertainment product.

Vinodh Menon (BSCPE '02)

Michael Mera (BSEE '03)
Technical Lead, Electrical Engineer
U.S. Army
Picatinny, N.J.

Carl Minton (MSCPE '99)

John Morton (MSEE '98)

Stephen Nash (BSCPE '03)

Troy Nergaard (MSEE '02)

Michael H. Newkirk
(BSEE '88, MSEE '90, Ph.D. '94)
Principal Professional Staff
Applied Physics Laboratory
Johns Hopkins University
ECE Advisory Board Member

Paul Erik Nguyen
(BSCPE '98, MSCPE '99)

J. Eric Nuckols
(BSEE '97, MSEE '99)

Neal Patwari
(BSEE '97, MSEE '99)
Assistant Professor
University of Utah
His research into "seeing through walls" made it into the popular press this year, and he recently received a 2009 Best Magazine Paper award from the IEEE Signal Processing Society.

Joseph Allen Payne (BSEE '00)

W. Bruce Puckett (MSEE '00)

Yaron Rachlin (BSEE/Math '00)
Senior Member of Technical Staff
Draper Laboratory
Cambridge, Mass.

Parrish Ralston
(BSEE '06, MSEE '08)
Graduate Researcher
Virginia Tech

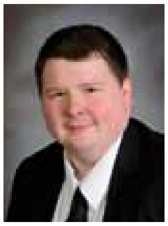
Christian J. Reiser (Ph.D. '05)
Lead Communications Engineer
MITRE Corporation
Washington Signal Processing Center

Steve Richmond (MSEE '01)

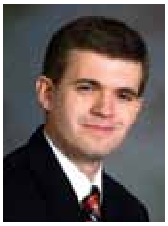
Jamie Riggins (BSEE/BSCPE '04)

Pablo Max Robert (Ph.D. '03)

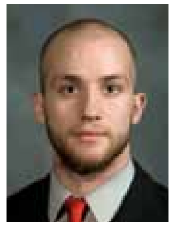
2009/2010 BRADLEY SCHOLARS



Willis Troy
BS ’07,
MS ’09,
Baylor University
Advisor: Michael Hsiao
Research: He is currently focusing on equivalence checking of sequential circuits via product machines that eliminate size constraints and allow large circuits to be tested, thus improving circuit verification speed.

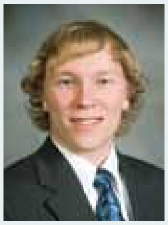


Ben York
BSEE ’08,
University of Alabama
Advisor: Jason Lai
Research: Designing and implementing high efficiency power conversion for renewable energy applications. Current focus is on advanced control methods to soft-switch converters in solar panel installations.



Phillip Zellner
BSEE ’07,
Virginia Tech
Advisor: Masoud Agah
Research: MEMS systems to act as “labs-on-a-chip” to perform analytical chemistry, diagnose diseases, and discover drugs. He has developed a first-ever, single-mask, single-etch process to create buried 3-D channels in silicon substrate. Previous techniques required multiple steps and were only 2-D.

Brittany Clore
CPE ’10
Fairfax, Va.
Gamma Beta Phi; HKN Treasurer
Career goals: Working in cyber security, possibly secure hardware design.
Experience: MITRE Corporation — working on an intrusion-tolerant server system.



Thomas Cooper
EE ’10
Oak Ridge, Tenn.
HKN; SEC; IEEE; Intramural sports: Galileo Engineering Community
Research: Developing dynamic spectrum access techniques
Why ECE: “I was driven by the desire to understand how these systems actually work, especially cellular radio networks.”

David Mazur
EE ’11
Pittsburgh, Pa.
IEEE; U.S. Soccer referee
Research: a signals processor to analyze and display power profiles of everyday electronics.
Most memorable: “There is nothing that you cannot do if you put your mind to it at Tech.”

Thomas W. Rondeau
(BSEE ’03, MS ’06, Ph.D. ’07)
Center for Communications Research, Princeton, N.J.
Has published a new book, *Artificial Intelligence in Wireless Communications*.

Thomas M. Rose (MSEE ’96)
Senior Engineer
Radar and Sensors Group, Boeing
University City, Mo.
Working with fire control radar for the F-15 Eagle.

Jon Scalera (MSCPE ’01)

Amy Schneider (BSCPE ’03)

Steven Schulz (MSEE ’91)

David C. Schroder (BSEE ’05)

Jeff Scruggs (MSEE ’99)

Kashan Shaikh (BSCPE ’02)

Raymond A. Sharp (BSEE ’02)

Rebecca Shelton (MSEE ’08)

Jacob Simmons (CPE ’08)

Roger Skidmore
(BSCPE ’94, MSEE ’97, Ph.D. ’03)

Jeff Smidler (BSEE ’98)

Amanda (Martin) Staley
(BSEE ’99, MSEE ’01)

Graham Stead (BSCPE ’93)

Douglas R. Sterk (MSEE ’03)
CPES Lab Manager
Ph.D. student, Virginia Tech

Scott Stern (BSEE ’93)
Program Manager
Compunetix
Monroeville, Penn.
Manages development efforts for mission-critical conferencing systems.

Samuel S. Stone (BSCPE ’03)

Anne (Palmore) Stublen (BSEE ’91)
Newark, Del.

Seema Sud (Ph.D. ’02)

Ethan B. Swint
Senior Engineer; Ramu Incorporated
Ph.D. student at Virginia Tech

David Tarnoff (MSEE ’91)
Assistant Professor
Computer & Information Science
East Tennessee State University

Daniel Tebben (Ph.D. ’06)

Jerry Towler (BSEE ’08)
MSEE student
Unmanned Systems Lab
Virginia Tech

Rose Trepkowski (MSEE ’04)

Christian Twaddle (BSCPE ’01)
Program Manager, ITT Corporation
Columbia, Md.

Matthew C. Valenti
(BSEE ’92, Ph.D. ’99)
Associate Professor, CS & ECE
West Virginia University
Morgantown, W.V.

Wesley Wade (BSEE ’93)

Kristin Weary (BSEE ’03)
Electrical Engineer
Bechtel-Knolls Atomic Power Laboratory
Niskayuna, N.Y.
Leading project to support shipping specimens out of the lab.

Michael L. Webber (MSEE ’03)

Jason Wienke (BSEE ’02)

Thomas Williams (BSEE ’00)

William J. Worek
(BSCPE ’99, MSCPE ’02)

Kai Xu (BSEE ’95)

Jason Jon Yoho (Ph.D. ’01)
Design Engineer
Picosecond Pulse Labs
Boulder, Colo.

Gregory A. Zvonar (MSEE ’91)

Richard Zimmerman (BSCPE ’07)

DONORS TO ECE During the Fiscal Year 2009

Alumni

Although every effort has been made to ensure the accuracy of this report, we acknowledge that errors may have occured. 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.

J. Shawn & Adele K. Addington
Glenn Michael & Rebecca S. Allen
Jack Bowles & Carol S. Amis
Brian Douglas Bailey
Rudolph Richard, Jr. & Angela P. Banks
Andrew Beach
Estate of Doris C. Belak
T. Wayne & Colleen F. Belvin
Brian LaRoy Berg
Jerry Bischof
Steven Parker, Jr. & Kristi L. Black
Gregory Edward & Laura J. Bottomley
William Jay Boyer
Robert Francis & Connie E. Bruce
Robert Lawrence & Caroline W. Calder
Leslie Haden & Pauline H. Christian
Floyd N. & Shirley I. Coppage
Ernest Dyson & Jackie A. Crack
Kenneth Emil & Lisa Cutler
Angela Lieberman & James W. Dalton
LCDR Richard Todd & Jennifer A. Davies
George Stephenson & Kathryn Y. Davis
John Dettra
Nithin Dhananjayan
Steve Otho Dixon
Edwin Lindsey & Mary Beth L. Dove
W. Douglas & Peggy ("Jean") J. Drumheller
Ben DuPont
William Ashley Eanes
G. Stephen & Debbie J. Ellis
Walter Lane & Dorothy Epperly
Samuel Macin & Jeffra D. Estill
Gilbert Lawrence & Jewel C. Faison
Chris Flohr
Robert William Freund
James K., Jr. & Diana George
Michele Urban & Mark J. Greenwood
James Thomas Griffin
Paul Stephen & Mary Hamer
Jesse T. & Valorie R. Hancock
Eva S. Hardy
Kurt Michael & Christine Hinds
J. B., Jr. Esq. & Shirley B. Hoofnagle
Bin Huang
Hsien Lu & Hui-Lein P. Huang
Kenneth Lee & Edward L. Johnson
Edward Andrew Jones
William Charles & Nancy M. Jorch
Michael Francis Kalanick
Gregory Kubovcik
Joseph Edward & Maryann W. Kusterer
Ting-Pui Lai
William Kenneth Lamp
John Wolfe & Patricia Lane
Peggy Carol Lee
Estate of Clovis Emanuel & Rosa H. Linkous
Michael Lee & Cheryl C. Oatts
John Keith, Jr. & Pauline R. Loftis
Paul Mailhot
Edith Dole & Ronald L. Marsh
John Rouse, Jr. & Sandra Marshall
Robert & Beverly T. Maslow
Brent Owen McClain
William Rex & Joyce McConnell
Matthew D. Miller
Jeannette Marcella & David L. Mills
Michael G. Morris
Stewart L. & Mary L. Ocheltree
Lowell Thomas & Carolyn Overby
Steven Mark, CPA & Elizabeth M. Parker
Troy K., Jr. & Annette Preddy
Jane Prey
Christopher Goodman Ranson
Charlene V. Reeves
Gerald F. Ricciardi
Arman Roshan
Daniel M. & Pamela Sable
Karl David & Susan Salnoske
Estate of James Hamilton Schaub
James Franklin & Nancy J. Schooler
Margaret Ficklen & Thomas A. Schubert PE
Estate of Edwin F. Sharpe
D. Wayne & Dorothy Snodgrass
Michael Elliot Sockell
R. Knox & Lori D. Stacy
Eric Brian Stogoski
Harvey Lee & Agnes Sutton
Douglas Andrew Teeter & Terri L. Stull
Ryan William Thomas
C. Hyde & Gloria J. Tucker
Martha Tullis
Aaron Brian Waller
Kristin M. Weary
Evan Michael Weiner
James Austin & Carla V. Wilding
Naveen Yadlapalli
Joseph Willard & Patricia L. Yoder

ECE Friends

William Allen Blackwell & Sherry L. Blackwell
Stanley Honda
James A. & Kathleen M. Eder
Howard D. Frisch & Amy R. Flax
Gerald G. Lessmann
David M. & Luwanna S. Lofe
Michael L. Miles
Scott A. Norton
Edith L. Schulz
James S. Thorp

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International Rectifier
Intersil Corporation
Linear Technology
Lite-On Technology Corporation
Monolithic Power Systems
National Semiconductor Corp
NXP Semiconductors
Richtek Technology Corporation
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Maxim Integrated Products
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Intel Corporation
Johnson Controls
L-3 Communications, Power Paragon Inc.
Microsoft Corporation
NetPower Technologies, Inc.
Nippon Chemi-Con Corp.
Northrop Grumman
Shindengen Electric Mfg. Co., Ltd.
TDK-Lambda Corporation
The Boeing Company
Toyota Motor Corporation
Universal Lighting Technologies, Inc. (formerly PEW)
Vacon, Inc.

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Fuji Electric Advanced Technology Co., Ltd.
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Kohler Company
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Magnetek, Inc.
Miller Electric Mfg. Co.
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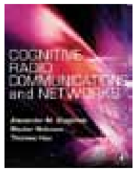
Delphi Power Systems
Electric Power Research Institute
Industrial Technology Research Institute
Institute of Nuclear Energy Research
National Semiconductor
Northrop Grumman Corp
Powerex
Tatung System Technologies
Total Energy Company
Visteon Corporation
Vollrath

HONORS & ACHIEVEMENTS

Books published

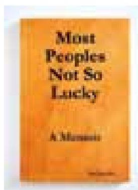
Peter Athanas was editor of *Reconfigurable Computing: Architectures, Tools, and Applications*, Springer, 2009.

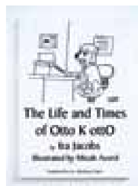
Charles Bostian and Thomas Rondeau (Ph.D. 2007) have a new book, *Artificial Intelligence in Wireless Communications*, Artech House, 2009.

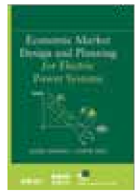


Tom Hou co-edited the textbook *Cognitive Radio Communications and Networks: Principles and Practices*; Academic Press/ Elsevier, December 2009.

Ira Jacobs published *The Life and Times of Otto K ottO*, Pocahontas Press, 2009; and *Most Peoples Not So Lucky: A Memoir*, Lulu.Com, 2009.

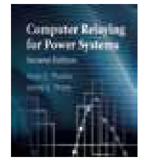






Lamine Mili was co-editor of *Economic Market Design and Planning for Electric Power Systems*, Wiley-IEEE Press, December 2009.

Krishnan Ramu published a Greek translation of *Electric Motor Drives: Modeling, Analysis and Control*, Klidarithmos Publishers, 2009. He also published *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press, 2009.



Arun Phadke and James Thorp published *Computer Relaying for Power Systems*, John Wiley & Sons, 2009.

S. Chhabra, O. Kilic and A.I. Zaghloul published *Co-Channel Interference in Satellite Links Utilizing Frequency Reuse*, VDM Verlag, 2009.

M.J. Al-Saleh and A.I. Zaghloul published *Direct Sensor-to-Satellite Links*, VDM Verlag, 2009.

Honors + awards

Jaime De La Ree received the William E. Wine Teaching Award.

Charles Bostian was honored with the title "Alumni Distinguished Professor Emeritus" by the Board of Visitors.

James Thorp has received the title of "Hugh P. and Ethel C. Kelly Professor Emeritus" from the Board of Visitors.

Dushan Boroyevich is the 2010 President-Elect of the IEEE Power Electronics Society. He is also an Elected Member-at-large of the IEEE Power Electronics Society AdCom.

Peter Athanas was the invited keynote of the International Conference on Field Programmable Logic and Applications, held in Prague, Czech Republic, 2009.

Krishnan Ramu delivered IEEE IES Distinguished Lectures in Malaysia (in two places) in December, 2009.

Anbo Wang was named a Fellow of the Society of Photo-Optical Instrumentation Engineers (SPIE).

Dan Stilwell was invited to give two lectures at the GkmM Summer School in Germany, sponsored by the German NSF.

The College of Engineering honored **Wayne Scales** as outstanding researcher, **Leslie Pendleton** as outstanding teacher, and **Masoud Agah** as outstanding assistant professor.

Conference chairs

Peter Athanas co-chaired the International Workshop on Applied Reconfigurable Computing, 2009.

Fred C. Lee was Conference Chair of the International Power Electronics and Motion Control Conference (IPEMC), May 2009, Wuhan, China.

Tom Martin was one of three technical program chairs of the Smart, E-textile Solutions symposium at the Industrial Fabrics Association International (IFAI) Expo in September 2009.

Saifur Rahman was chair of the IEEE Asia Pacific Power and Energy Conference in China, March 2010.

Lamine Mili was chair of the NSF-VT Resilient and Sustainable Critical Infrastructures (RESIN) workshop held in Alexandria, Virginia, in December 2009.

Patrick Schaumont was program co-chair of the Seventh ACM-IEEE International Conference on Formal Methods and Models for Codesign (MEMOCODE), 2009.

Anbo Wang co-chaired the U.S.-China Workshop on Optical Fiber Sensor Research, Development and Applications, Wuhan, China, July, 2009. He was co-chair of the U.S.-China Workshop on Bio-inspired Smart Systems: Materials, Mechanics, Control, and Sensor Innovation, Dalian, China, July, 2009. Wang co-chaired "Optical Fiber Sensors"and "Photonic Microdevices/Microstructures for Sensing" of the SPIE Symposium on Defense, Security and Sensing, Florida, April, 2009.

Editorships

Tamal Bose is associate editor of *the Journal of Electrical and Computer Engineering*, Hindawi Publications and associate editor of *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences*, Japan.

Mike Buehrer is associate editor of *IEEE Transactions on Wireless Communications* and associate editor of *IEEE Transactions on Communications*.

Mohammed Eltoweissy is guest co-editing a special issue of *IEEE JSAC on Mission Critical Networking*.

Tom Hou is associate editor of *IEEE Transactions on Mobile Computing*.

Michael Hsiao is associate editor of *ACM Transactions on Design Automation of Electronic Systems*. He serves on the editorial boards of *the IEEE Design & Test of Computers*; *the Journal of Electronic Testing: Theory and Applications;* and *the Journal of Embedded Computing*.

T.C. Poon is Division Editor of *Applied Optics*. He is Lead Feature Editor of "Digital Holography and 3-D Imaging" and "Acoust-Optics," *Applied Optics*. He is also Focus Issue Editor of "Digital and Computer-Generated Holography," *Chinese Optics Letters*.

Saifur Rahman was series editor of the *IEEE Smart Grid Expert Now* online tutorial series in 2009.

Sandeep Shukla is associate editor for *IEEE Transactions on Computers*; *IEEE Embedded Systems Letters*; *IEEE Design & Test*; and *Elsevier Journal on Nano Communication Networks*.

Alumni honors

Laura Bottomley (BSEE '84, MSEE '85) received a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring.

Harold L. Martin Sr. (Ph.D. '80) has been named the 2010 Virginia Tech College of Engineering Distinguished Alumnus. Martin became the Chancellor of NCA&T State University last summer.

Joe May (BSEE '62) was inducted into the Virginia Tech College of Engineering Academy of Engineering Excellence.

Noel N. Schulz (BSEE '88, MSEE '90) was elected president-elect of the IEEE Power and Energy Society, and

Miroslav M. Begovic (Ph.D. '89) was elected treasurer.

Joseph Vipperman, Jr. (BSEE '62) was inducted into the Virginia Tech College of Engineering Academy of Engineering Excellence.

Patents awarded

"Methods of forming buffer layer architecture on silicon and structures formed thereby," M. Hudait.

"Tensile Strained NMOS Transistor Using Group III-N Source/Drain Regions," M. Hudait.

"Dopant Confinement in the Delta Doped Layer Using a Dopant Segregation Barrier in Quantum Well Structures," M. Hudait.

"Selective High-K Dielectric Film Deposition For Semiconductor Device," M. Hudait.

"Method and Apparatus for Dynamically Connecting Modules in a Programmable Device," C. Patterson.

"Hybrid Control Methods for Digital Pulse Width Modulator (DPWM)," J. Li, D.S. Ha, Y. Qiu, M. Xu, and F.C. Lee.

"Multiphase Voltage Regulator Having Coupled Inductors with Reduced Winding Resistance," M. Xu, Y. Dong, F.C. Lee.

"Input Current Sensing AVP Method for Future VRM," M. Xu, F.C. Lee, J. Zhou.

"Co-Fired Ceramic Inductor with Variable Inductance, and Voltage Regulator Having Same," M. Lim, J.D. Van Wyk.

"Common Mode Noise Reduction using Parasitic Capacitance Cancellation," S. Wang, F.C. Lee.

"Phase Compensation Driving Scheme for Synchronous Rectifiers," D. Fu, F.C. Lee.

"Hybrid Filter For High Slew Rate Output Current Application (Divisional App.)," M. Xu, Y. Ren, F.C. Lee, A.P. Schmit.

"Hybrid Control Methods for Digital Pulse Width Modulator (DPWM)," J. Li, D.S. Ha, Y. Qiu, M. Xu, F.C. Lee.

"Hybrid Filter for High Slew Rate Output Current Application," M. Xu, Y. Ren, F.C. Lee, A.P. Schmit.

"Cancellation of Inductor Winding Capacitance," Shuo. Wang and F.C. Lee.

"Generalized Cancellation of Inductor Winding Capacitance (Continuation-in-part)," S. Wang and F.C. Lee.

"Holey Optical Fiber with Random Pattern of Holes and Method for Making Same," G. Pickrell, D. Kominsky, R. Stolen, J. Kim, A. Wang, A. Safaai-Jazi.

"Multi-cavity Fabry-Perot Interferometric Thin-Film Sensor with Built-in Temperature Compensation," Y. Zhang, K.L. Cooper, A. Wang.

"High-Quality Detection Based on Sequential Interference Cancellation Techniques," M.A. Nguyen, A.I. Zaghloul.

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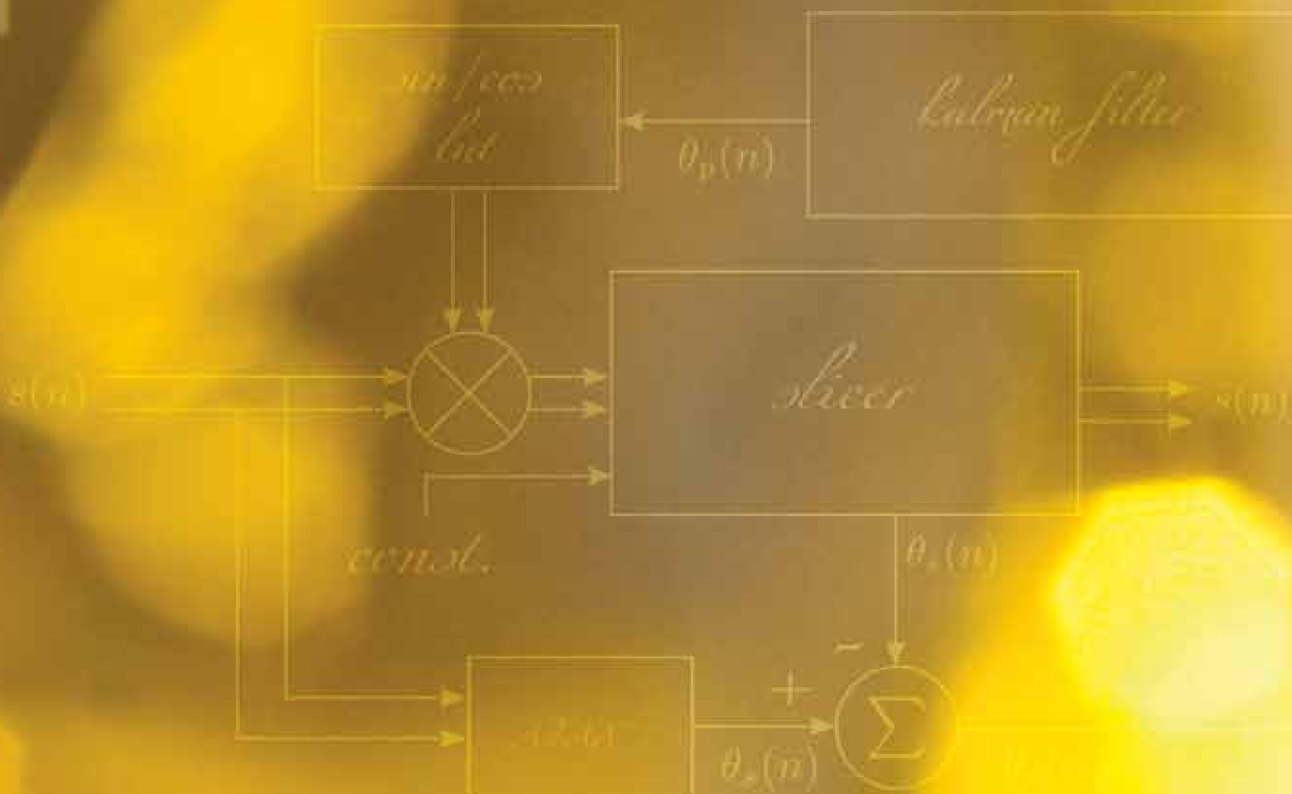

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