ECE 2009

The Bradley Department of Electrical and Computer Engineering

VirginiaTech
Invent the Future

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Photography:
Josh Armstrong: p. 5
Rick Griffiths: p. 9
Michael Kiernan: p. 16
John McCormick: pp. 3, 7, 10, 28
Christina O'Connor: pp. 6, 10, 22, 23, 30, 31, 32, 33, 34
Jim Stroup: pp. 2, 4, 8, 13, 20, 21
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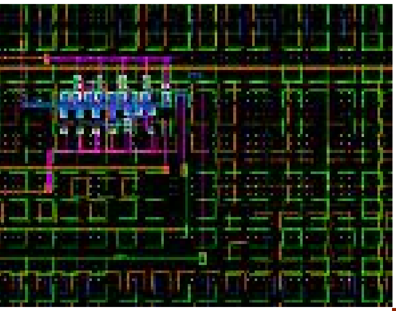

RESEARCH

UNDERGRADUATE RESEARCH

ECE PEOPLE

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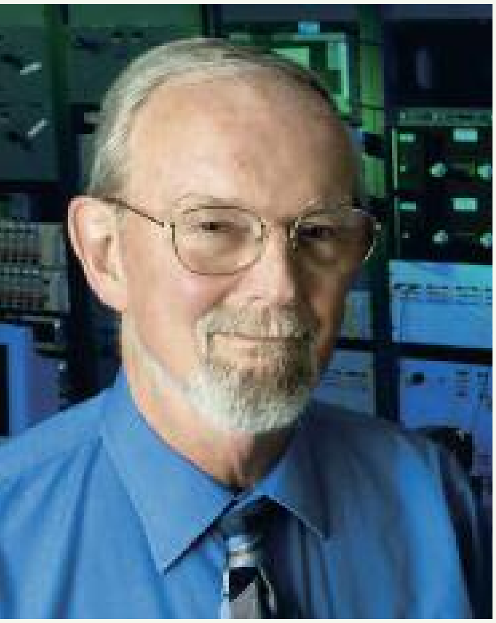
PERSPECTIVES from the Department Head



James S. Thorp
Department Head

Much of the technology needed for energy independence, sustainable infrastructure, and environmentally friendly lifestyles will be developed by electrical and computer engineers. ECE at Virginia Tech is ready for that challenge.

As the country seeks energy independence, a sustainable infrastructure and an environmentally friendly lifestyle, much of the technology needed will be developed by electrical and computer engineers. ECE at Virginia Tech is ready for that challenge. We believe our work and ideas will also generate opportunities and jobs to help build a robust economy.

Much of the work to be done harkens back to the roots of our field – manipulating and transmitting power and energy. We take pride that we have one of the largest and oldest power engineering programs in the country. The first "smart grid" technology was built here, and we continue to be leaders in transmission and power network technology. Our engineers are also involved in developing energy storage technology, alternative energy technology, and technology that reduces energy use.

In this issue, you'll read how a huge 10-year effort by the Center for Power Electronics Systems changed power processing with modular electronics technology that can help the country save 30 percent of its electricity use. You'll read about Leyla Nazhandali's NSF CAREER award (p. 12) that will help her develop technology for mobile embedded systems to operate at less than 10 percent of the power they now require. And don't miss the article on how Lamine Mili, Sandeep Shukla, and Yilu Liu are working to extend complex systems theory to making our power and communications infrastructures more resilient (p. 9).

In the communications area, Tamal Bose, co-director of Wireless@VT is involved in several stimulus projects with Virginia firms (see p. 20). Wireless@VT is also building the largest cognitive radio network testbed in the country, installing nodes in a new building on campus.

ECEs are also critical to solutions in biomedical applications. On page 16 we describe how Yue (Joseph) Wang is applying bioinformatics and systems theory to unravel the mysteries of cancer and other diseases.

While our efforts and successes continue to grow, the tremendous growth in faculty since January of 2005 slowed this year. This fall, we welcomed Mike Ruohoniemi and Joseph Baker, who completed our hiring for the Center for Space Science and Engineering Research. With their arrival, ECE became the lead on the SuperDARN network, an international collaboration to map space weather phenomena. Mike also obtained a new $2 million grant to build more radar stations in the United States (p. 27).

Our faculty members continue to be honored for their efforts. Sandeep Shukla has just returned from serving as an invited professor at the French National Institute for Computer Science and Automation. The Homboldt Foundation of Germany honored him with the prestigious Friedrich Wilhelm Bessel Fellowship for lifetime achievement within 12 years of completing a Ph.D. and he will spend the summer in Germany as a fellow. In the teaching arena, Jaime de la Ree was awarded the university Wine Award for a history of teaching excellence.

I offer my thanks to Dan Sable, who finished his second term as the chair of the Advisory Board, and to Gino Manzo, who is the new chair. Dan was responsible for the early success of our Space program and Gino hopes to make a similar impact on our microelectronics program.

I will be retiring this summer, but intend to stay in Blacksburg and take advantage of all the nation's new-found interest in research in energy.

I leave the ECE Department in good hands. We conducted a national search for department head this year and had several strong and exciting candidates. We are delighted that our own Scott Midkiff has accepted the position. Scott is an excellent choice to lead the department to increased stature and future success as we tackle the technological issues the country faces today.

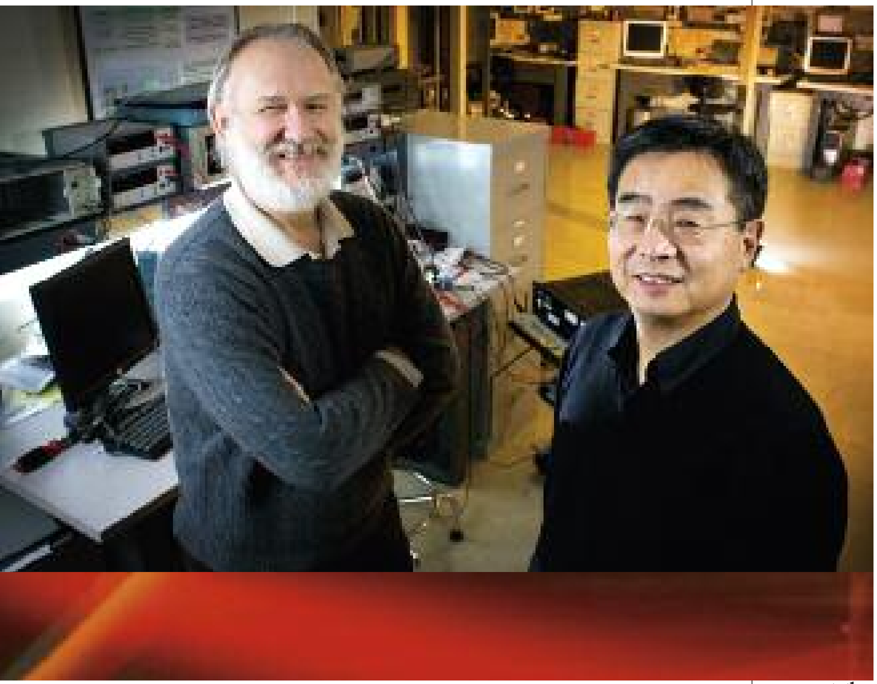
CHANGING THE WAY ELECTRICITY IS USED

Power electronics can slash electricity use 33%

A decade ago, Virginia Tech power electronics researchers adopted three verbs – standardize, modularize, and integrate – and developed a concept that not only triggered a multi-university, multi-million-dollar center, but also impacted billions of dollars of commercial technology and has the potential to slash U.S. electrical use by up to 33 percent.

Power electronics is the use of electronic circuits to convert and control electricity. The technology is used to process and convert raw, generated electricity into the voltage, wave form, and type (ac or dc) needed by today's machines, motors, and electronic equipment.

In 1998, power electronics was a $60-billion industry worldwide that impacted another $570 billion in hardware electronic sales. Power electronics systems were typically custom-designed, nonstandard units containing 300-400 electronic components. They were expensive and required long development times, plus there was little integration and fairly low reliability, according to Fred Lee, director of the Center for Power Electronics Systems (CPES).



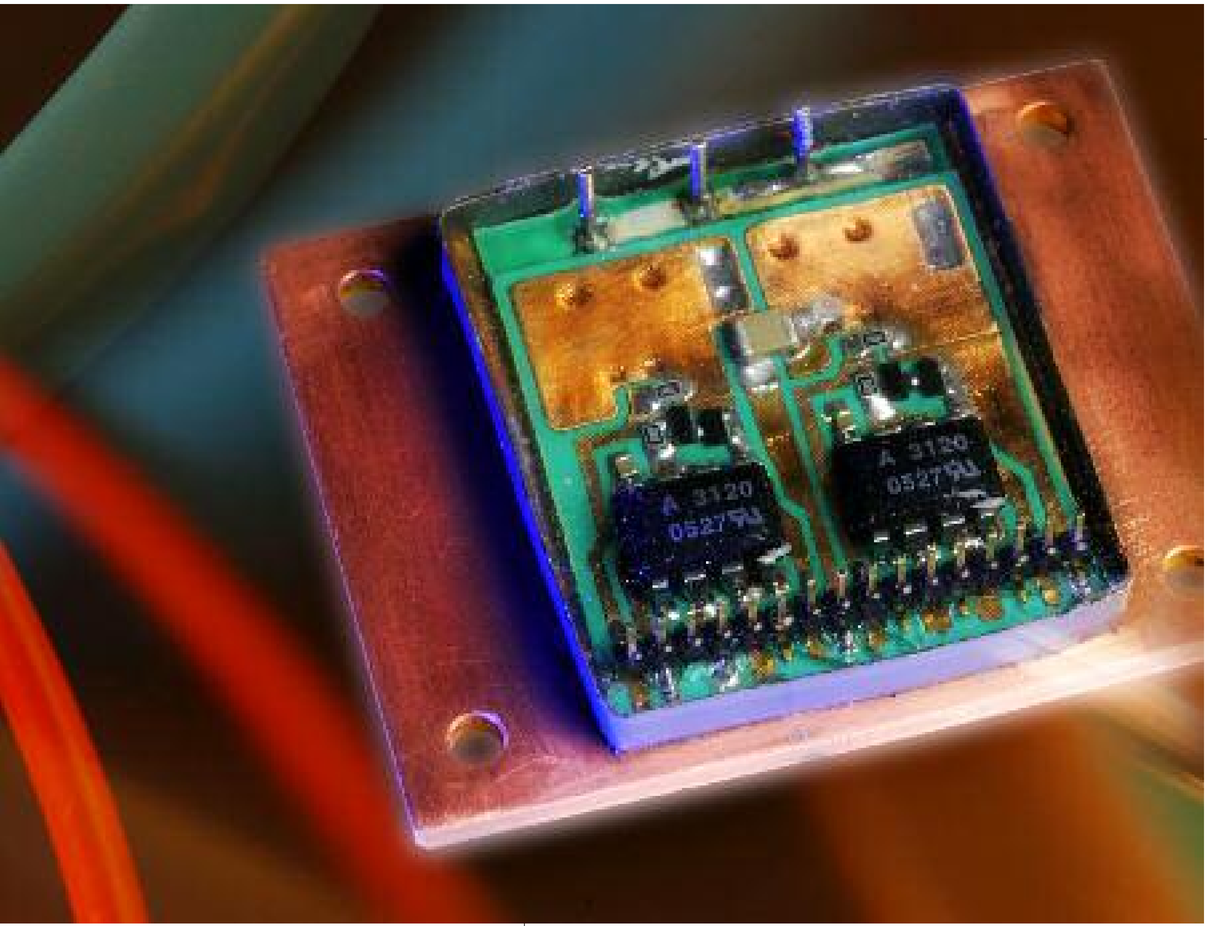
Right: Fred Lee, director of the Center for Power Electronics Systems (CPES) and co-director Dushan Boroyevich, left.

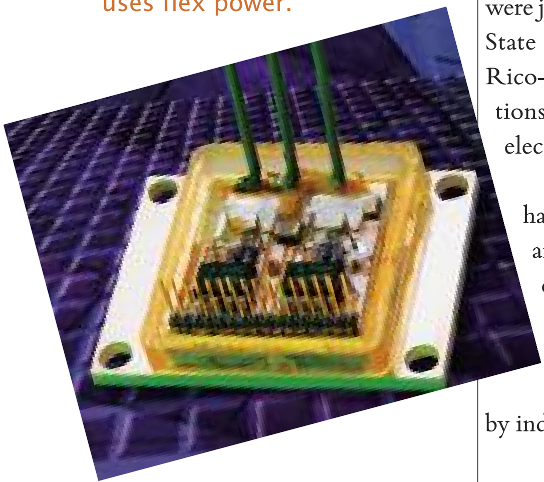
The integrated power module

In the late '90s, Virginia Tech's power electronics researchers were tackling a problem for Intel, trying to boost the speed of the power processing so the Pentium II chip could achieve its design speed. The solution came from "taking the complicated solution and breaking it into small, modular pieces, then making it scalable," Lee says. "We gave the idea – the multi-phase voltage regulator module (VRM) – to industry and today every microprocessor in the world is powered by the technology."

The VRM, he says, helped to revitalize the U.S. power electronics industry. During the '90s, power supply manufacturing was being moved offshore with the rest of electronics equipment. "The industry was bottom-line oriented, and there was little focus on research. Today, just the power modules for microprocessors alone comprise a couple billion-dollar industry."

The VRM success triggered the Virginia Tech team to propose that power electronics technology for all-sized electrical applications, from aircraft to portable phones, could be made more efficient by integrating intelligent power electronics modules (IPEM). The concept met with approval among researchers and industry.





Integrated Power Electronics Modules (IPEM) developed at CPES that could improve efficiency and reliability of future electric energy systems while decreasing costs. The top IPEM uses embedded power technology and the bottom uses flex power.

Long-term NSF support

In 1998, the Virginia Tech researchers teamed up with power electronics researchers at the University of Wisconsin-Madison and advanced power semiconductor researchers at Rensselaer Polytechnic Institute to form CPES, one of 20 Engineering Research Centers (ERC) sponsored by the National Science Foundation (NSF). They were joined by researchers at North Carolina A&T State University and the University of Puerto Rico-Mayagüez, institutions with solid reputations in undergraduate engineering and power electronics-related research.

"This is an enabling technology that could have such high impact for both energy savings and U.S. industry, that it was a perfect candidate for long-term funding," Lee explains. NSF ERC funding was a 10-year commitment, contributing $30 million to the effort. Another $47 million was contributed by industry partners and other funding agencies.

The paradigm shift

The paradigm shift from custom, complex systems to modular, integrated building blocks required technical advances in multiple areas simultaneously, from semiconductor adhesives, to system integration models. In pursuing these advances, CPES has generated more than 1700 technical papers, theses, and dissertations, 131 invention disclosures, 50 patents, and 331 licenses.

CPES demonstrated the first IPEM in 2000 and the concept moved quickly into the marketplace. Today, many power electronics firms manufacture some version of an IPEM, according to Lee. The concept has seen the most impact in three applications, he says: motor drives, electronic ballasts, and information technology. These are also three applications that can have the most impact on energy consumption.

Motor drives

Motor drives account for about 50 percent of the electricity use in the United States and have been a targeted application for IPEMs since the start, with a focus on variable-speed motors. Variable-speed drives that match the output to the load can often achieve an energy reduction of 30-35 percent. The larger motor drives that power factories and large equipment typically use variable speed technology. However, smaller applications, such as residential air conditioning and other home appliances, typically do not use variable-speed drives in this country, according to Lee.

"A constant-speed drive has a cheaper installation cost, even though it costs 30 percent more in energy use," he explains. In Europe and Japan, where energy costs are higher, manufacturers offer variable-speed equipment, and Lee expects more offerings in the United States, now that IPEMs are reducing the initial purchase cost.

The development of motor drives with integrated power electronics is a major success for the

Standardize
Modularize
Integrate

CPES integration concept, Lee says. "The University of Wisconsin had the strongest reputation in U.S. motor drives research," he explains. "Once they started working with the IPEM concept, the Wisconsin researchers developed a unique modular integrated approach in the motor. A motor was always a 'lump of iron,' plus a separate electronics drive. Now, Wisconsin has an approach that integrates both parts together. They sliced the power electronics functions into pieces and integrated the drive module with the motor module. This is a huge advance."

Electronic ballasts

The country's second biggest use of electricity – 20 percent – is in lighting. As the United States moves away from incandescent lighting, more lights will be using ballasts, which are used in fluorescent, LED, and other lighting. In 2002, CPES developed IPEM technology for electronic ballasts for high intensity discharge (HID) lamps and continues to develop technology to replace magnetic ballasts with power electronics.

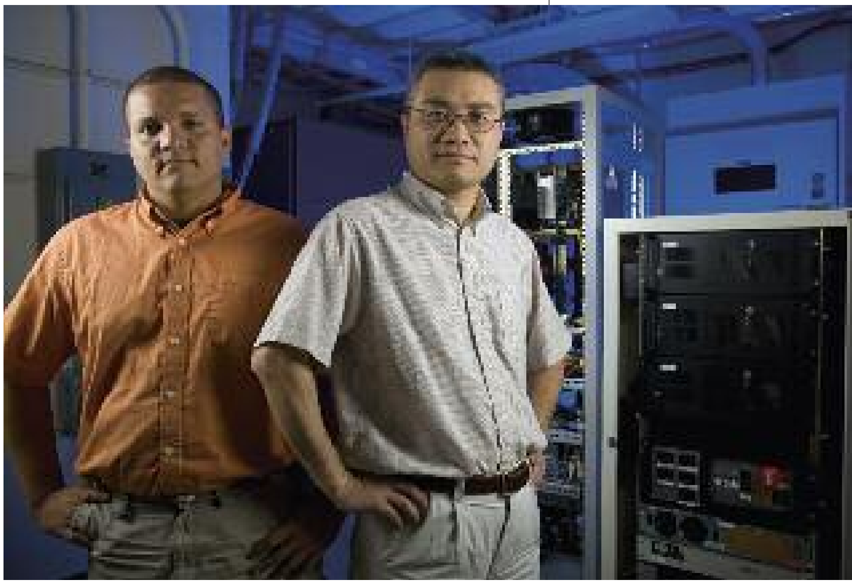
"With our developments, the electronic ballast can now compete in cost with magnetic ballasts, and it is small enough to fit into the lamp fixture," Lee says. "This will lead to even greater energy savings." He cites Tech's recent replacement of all the ballasts on campus with electronic devices and the resulting 30 percent savings in electricity usage.

Information technology

Computing technology consumes between 10-15 percent of the country's electricity. Starting with the success of the VRM, the CPES integrated module concept has taken off throughout the computing industry, Lee says. "We proved the concept with the VRM for microprocessors, then similar technology was developed for memory, servers, and other components. All the solutions are evolving around scalability, modularity, standardization, and integration. When you add in the movement to incorporating the technology in portable electronics, including cell phones, PDAs and GPS systems, that's another multibillion dollar industry zeroing in on the same solution."

The technology is currently being incorporated in the telecomm industry, he says. "It's such an obvious solution, whether it is wireless or wired. When we came up with the multiphase idea, power supplies in switchboards were very customized with no standardization." The old switchboards had converters that converted 48 volts to various other voltages, he explains. "Today, they are leveraging the VRM technologies and infrastructure developed for computers. They no longer need the highly customized and bulky 48 volts dc-dc converters often referred to as 'bricks' in the switchboard, and the industry is saving 15 to 25 percent in the cost of telecomm power equipment."

So many firms are using the concept that it is very hard to quantify the impact of the idea that triggered the technology, he says.



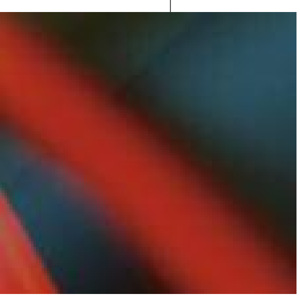
Fred Wang, right, with student Luis Arnedo, is applying the modularized power electronics technology to high-power applications that range from tens of kW to megawatts of power. Applications include ships, factories, homes, and even microgrids.

Power electronics education

The NSF funds an ERC for 10 years, averaging about 15 such centers at any one time. The goal of the ERC program is not just scientific and technological advancement, but also technology transfer and increasing the diversity of the scientific and engineering workforce. CPES has been cited as a model ERC for both education/outreach and for industrial collaboration and technology transfer.

The technology transfer is evident not just in the commercialization of so much technology based on the CPES concept, Lee says, but also through the 149 industrial internships and 250 technology transfer activities. “One of our own measures of success was to see the technology moved quickly to market,” he says.

When the ERC was first formed, few students across the country specialized in power electronics. In its 10 years of operation, CPES graduated 105 Ph.D. students and 181 master’s students. The center developed 15 new power electronics courses and 27 distance courses across the five universities, plus instituted an undergraduate minor to encourage undergraduates to enter the field.



Next up: sustainable buildings

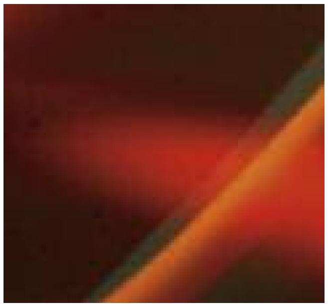
The NSF ERC funding ended in 2008, but the five CPES universities plan to continue collaborating. “Almost unanimously, we all want to stick together and work on energy efficiency. We want to tackle alternative and energy efficiency solutions,” Lee says, “and we believe that future, sustainable buildings is an ideal application.”

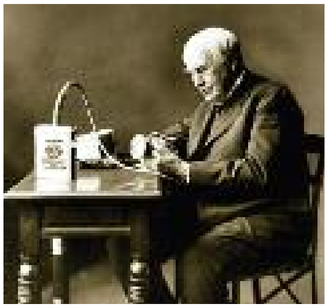
Virginia Tech researchers are developing a dc-power distribution testbed, with a high-voltage (~300 V) bus powering HVAC, simulated kitchen loads, and other major appliances; and a low-voltage (48 V) bus that coincides with telecommunications and computer loads. The system’s energy sources include a 3.5 kW wind-turbine generator, 5 kW PV solar panels, a lithium-ion battery bank for energy storage and a hybrid electric car with bidirectional energy flow.

University of Wisconsin researchers are developing a high-frequency (400 Hz or greater) ac power distribution testbed. With a high-frequency ac architecture, low-cost frequency converters can be used to efficiently power key motors in a home, such as the furnace fan, air conditioner compressor and fan, refrigerator, and heat pumps. The use of high-frequency systems may also reduce the cost of lighting converters while enabling the use of commercial-grade ac switchgear and protection devices.

Rensselaer researchers are developing an integrated energy system architecture that can provide and optimize the energy supply to portable entertainment and information appliances. The energy system module will be able to interact simultaneously with multiple energy sources, such as energy-harvesting MEMs, solar cells, and micro-fuel cells.

CPES researchers expect these efforts and others to have a major role in the country’s transition to sustainable development. “Our goal is to develop electronics that can reduce electricity use while enabling new technologies to evolve,” Lee concludes.





National Park Service

WILL EDISON WIN IN THE END?

**"Hell, there are no rules here—
we're trying to accomplish something."
—Thomas Edison**

Edison was probably right: we should use dc distribution systems, says Fred Lee, director of the Center for Power Electronics (CPES) and a University Distinguished Professor. "Using dc probably makes better sense today because of power electronics and alternative energy sources," he says.

"To run a motor today, you start with power from the ac grid and you first rectify the ac into dc," he explains. "When you rectify, you need to make a power factor correction to make sure your current works with the voltage, in phase and with a compatible wave shape." Without this correction, 130 watts that come into the home may only contain 100 that are usable.

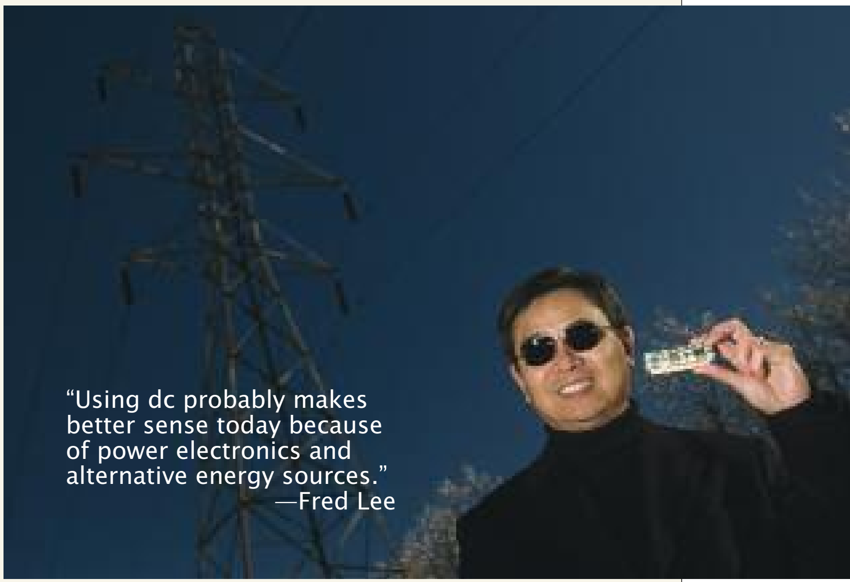
"That's a total waste," Lee says. "Taking ac, rectifying it to dc, then inverting it into ac again for a variable speed drive ... that process is totally unnecessary with dc power and alternative energy sources."

He cites another example: "Computers all run on low voltage. The first thing we do is convert our ac power to 400 V, then convert it into the 12 or so volts needed by the computer. Every conversion wastes energy. If I work with dc directly, I can save all that wasted energy."

The ac infrastructure took 100 years to build and would take years to change, he admits. He expains, however, that off-the-grid or power sub-systems may be cost-effective in the near future using dc systems.

A large data center could be converted to a dc sub-system, for example. "Data centers were all built without considering the optimal power system. The internet era erupted so abruptly that they quickly grabbed components off the shelf and set them up," he says.

Right now, data centers using utility ac install an online uninterruptible power supply to make the data center fault tolerant. They take the ac voltage, convert it to dc, then invert it back to ac. The ac then flows into the servers. Then, each server takes the ac and rectifies it into dc. "You could probably save 20 percent of the electricity by eliminating those conversions. If you add the heat and air conditioning, you can definitely save more than 20 percent," he says



"Using dc probably makes better sense today because of power electronics and alternative energy sources."
—Fred Lee

"It's all talk right now; nobody is doing anything commercially," he adds.

CPES researchers are exploring the concept of dc systems with a new dc distribution testbed being established in Whittemore Hall. Four rooms are being converted into a "living lab" for students, faculty and staff, with a conference room, library/lounge, kitchen, and utility room.

REMOVING A BARRIER TO TECHNOLOGY TRANSFER

CPES has developed an intellectual property (IP) process that is almost as fast as industry's and may be adaptable for other university research groups, according to CPES Director Fred Lee.

The NSF has cited CPES as a model Engineering Research Center for technology transfer and industry collaboration. Lee says he suspects part of the CPES technology transfer success is due to the novel process it has developed for patents and invention disclosures.

The interests of protecting IP while publishing research results in a timely manner often conflict. IP issues sometimes frustrate both academic researchers and interested industrial firms, according to Lee. Furthermore, universities typically claim ownership of all IP developed in their labs, but do not always have the resources or market knowledge to select which inventions to pursue.

In some fast-moving fields like electronics, speed can be an issue. Lee says he recalls several cases in which his team lost the patents on discoveries. "We like to publish our research discovery as fast as we can to help our graduate students. If we can't protect the idea quickly, then it becomes public domain. This is how we set our priorities."

In 2003, CPES instituted a new IP process that taps expertise from industry partners and helps university technology move quickly into commercialization. Funding for patents is contributed by a group of industrial partners called "Principal Members, and Principal Members Plus," who each contribute $5,000 a year above and beyond their respective membership contribution. Those funds are then pooled to establish the Intellectual Property Protection Fund (IPPF).

"Working with Virginia Tech Intellectual Properties (VTIP), we have established a very effective process," Lee said. When a CPES researcher develops technology that may have IP value, we send the information to the IPPF members, organize a teleconference, and ask for a vote. If the IPPF members determine it is worthwhile and has market value, VTIP sends the patent information to a patent lawyer. The legal expenses are paid from the IPPF. "Now, there is no delay; we are almost as fast as industry," Lee noted.

Each of the IPPF members gets non-exclusive, royalty-free access to the IP (without additional cost or licensing fees). "Engineers can use the technology without involving corporate lawyers and without having to develop their own proprietary technology. The firms can use the technology in any way they desire, and we don't have to go back and monitor it," Lee said. Firms that leave the program do not get any new IP information developed afterward.

"We won't get personally wealthy with this process, but it is very good for our program," Lee said. CPES receives generous industrial membership contributions in excess of $1.5 million a year. The system also negates the need to protect IP, he said. "As university professors, we don't really want to sue a company."

The system has worked well, he said. Currently, 32 firms are Principal Members and Principal Members Plus.

Visit *www.cpes.vt.edu* for more information.

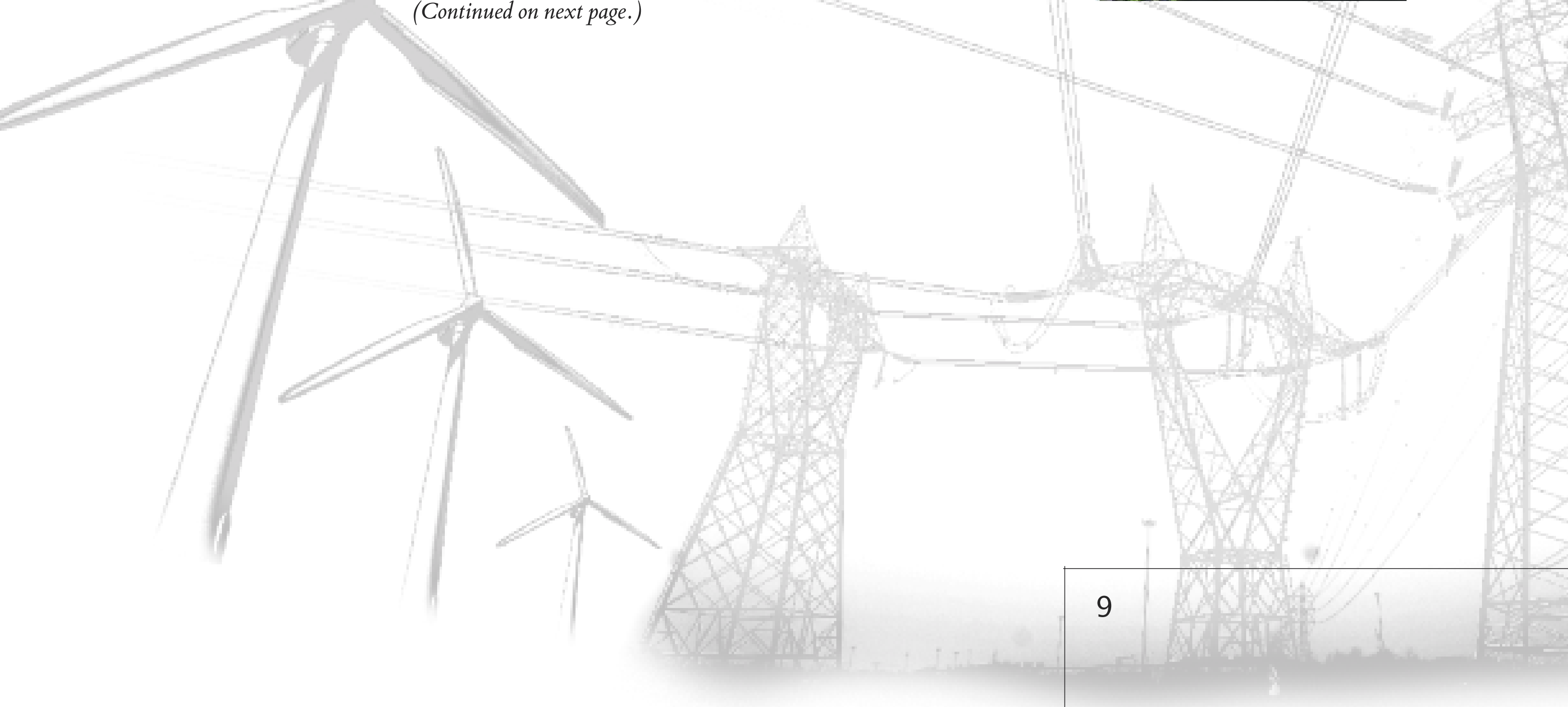
CPES has been cited by the National Science Foundation as a model Engineering Research Center for technology transfer and industry outreach.

RESILIENT SUSTAINABLE INFRASTRUCTURES

While smart grids, microgrids, and even dc-power grids are being discussed to improve the nation's infrastructure, a team led by ECE researchers is exploring how a complex systems perspective can make power and communications networks less vulnerable to catastrophic failures. They hope to ultimately develop a safety net that incorporates local alternative energy generation and energy retail markets.

The $2-million effort, headed by ECE Professor Lamine Mili, is funded by the National Science Foundation (NSF) under its Emerging Frontiers in Research and Innovation program. ECE's Sandeep Shukla is a co-principal investigator (PI), along with Michael von Spakovsky of mechanical engineering, Benjamin Hobbs of Johns Hopkins and Arnold Urken of Stevens Institute of Technology. ECE Professor Yilu Liu is also on the project.

"Our goal is to improve the resilience of interdependent complex networks, such as power and communications, when facing catastrophic failures and natural disasters," Mili said. *(Continued on next page.)*



“...the local microgrids could tap the smaller amounts from alternative energy sources to keep the lights on locally...”

Rob Roberts

Lamine Mili

Sandeep Shukla

Yilu Liu

“Currently, the monitoring, protection, and control of electric power systems rely heavily on computer-based communications networks. Consequently, the failure of one can affect the functioning of the other. A series of cascading events may have a catastrophic impact on the whole society,” he explained. The risk of such events is increasing, he said, because of the current trend in operating infrastructure systems closer to their stability and capacity limits.

Simple rules grow complex systems

When viewed locally, complex systems seem to have grown by basic simple rules, explained Shukla, who is a co-PI. “For example, a network grows by simply connecting another node to existing nodes, or a forest grows by having its seed grow more trees in its neighborhood,” he said. “Such simple local phenomena give rise to very complex dynamics.” Fractals are an example of such a system.

Complex systems that develop without central planning are usually tolerant of defects and faults that are expected or planned for, but are not resilient to unanticipated problems. “Such systems are susceptible to cascading failure – like a wide area blackout on the power grid – where a failure in one location spreads through domino effect to cover larger and larger parts of the system,” Shukla said.

Extending the HOT model

The problem gets more complicated when two systems are intertwined, as with the power and communications networks. The team has selected the highly optimized tolerance (HOT) model, which was developed for a single complex system, and plans to extend it to accommodate the interdependencies of the power and communications systems subject to cascading events within and across these infrastructures. They will validate their new models with data from the North American Electric Reliability Corporation (NERC) and from Central Florida and Southern Brazil testbeds.

“The reason for such modeling,” Shukla said, “is that by understanding the dynamics, we can take safety measures against the unanticipated failures.” Since both the communication network and the power grid are complex systems and have cascading failure possibilities, “we have to optimally place guards to contain the failure locally. This must be done in a way that the cost of guarding for fault containment does not exceed the projected cost of failure. In our costs, we include resources, dollars, and human lives,” Shukla said.

Once the possibilities and vulnerabilities can be measured and protective actions identified, a computerized control system will be developed. The team from Stevens Institute of Technology is working on software agents and decision theories that will enforce the protection mechanism, look for vulnerabilities and make decisions about emerging problems.

Microgrids with alternative energy sources

The team anticipates that local distribution grids incorporating non-traditional energy sources – called microgrids – may be part of their strategy, according to Shukla. "In a cascading blackout, if a part of the power grid gets disassociated from the rest of the grid, the local microgrids could tap the smaller amounts from alternative energy sources to keep the lights on locally," he said. Furthermore, they will provide a power system with an enhanced level of resiliency that will enable it to recover from a blackout in a speedy and less costly way.

A sustainable power grid involves not just reliability and resiliency issues, but also environmental and economical issues. Michael Von Spakovsky of mechanical engineering is exploring various scenarios of fuel mix and technologies that are more efficient and generating less pollutants and greenhouse gas emissions.

The revenue model for such locally generated energy provided by local energy sources should be economically viable without public subsidies. So, economists and environmentalists from Johns Hopkins are on the team, working on new environmentally friendly electric energy market models. "We expect the communication network to play a crucial role, as the price of microgrid-enabled energy will be based on auction strategies in virtual markets and the price negotiations will be done over the microgrid's associated communication network," Shukla said.

Meeting the grand challenge

All of the efforts, from network stability to auction markets and environmental assessment, are needed to meet what Mili calls the grand challenge. "We need to discover how to design, manage, and operate in a robust and sustainable manner such a complex multilayered system of systems, where each layer contains millions of components switching on and off in a random manner and spreads over a continental or global scale," he said.

"This work will provide a basis for using the communications

Courtesy of James S. Thorp

Courtesy of James S. Thorp

Fractals are well known representations of complex systems. The two shown here describe the dynamics and complexity of the power system. Top: A low resolution representation of a true fractal, showing that the computations in the power system are not necessarily clear cut. Bottom: A truncated fractal color coded according to where the energy flows.

90%+ Less Energy

EXTREME VOLTAGE SCALING

Improving security of embedded systems while cutting energy use by 90%+

ECE's Leyla Nazhandali hopes to cut the energy consumption of some embedded systems by more than 90 percent with an extreme version of a well-known power-saving mode that is currently used in many digital devices including laptops. She is applying subthreshold voltage technique, which she expects will also improve the security of embedded microprocessors by protecting them from power side channel attacks.

She received a National Science Foundation (NSF) Faculty Early Career Development Program (CAREER) Award to support her efforts. CAREER grants are NSF's most prestigious awards for creative junior faculty members who are considered likely to become academic leaders.

Courtesy of the U.S. State Department

Operating in the twilight zone

In subthreshold operation, the voltage is reduced below the level that turns transistors on and off. "Subthreshold voltage technique can be considered the extreme case of voltage scaling, which lowers the voltage source of the hardware," she says. "As you reduce the voltage, energy consumption is reduced quadratically. That is a very good gain for what you are losing."

Traditional voltage scaling typically is limited to about half the circuit's nominal operating voltage. In subthreshold-voltage design, however, the voltage is reduced below the level needed to turn the system on.

"Designers typically avoid this twilight zone region," she explains. When you operate in this region, the switch is not completely off and you are left with leakage current."

The transistors are not switching as usual, but are able to complete the computation by modulating the leakage current that passes through them.

"Your computation is fine, it's just much slower," she comments. "In fact, the performance degradation becomes exponential in subthreshold region as you lower the voltage."

Parallel construction

Subthreshold-voltage operation with its unique advantage of lowering the power consumption by several orders of magnitude has opened new avenues of low-power design, according to Nazhandali. Most of the work to date has been simple FFT chips and microprocessors with low performance. "They have been targeted for applications that can tolerate a low speed, such as environmental or structural health monitoring sensors that wake up once a day, then go back to sleep," she explains.

Her goal is to achieve the energy savings through subthreshold operation, but boost the performance by using parallel coprocessors – making it possible for applications such as image and signal processing. "The subthreshold cores combined will deliver the performance expected from a single superthreshold core while collectively consuming less than 10 percent of its power consumption," she says.

Nazhandali's team simulated a prototype design for a popular DSP application. Using the same settings as a superthreshold embedded system, the multi-processor system at subthreshold will last 30 days running on a AA battery. The compar- *(Continued on p. 15)*

Top: Leyla Nazhandali won an NSF CAREER award to pursue work in subthreshold voltage investigations.
Bottom: Nazhandali prepares a circuit board for a hands-on unit to introduce younger students to embedded systems technology and design.

Encouraging women in computer engineering

Christopher Andrews

SMART VEHICLE PROJECT

Students are asked to program a "smart" car that was built by Nazhandali's team to achieve several tasks including steering over a curvy black line. The car sports two independently controlled motors. By turning one motor slower than another, the car can steer left or right. The car has two infrared sensors that can detect if they are over the black line. The students do not need programming skills and only need to solve the problem in general terms, such as deciding which motor should run faster.

Students eventually improve on their solution as they try to increase the speed of the car and steer through sharper turns. In addition to learning about how embedded microprocessors can better our lives, the students discover actual physical constraints when designing such systems, including the tradeoff between speed of the car and accuracy of steering.

Every CAREER grant has an educational component, and Nazhandali's goal is to encourage women and underrepresented groups to pursue studies in computer engineering. "The underparticipation of women and minorities in computer engineering significantly impacts society," she says. "It threatens the competitive vitality of the workforce and the profession, limits the creativity of future technologies, and restricts employment opportunities of more than half the U.S. population."

From a number of studies on the issue, she has concluded that illustrating how computer engineers benefit society is important to recruiting and retaining women students. "We suspect this is important for all other students as well," she says. She also believes that a lack of role models and mentorship is an important reason why women leave the field.

To combat this problem, she is developing an outreach program she calls "embedded for life." Her team is developing three discovery-based teaching modules for pre-college and early college students. Each module presents a problem that can be solved with embedded systems and offers a hands-on project that engages students in problem solving with embedded systems.

The first module involves highway safety, discussing embedded systems such as anti-lock brakes, electronic stability control, and cruise control. Students then are asked to program a "smart" car to steer along a black line. Another module describes using biometrics for security authentication and involves the students in work with photo sensors and simplified fingerprints.

Nazhandali is arranging for the modules to be used with ongoing Virginia Tech campus outreach programs sponsored by the National Society of Black Engineers, the Society of Women Engineers, Association of Women in Computing, and Center for Enhancement of Engineering Diversity. The modules will also be offered at the national level in collaboration with the IEEE Teacher in Service Program.

The smart vehicle project won an IEEE Real World Engineering Award in 2007 and is posted at *www.realworldengineering.org*.

Freshman engineering students work with the smart vehicle project developed by Nazhandali.

SEEKING THE ENCRYPTION KEY IN SUB-THRESHOLD VOLTAGE CIRCUITS
Nazhandali meets with Steven Griffin, an undergraduate working in her laboratory. Griffin spent last semester using attack techniques to attempt to discover the encryption key in sub-threshold voltage circuits. This semester, he is developing a hands-on project for high school students to illustrate how important encryption is to everyday life. Griffin says that doing research as an undergraduate helps the students learn the skills they've used "while developing new and cutting edge ideas that may even have real world applications."

able conventional superthreshold system will last 10-12 days. "That's a big difference. The longer battery use is particularly important in applications where battery access is difficult, such as heart defibrillators or remote operations," she says.

While the energy savings are significant, there are several challenges to overcome with her technique. Her 16-core system is six times larger than a conventional system. "We are working to improve this, but the larger chips will still be the same size or smaller than the battery. When you add the sensors, the chip size becomes even less important," she says. Potential applications include handheld land mine detectors and security cameras.

Thwarting side channel attacks

Saving energy isn't Nazhandali's only goal. She also wants to improve the security of embedded systems. She expects her technique will help protect against power side channel attacks in which the secret key and data can be inferred by analyzing the power consumption pattern.

"In subthreshold operation, there are fewer peaks, because most of the power is leakage power. The power profile is not as revealing as with superthreshold technology," she explains. "We can more easily hide the information that is given away by power consumption in regular designs."

Her designs and architectures are partitioned into security-critical and non-critical regions, with security-critical running at subthreshold voltage. "You need very sensitive tools in order to measure power consumption of a device running at subthreshold. Plus, we can drown out the subthreshold operation with higher power elsewhere and still remain in low power."

E-passports and credit cards

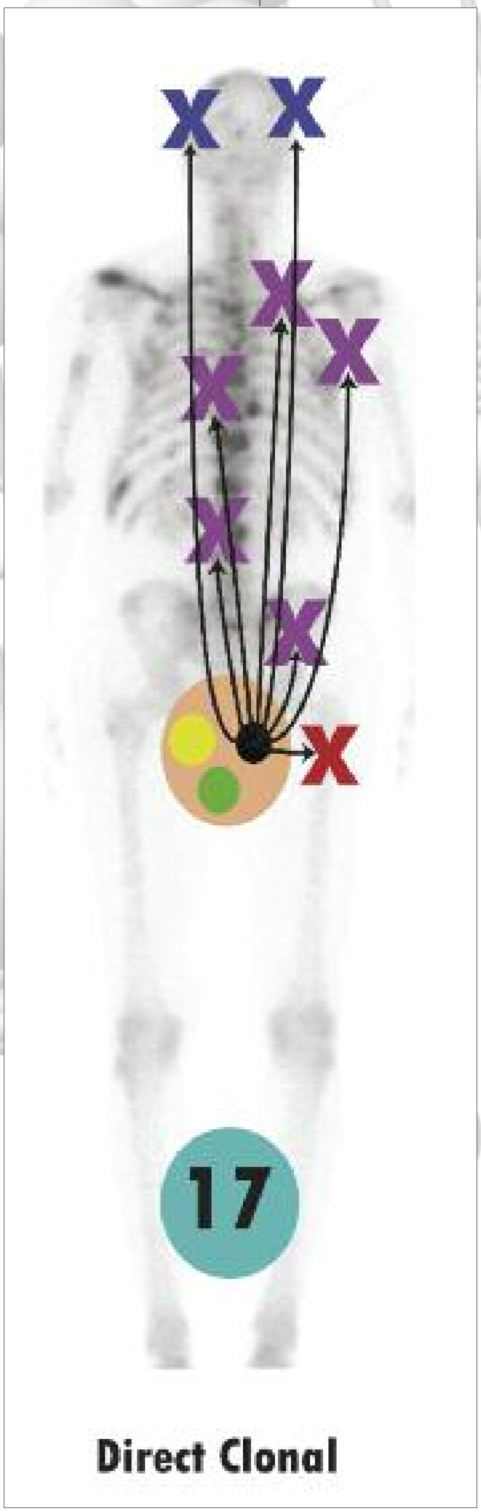
While subthreshold technology can improve security and energy use, it is slower than conventional operation. "We are initially targeting applications where security is important, but speed is not," she says.

She suggests e-passports and credit cards as ideal candidates for the technology. "Being low-power is an important factor for e-passports as they are either running on a small battery that should last as long as the passport is not expired or they are getting power from tiny amounts of remotely induced power. However, speed is not critical because the interview and questions take longer than processing the passport," she explains. "When security is very high, you are able to compromise on speed."

Before the technology can be widely used in any application, however, "we need to develop architectures that can exploit the concept, along with design and simulation tools," she says.

Nazhandali is collaborating with fellow ECE CAREER award recipient Patrick Schaumont on the security issues. "This is one of the wonderful aspects of Virginia Tech," she says. "I wasn't involved in security issues, but after talking with him about his work on side-channel attacks, I realized my technique had strong security potential."

NEXT GENERATION GENOME



Cancer is notoriously different for every patient. Many men who get prostate cancer die of other causes before the cancer grows harmful. Other prostate cancers are aggressive, grow quickly, and spread to other parts of the body. Ovarian cancer, although noted for its lethal character, also has variable degrees of aggressiveness. If doctors could know the aggressiveness of each patient's cancer, treatment could be tailored for better results.

A team of ECE researchers led by Yue (Joseph) Wang has helped identify biomarkers that can differentiate between aggressive and slow growing prostate cancers and between different levels of aggressiveness in ovarian cancers.

Wang's group at ECE's Computational Bioinformatics and Bioimaging Laboratory (CBIL) applies electrical and computer engineering methodologies, computational, and modeling tools to solve biomedical problems that influence cancer and diabetes, and to gain a deeper understanding of the structure and function of the genome. Wang collaborates with medical researchers at Georgetown, Johns Hopkins, and Wake Forest universities as well as with National Children's Hospital.

CBIL is based at the Advanced Research Institute (ARI) in Arlington, Va. and its faculty and students conduct about $1.2 million in research each year.

A team of ECE researchers led by Yue (Joseph) Wang has helped identify biomarkers that can differentiate between aggressive and slow growing prostate cancers and between different levels of aggressiveness in ovarian cancers.

Biomarkers for aggressive cancers

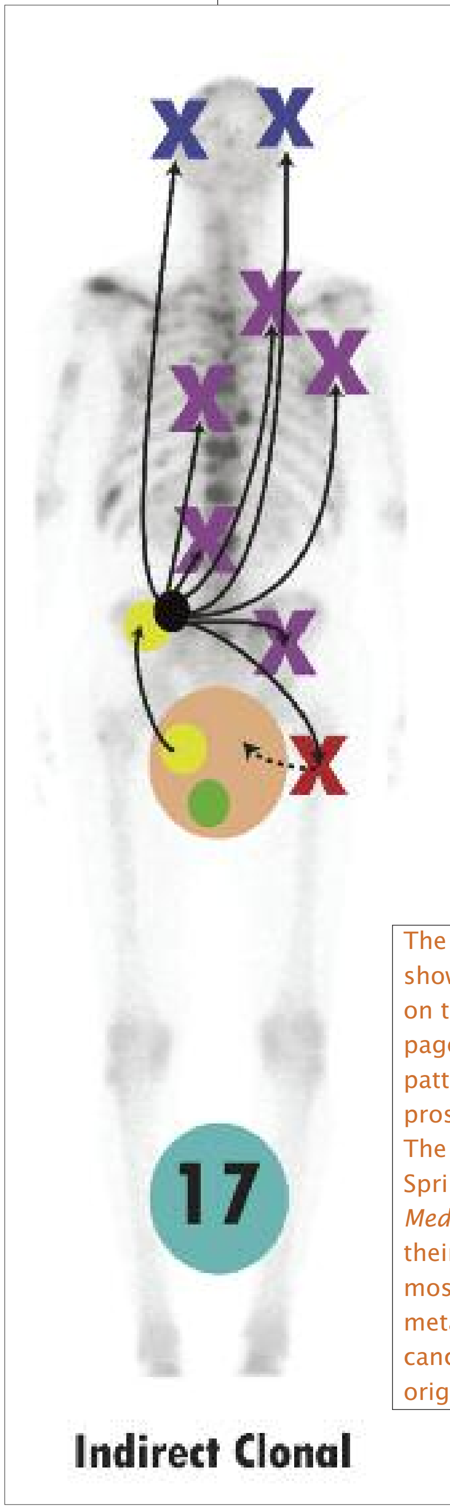
The biomarkers for aggressive prostate and ovarian cancers are based on different copy numbers of a segment of DNA. Humans should normally have two copies of each strand of DNA, Wang explains, one from each parent. "This is a nice, built-in redundancy that engineers can appreciate. It helps keep our system stable," he says. "If one copy gets deleted for some reason, you still have a copy to sustain normal function."

Researchers continue to delve deeper in the human genome and recently discovered that strands of DNA segments can get partially or completely deleted (or in contrast amplified) and that many differences can exist between populations and individuals. These changes can be inherited and are called copy number variation (CNV), or, if they occur through local mutations after birth, they are called copy number alternations (CNAs).

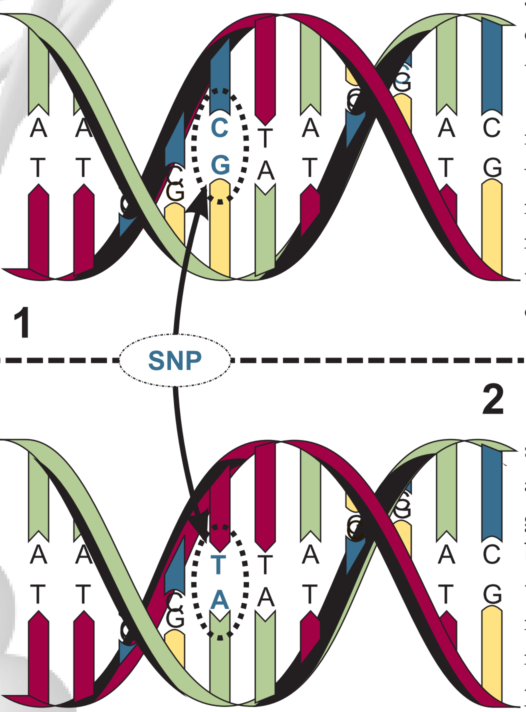
Copy number changes can cause disease. Wang provides an example of critical cancer suppressor genes in the human body: "If that gene or part of that gene has been deleted, the person's risk of cancer increases. If one copy is deleted, the person may be ok, but if both get deleted, the person will almost definitely get cancer."

Cancer genes – called oncogenes – also exhibit copy number changes. "Once a person has cancer, the cancer evolves and the oncogene gets amplified. A gene may have three, four, or five copies," he says. "We have seen either some deletions or amplification in different DNA segments."

The segments contain sequences of nucleotide base pairs, whose measured hybridization intensities can be treated as signals by electrical and computer engineers. Wang's team applies signal processing, pattern recognition, and computational modeling to analyze the sequences in the cancer genes to extract the gene copy number differences. "What we do is to identify where those changes occur and how often," he says. *(Continued on p. 18)*



The two figures shown here and on the opposite page show potential patterns of metastatic prostate cancer spread. The team reports in a Spring 2009 *Nature Medicine* article that their results show most, if not all, metastatic prostate cancers have clonal origins.



The molecules that make up DNA are called nucleotides, represented by the letters A, C, G, and T. When the sequence of nucleotides differs between two or more genomes, it is called a single nucleotide polymorphism or SNP (pronounced snip).

Wang is collaborating with three groups on this problem. Working with Dr. Steve Bova at Johns Hopkins, the team is investigating the patterns in copy number changes between metastatic prostate cancers across subjects. “Our research shows that the copy number changes are structural markers,” he says. The results of this research will be published in the up-coming issue of Nature Medicine.

Wang is also working with Dr. Ie-Ming Shih at Johns Hopkins on ovarian cancer. The team collected a group of patients that have highly aggressive and less aggressive ovarian cancers. “Our analysis clearly revealed that the copy number changes or the mathematically defined genomic instability index clearly can differentiate between aggressive and less aggressive forms of ovarian cancer,” he says. The research will be published in the upcoming issue of Cancer Research.

Wang is involved in a third study of the copy number analyses with a group at Wake Forest University led by Dr. Jianfeng Xu. Instead of studying metastasis, they are exploring whether they can identify the genetic origin of the prostate cancer, that is the consensus regions in relation to either oncogenes or cancer suppressor genes.

Next generation genome

Wang’s work with copy number changes stems from a broader effort called the next generation genome. “When the mapping of the human genome was completed, we thought that the basic building blocks were known and we just needed to figure out how they worked,” Wang says. With microarray technologies, researchers began studying downstream effects, such as gene expression, proteomics, and metabolism and changes in the cell.

“We hoped we could use reverse engineering and the vast new measurement capability to understand the initiation and progression of disease. It turns out it may not be so simple,” he says. “In the past eight years, biomedical researchers have made many discoveries, but unfortunately, all the biomarkers from molecular analysis can only explain less than 15 percent of common diseases.”

Now, many researchers are going back to the genome again, studying sequencing. “We’ve come full circle,” Wang says. The next generation sequencing is moving in multiple directions. One is the copy number variation. Another is the investigation of differences on a single nucleotide base pair of DNA. When a single nucleotide, an A, C, G, or T in the genome is different between members of a population, it is called a single nucleotide polymorphism, or SNP (pronounced snip).

Genetic information as signals

Wang’s team has several projects using bioinformatics to analyze SNPs. They are working with Wake Forest researchers (a team led by Dr. David Herrington) to understand SNP influence on cardiovascular disease and (with a team led by Donald Bowden) in populations with high incidence of diabetes, such as African Americans and Hispanics. They are also working with Eric Hoffman at Children’s National Hospital in Washington, D.C. to study diabetes in young children. “Because of the morbidity of metabolic syndrome, diabetes is increasingly important. We want to understand it and find ways to prevent and treat it,” Wang says.

The difficulty with SNP research is its complexity, Wang says, noting that there are an estimated 3 billion nucleotides in the human genome. “When we first worked analyzing genes with microarrays, we dealt with about 30,000 genes and had to find the 50 genes responsible for the issue being studied,” he says. Gene chip technology has changed dramatically in the past five years to where an SNP microarray can process 1 million SNPs, “and we have to find 10-15 causal SNPs. It’s extremely difficult if not impossible.”

The combined effects of SNPs add to the complexity of the problem. “When we find two, or three, or five SNPs working together, we can identify their nonlinear, higher order interactions within relevant biological pathways. We are still at the beginning of understanding the form and order of the complex gene-gene or gene-environment interactions,” Wang says.

A SNP sequence, or signal, is intrinsically digital, according to Wang. “They are not continuous. This makes it a good, firm playground for us electrical and computer engineers,” he says. Sometimes even a single SNP or a subset of SNPs cannot explain the whole issue, so researchers look at the construct’s alterations. “We need to look at how and which part of the genomic waveform or sequence they have changed,” he says.

Wang’s dream is a personalized medicine in which doctors can precisely determine how an individual patient’s cancer or other disease will behave, then target a precise treatment plan based on expected outcomes. He is working to help achieve that dream, but also enjoys the fun of solving a mystery. "I have so much curiosity about the biological system," he says.

Decoding the genome's software

That curiosity is leading him into a third area of research called epigenetics, which he describes as the software of biology. "The genome, the DNA, the downstream effects on gene expressions, proteins, and metabolic processes — those are all the hardware," he says. "We know little about the software that works on the combined genetic and environmental base to determine various complex phenotypes."

Wang and his wife have sons that are identical twins. "They have identical DNA and come from the same cell, but they are not the same person. This is an indication that the hardware of the genome in the cell nuclei does not determine everything," he says. He is interested in helping to figure out the mechanisms that guide the human genome to develop a complete organism.

"This is going to be challenging," he says. He describes two mechanisms that researchers currently suspect might explain how the software works with the hardware to determine which characteristics are expressed by the genome in a particular cell, organism, or individual. One mechanism, called methylation, could control how a gene is turned on or off. The other mechanism, called histone modification, can affect a gene's activity level. "This is the fine tuning mechanism."

Wang is developing a project with Leena Clarke of Georgetown University Hospital to investigate the epigenetics effect on breast cancer. "We want to figure out how the software works so that a prevention strategy can be developed," he says. The epigenetics effect would occur during the developmental phases. "Epigenetics are more active during youth – when the human genome is trying to develop a fully mature human being." During puberty, epigenetics are active in transforming stem cells into mature mammary glands.

"We believe that if the development during puberty is complete, which is normal development, there is much less risk of breast cancer later," he explains. "Some girls have denser breasts, indicating that development wasn't as complete. Why is that a higher risk? Because that particular person has a lot of stem cells left over." Stem cells can easily become any kind of cell, including cancer.

Rob Roberts

Wang's dream is a personalized medicine in which doctors can precisely determine how an individual patient's cancer or other disease will behave, then target a precise treatment plan based on expected outcomes.

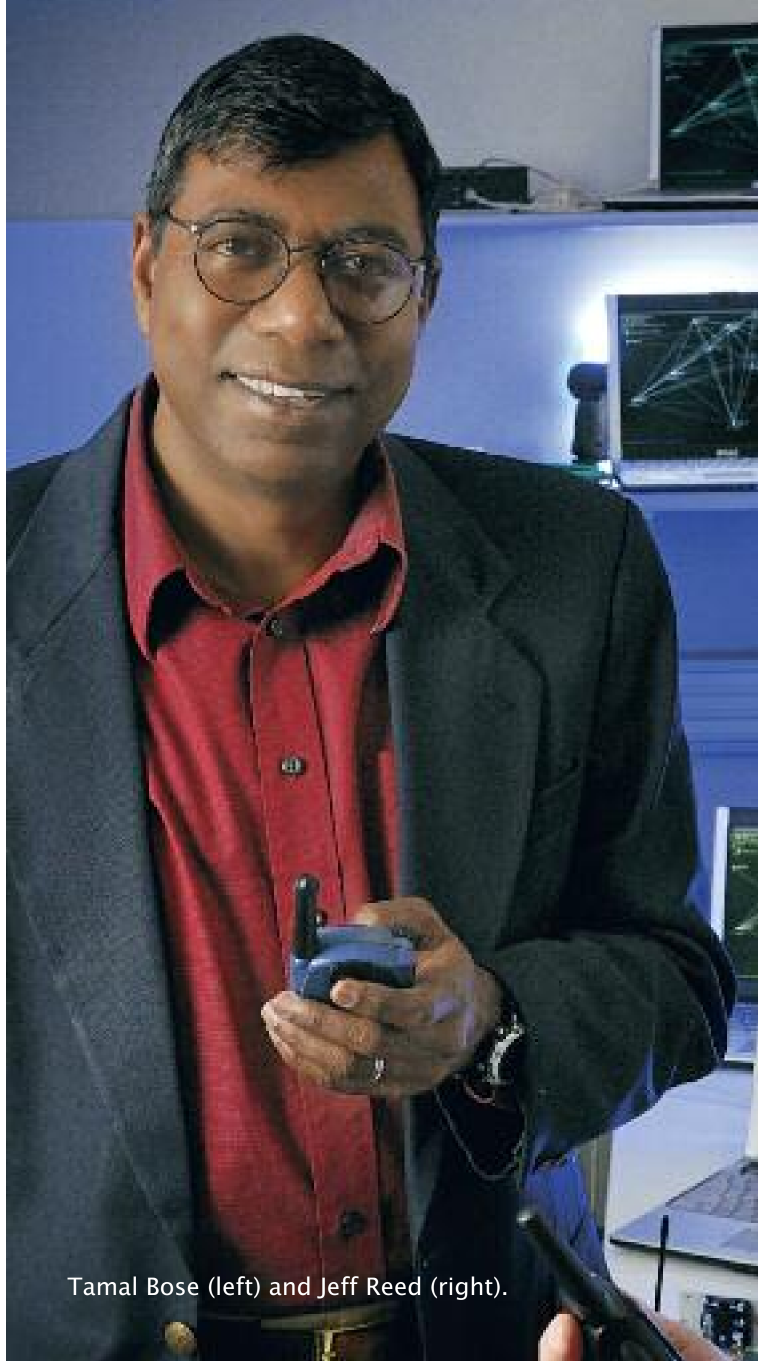
The transformation from stem cell into mammary gland cell would be heavily affected by epigenetics. "If the regulators – DNA methylation or histone modification – malfunction, we end up with enough leftover stem cells to cause problems later," he says. "We are trying to investigate which markers, which segment of DNA, is affected by methylation or modifications."

Wang describes how many areas of investigation have opened up for electrical and computer engineers in biomedical research. "We face an

For more information:
www.cbil.ece.vt.edu

COGNITIVE RADIO GOES JAMMIN'

According to the Cyberstates 2008 report by the AeA (formerly American Electronics Association), Virginia has the highest density of high-tech workers in the country. Initiatives across the state aim to build on this base and develop the technology that keeps Virginia firms competitive. ECE's Tamal Bose is working on two projects with firms in central Virginia — jammers for IEDs and remote kill switches with geolocation technology.



Tamal Bose (left) and Jeff Reed (right).

Tamal Bose is an expert in signal processing, with funding support from NASA, NSF, CAER, Rockwell Collins, U.S. Army, DISA, and ICTAS.

From jamming radio-triggered explosives to building the country's first-of-its-kind cognitive radio testbed, Tamal Bose is applying signal processing technology to business demands of today and to the needs of tomorrow's technology.

Bose's team is working on jamming and kill-switch technology that will help build the technology and competitive base of Virginia firms. The projects are funded by the Center for Advanced Engineering and Research (CAER), an organization that teams university research with growth industries in central Virginia.

Cognitive jammers

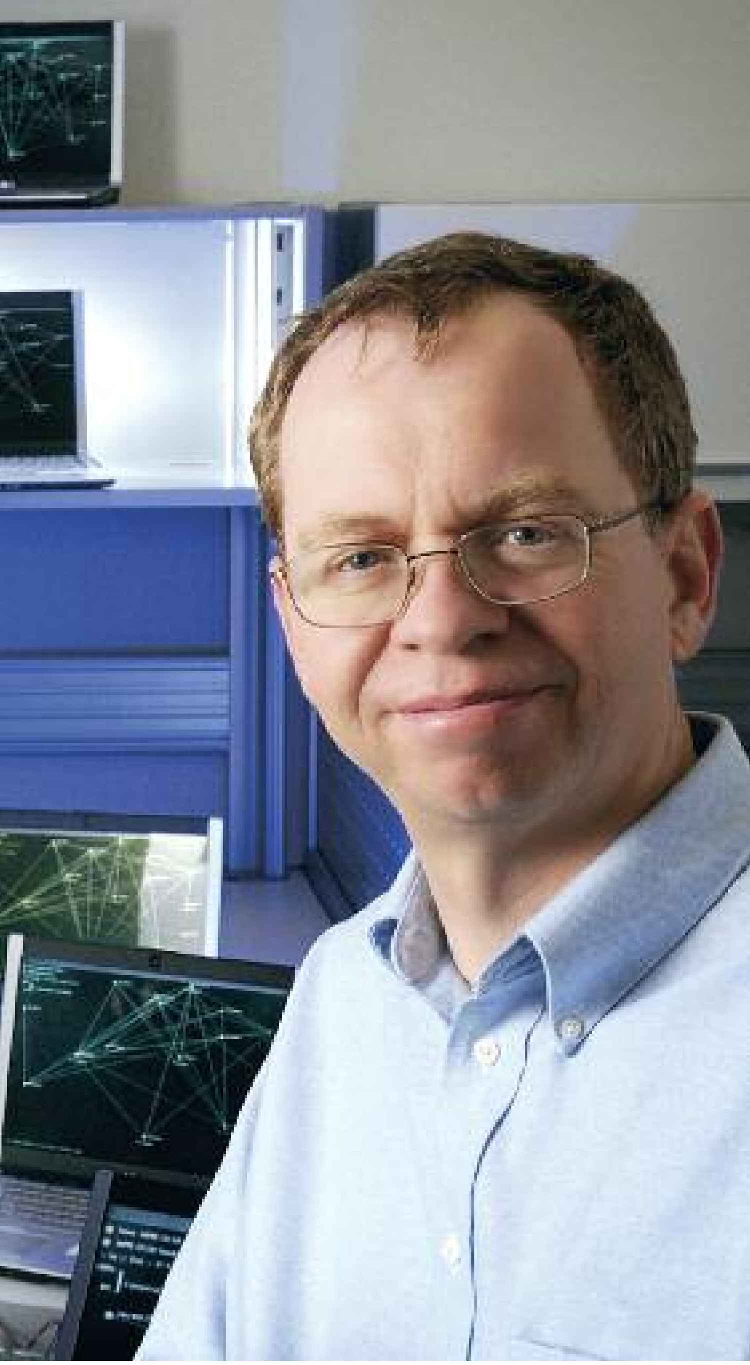
Bose is working with Advanced Management Technology, Inc., (AMTI) to create smart, collaborative jammers that prevent detonation of radio-triggered IEDs (improvised explosive devices). The electronic triggers for IEDs are often radio signals, according to Bose.

"By using cognitive radio techniques, we can design smart jammers that don't wipe out the entire frequency band," he said. "Instead, the jammer can look at the statistical properties of the signal and decide what to jam and what not to jam. They learn from their past experience in the radio environment."

Jammers have been used with convoys in Iraq, he noted. "They have used jammers to create a bubble around the convoy, but communication within the convoy could be disrupted. With smart jammers, communication does not get disrupted and enemy communications can be jammed without them realizing it," he said.

Wireless features for kill switches

Another business development project – with Blue Ridge Technologies – involves designing an architecture for incorporating wireless technology in a remote kill switch. Most electrical kill switches have a hard physical interface between the device and the controller or use low power, short-range, wireless technologies.



"This technology would use existing networks to remotely control equipment," Bose said, adding that applications would be in commercial, residential, industrial, and military situations. "Leasing and rental firms would like to be able to deactivate equipment with past due payments, for example. Or large industrial complexes can shut down critical equipment from a central location during emergencies." The kill switch would include geolocation technology so that the firms can locate their equipment and disable it when needed.

The challenge is including all the features, but keeping it extremely simple to use. "If it is too complex, it won't be used; also it will be more expensive," he said.

For more information on Wireless@VT, please visit *www.wireless.vt.edu*. For more information on WICAT, visit *www.wicat.poly.edu*. For information on CAER, please visit *http://region2000.org/the-caer.html*.

Cognitive radio network testbed

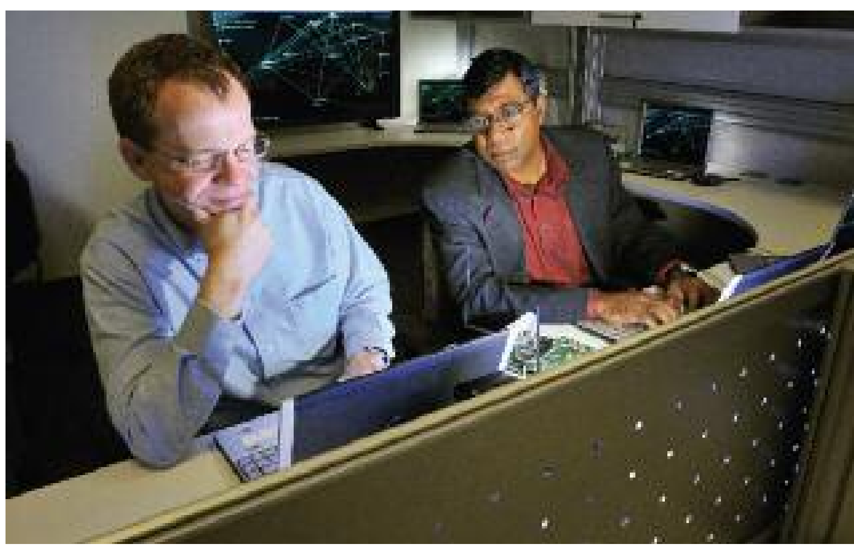
Bose is co-director of Wireless@Virginia Tech and is involved in building the teams and the technology for large research efforts in wireless communication. He serves as the lead investigator at Virginia Tech for the Wireless Internet Center for Advanced Technology (WICAT), headed by the Polytechnic Institute of New York University. WICAT is one of 40 I/UCRC multi-university research centers funded by the National Science Foundation (NSF).

Virginia Tech's involvement with WICAT focuses on cognitive radio based wireless networks and building a cognitive radio network testbed.

The testbed will be the first of its kind in the country, employing 48 cognitive radio nodes in the ceiling of the new ICTAS (Institute for Critical Technology and Science) building on campus. Built with funding from ICTAS, the testbed is currently six nodes, but with a new $347,000 DURIP award from the Department of Defense, the system will be expanded this year. Jeff Reed is the principal investigator, and Bose is co-investigator.

The testbed will be used for experiments such as dynamic spectrum access, where secondary users share the same frequency as licensed users. "We'll be able to do jamming projects, test interoperability of different radios, and test the effectiveness of algorithms for many different applications," Bose said.

Wireless@Virginia Tech is also hoping to make the testbed a community resource, allowing groups across the country to log in and control the nodes remotely.



Reed and Bose examine the features of nodes that will be installed in the ceiling of the new ICTAS building.

Making Assistive Technology

ENGINEER-FRIENDLY

Commercial software was costly, hence, Open Scan & Read was born.

Assembling a team of five undergraduate cohorts with strong communication and engineering skills, Grieves set about investigating existing solutions for students with disabilities, particularly learning disabilities.

Jason Grieves (ECE '08) loves a challenge. Legally blind for his first 16 years, Grieves and his family were told he'd never function without his thick lens glasses and that getting his high school diploma would be extremely difficult. He enlisted the help of friends, family, faith, and assistive tools – and graduated first in his Chesapeake, Va., class.

Wearing contact lenses but still with limited sight, Grieves decided upon a career perfecting assistive technology for students with disabilities and enrolled at Virginia Tech. He majored in computer engineering, although some warned that visually impaired students aren't built for engineering and math – complicated equations and block diagrams seem inherently visual and aren't easily translated by computerized assistive technology.

"But I knew tools could be developed," Grieves said, "and I have a passion to help others."

Grieves did a joint internship with Microsoft and the U.S. Patent and Trademark Office, working with students with a variety of disabilities. Then he worked with IBM and, finding their AIX servers had no assistive tech support, worked to remedy that. He also served on the Virginia Tech's Americans with Disabilities Act board and trained students with a variety of disabilities at the university's Assistive Technologies Lab.

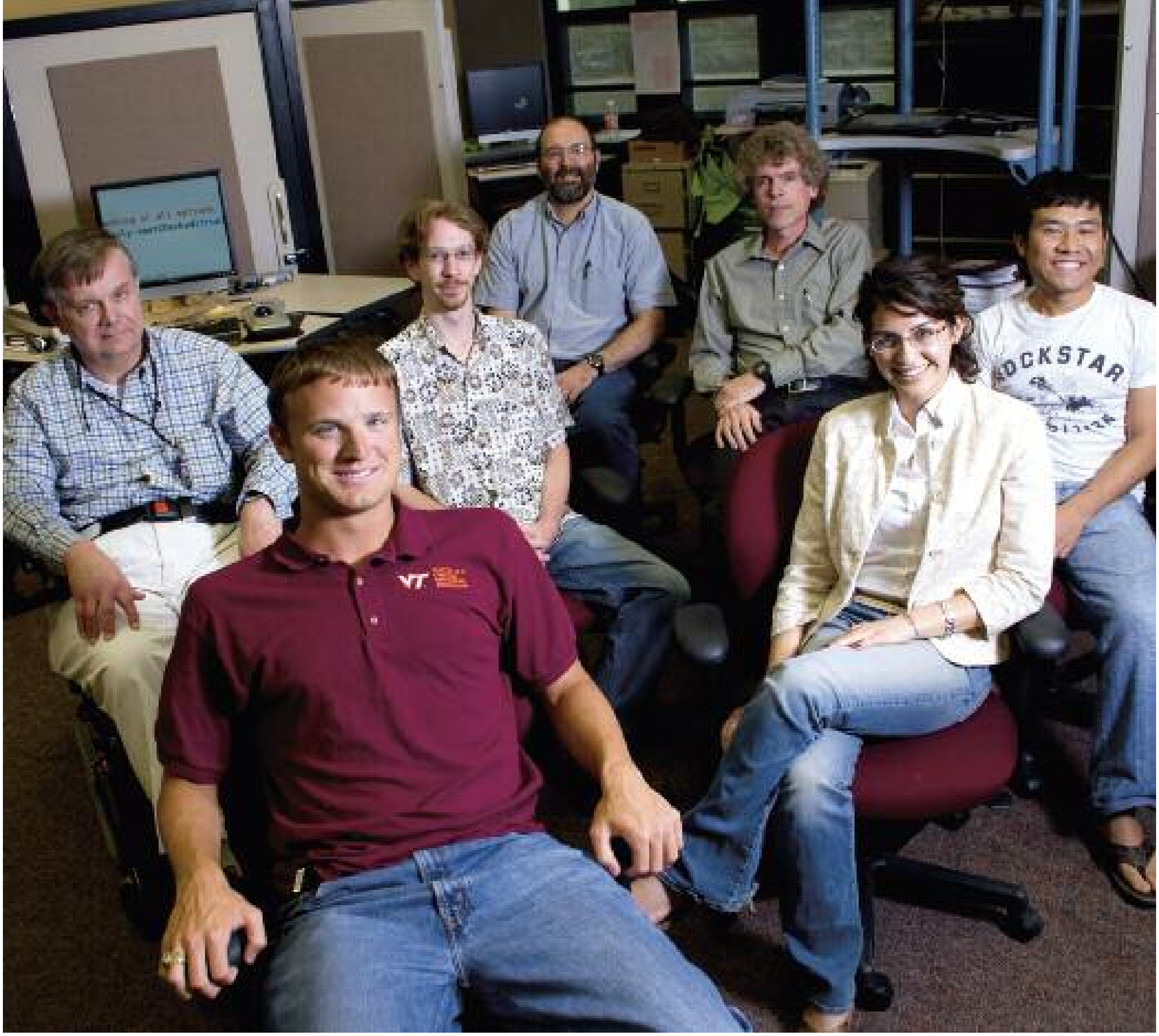
"I had a vested interest in assistive technology," he said. "So I decided to do my undergraduate research project in this area."

Assembling a team of five undergraduate cohorts with strong communication and engineering skills, Grieves set about investigating existing solutions for students with disabilities, particularly learning disabilities. Lynn Abbott, a faculty member with a strong image-processing background, was their advisor. Although their initial goal for the research was focused on the interpretation of printed mathematical functions, after research, the group decided to develop a broader prototype.

They brainstormed ideas for new software. The group found the most useful technology employed bimodal learning, allowing students to hear and see printed material. Concerned with the lack of user-friendly materials for science, technology, engineering and mathematics, they decided to develop a graphical user interface (GUI) that provided several features including scanning, OCR, and organization integration.

"Also, the commercial software was extremely expensive," Grieves said. "We felt it was important to develop a new solution. Hence, OSR (Open Scan and Read) was born."

The group worked on an open source and free software project



that anyone could experiment with and modify. They agreed to provide bimodal learning in math and technological formats, with a time management component.

"The ultimate goal of our project is that our software can simply take any scanned images (with text characters, math symbols and other symbols) and convert them into descriptive expression. The software would have a TTS (Text to Speech) feature where the text can be read to the users using a speech engine," said team member Tran Pham, (CSE '09) who realized the tools would also be useful to ESL (English as Second Language) students for improving their articulation.

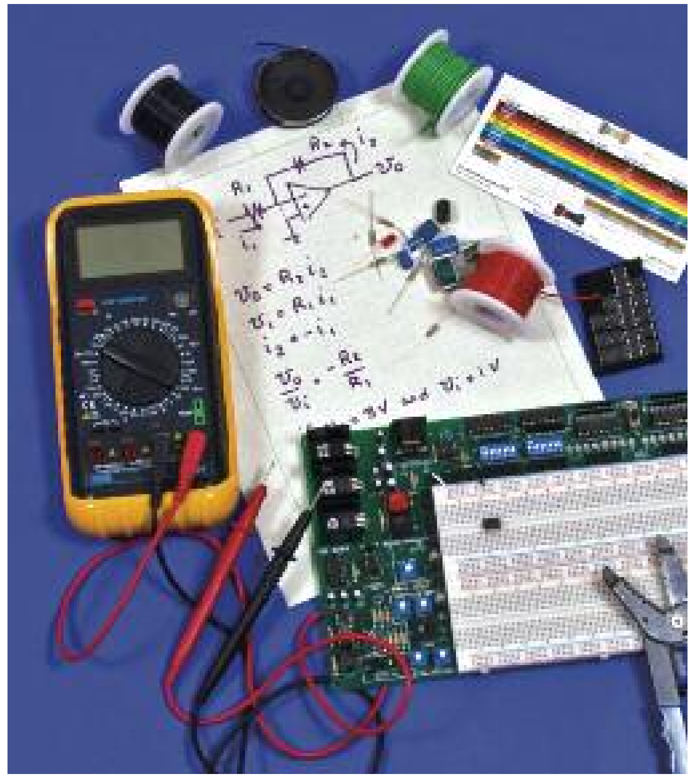
Team member (ECE '09) Katherine Smith continued the project with a new team of students this year. "I believe that a pilot program created by students, targeted for students is the ultimate design and prototype opportunity," she said.

Grieves, who graduated in May, is now working at Microsoft as a program manager in their accessibility group. He's still learning about various disabilities and he's still working on the design and testing of new software. It is still a passion for him.

—by Su Clauson-Wicker

Top photo from left: Bill Holbach, director of the Assistive Technology Lab, Jason Grieves, Derrick White, Hal Brackett, Lynn Abbott, Katherine Smith, and Tran Pham.

Lab-in-a-box goes online



S.C. Ball

A team of faculty members led by Kathleen Meehan has received $500,000 in NSF funding to extend the Lab-in-a-Box curriculum online.

Lab-in-a-Box is the name for a personal laboratory kit developed by a team of ECE faculty and first used in the curriculum in 2004. The kit can be used anywhere and was developed to give students hands-on experience and to encourage exploration and experimentation outside the classroom-laboratory.

"The kit's primary goal is to instill self confidence and improve self reliance in the students, when they build a circuit with physical components rather than symbolic parts," Meehan said.

Students purchase the Lab-in-a-Box kits and build circuits and systems for their homework and project assignments. The kit includes a digital multimeter, a software oscilloscope, a powered circuit trainer with an attached breadboard, wires, and various electronic components. This represents the major measuring equipment and tools that once were restricted to laboratory benches, according to Robert Hendricks, who led the initial development.

The kits are used by students starting in the sophomore-level courses in Electric Circuit Analysis (ECE 2004) and Introduction to Computer Engineering (ECE 2504).

The new effort extends the functionality of the kits, adding online multimedia learning materials. Online availability will also enable community college programs that have no classroom laboratories to incorporate the hands-on experience in their curricula. "Getting this experience to community colleges is critical," Meehan said. "Many community college students transfer to full-time ECE programs and need this experience for a successful transition."

Cyber security master's starts in Northern Virginia

As the Conficker worms its way into national cyberfears and lawmakers craft proposals to empower the government to enforce security standards for private industry, Virginia Tech is laying out plans for a master's degree in information security.

The proposed eMISA (executive Master of Information Security Assurance) program will integrate information assurance engineering, management, technology, and policy studies and is aimed at working information assurance professionals. It will be offered at Tech's Arlington (Ballston) facility starting in spring 2009.

The eMISA program was conceived acknowledging that information assurance is a multi-disciplinary field shaping security measures in the design, implementation, deployment, management, and operation of the ICT-integrated infrastructure systems. The degree will require foundational expertise in areas including computer science, software engineering, telecommunications, information technology, management, policy, and infrastructure studies. Students will also study forensics, cryptography, and information security and trust technologies while developing student management skills.

The entire eMISA program is designed for completion within 18 months. Face-to-face weekend classes and seminars will be supplemented by online information. The program includes extensive hands-on laboratory experience, case studies, and a final project. Field study will be coordinated with international industrial and academic partners in Europe and Asia — where students will be exposed to information assurance standards at the global scale.

The eMISA program targets the working professional with an undergraduate background in science and/or engineering. A minimum of five years of job experience in an information-assurance-related field is required.

The program conception is guided by an international advisory committee from institutions such as the U.S. National Security Agency, U.S. Dept. of Homeland Security, U.S. Department of Commerces, SAIC, Booz Allen, Boeing, Fraunhofer Institute of Secure Information Technology in Germany, as well as other US and European institutions.

The eMISA program will be supported by faculty members from ECE and computer science. For more information, visit *www.emisa.vt.edu*.

—by Su Clauson-Wicker

Dominion donates smart grid equipment

Dominion Virginia Power has donated $400,000 in smart-grid equipment and started a $45,000 fellowship fund for ECE graduate students to gain experience using state-of-the-art technology to help improve the U.S. power infrastructure.

The equipment is the "latest and greatest" generation of microprocessor-based high-voltage transmission protection systems, said Matthew Gardner (BSEE '03,MSEE '05, Ph.D '08), an electric transmission planner for Dominion.

The equipment – identical to what is being installed on Dominion's power system – is used to monitor the operations and power flows on the transmission grid, as well as detecting and locating system faults, Gardner said.

The four units are large, 3 feet by 8 feet each, cost upward of $140,000, and will be installed in the power engineering laboratories in Whittemore Hall.

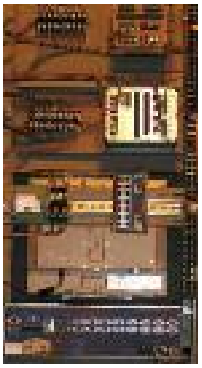
"This brand new, state-of-the-art equipment will allow our graduate and undergraduate students to implement advanced protection schemes that take advantage of intelligent electronic devices," said Jaime De La Ree, assistant department head.

The $45,000 Dominion Virginia Power fellowship fund will support a master's student in power engineering. It would pay for tuition, fees and a stipend for a master's student who would intern and then possibly work for the Richmond-based power company.

Virginia Tech has a long history of power engineering excellence and has one of the largest and oldest power programs in the country. The first smart grid technology, phasor measurement units (PMUs) now being used worldwide to improve reliability of power grids, was built at Tech. ECE researchers also deployed the first national network, the Frequency Monitoring Network (FNET), to monitor frequency of the power grid.

"Thanks to Dominion, our students will have experience and expertise in the technology needed to build smart, sustainable power grids. Dominion's support in this tough economic climate signals their approval and confidence in our students and our programs," said De La Ree.

Courtesy of Dominion Power



Left: New digital relays under construction for ECE. Right: Rear view showing the relay interconnection.

Solar-powered sun teaches kids about energy

For their project in Senior Design in Power Engineering, a group of ECE students designed and built a solar-powered sun for a preschool program – and used it as an educational tool to teach four-year-olds about solar energy in the process. Whitney Bopp, Marko Cruz, and Christa Hixson worked with Virginia Tech's Child Development Center for Learning and Research to build a solar-powered unit for a playground outside Wallace Hall.

The ECE students built the solar-powered "sun" to help teach the young children how they can gather energy from the sun and put it to good use, how weather affects the amount of energy collected from solar panel, how light energy is transformed into electricity, and how other forms of energy are converted into electricity.

"Sunny" is 36 inches high and sports LED facial features. A sound module causes LED strips on the rays to blink when it senses sound or vibrations. Two solar panels generate the power for the demonstration.

Whitney Bopp and Marko Cruz demonstrate a solar-powered "sun" built to teach young children about solar energy.

EDUCATION NEWS

Duping the GPS SYSTEM

ECE's Brent Ledvina and colleagues from Cornell have built a system demonstrating how GPS signals can be spoofed. The team believes that current U.S. government countermeasures would not guard against their system. By demonstrating the vulnerability, they hope to devise methods against such attacks.

The team programmed a briefcase-size GPS receiver used in ionospheric research to send out fake signals. The phony receiver was placed in the proximity of a navigation device, where it anticipated the signal being transmitted from the GPS satellite. Almost instantly, the reprogrammed receiver sent out a false signal that the navigation device took for the real thing.

Handheld GPS receivers are popular for their usefulness in navigating unfamiliar highways or backpacking into wilderness areas. But GPS is also embedded in the world's technological fabric. Such large commercial enterprises as utility companies and financial institutions have made GPS an essential part of their operations.

"GPS is woven into our technology infrastructure, just like the power grid or the water system," said Paul Kintner, electrical and computer engineering professor and director of the Cornell GPS Laboratory. "If it were attacked, there would be a serious impact."

At Virginia Tech, Ledvina developed the enabling software technology that allowed the signal to be sent out in real time. Cornell professors Todd Humphreys and Mark Psiaki were also on the spoofing team.

The idea of GPS receiver spoofing isn't new; in fact, the U.S. government addressed the issue in a December 2003 report detailing seven countermeasures against such an attack. But, according to the researchers, such countermeasures would not have successfully guarded against the signals produced by their reprogrammed receiver.

"We're fairly certain we could spoof all of these, and that's the value of our work," Humphreys said.

—by Lynn Nystrom

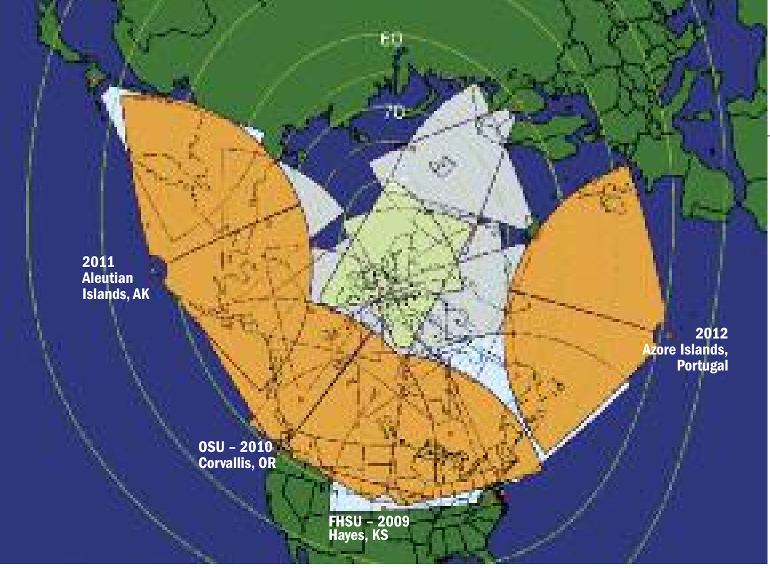
Predicting ground-level geomagnetic perturbations

The National Science Foundation has awarded a $360,000 grant to Space@VT researchers to construct a computer model that predicts variations in the magnetic field that occur at the Earth's surface and are caused by currents in the ionosphere.

The currents are a result of the interaction between the solar wind and the interplanetary magnetic field (IMF) with the Earth's magnetosphere.

The Virginia Tech model will be based on prior worldwide measurements of the magnetic perturbations and solar wind values obtained over a period of years. The predictive capability will use real-time measurements of the IMF on a satellite positioned in the "upstream" solar wind, sunward from the Earth.

Daniel Weimer and Robert Clauer serve as principal investigators on the project, which is funded by the Upper Atmosphere Research Section through National Space Weather Program (NSWP). The NSWP goal is to ultimately achieve timely, accurate, and reliable space environment observations, specifications, and forecasts.



SuperDARN

SuperDARN is the sole instrument that is capable of providing direct measurements of plasma convection and electric fields in the ionosphere on global scales with high temporal resolution.

For the past 15 years, engineers and scientists have gained a greater understanding of global warming, the effects of geomagnetic storms, the impact of the solar wind interacting on the magnetized region around the earth, and other dynamic processes that occur in the Earth's near-space environment.

Among their tools, they use a high-latitude network of radars to obtain increasingly sophisticated views of electric fields, plasma structures, atmospheric waves, and other effects in the ionosphere and atmosphere.

The radars have an elaborate technical name — the Super Dual Auroral Radar Network — providing an acronym with a humorous touch, SuperDARN. The network is an international collaboration with support provided by the funding agencies of more than a dozen countries. The radars combine to give extensive views of the upper atmosphere in both the Arctic and Antarctic regions.

The view is about to get much bigger.

ECE's J. Michael Ruohoniemi is the lead principal investigator on a new $6 million grant to build additional radar units. Nearly $2 million of the award will go to the Center for Space Science and Engineering Research (Space@VT).

Other participants in the grant from the National Science Foundation (NSF) are Dartmouth College, University of Alaska at Fairbanks, and the Johns Hopkins University Applied Physics Laboratory (JHU/APL). The ECE group is directing the first construction that will take place at a site in Kansas later this year. Other potential sites are currently being reviewed in Oregon, the Aleutian Islands, and the Azores.

Construction of the new radars will occur in pairs at a rate one pair per year at each of four sites, for a total of eight radars over four years. The new radars will join three existing mid-latitude radars to make up a continuous chain of coverage that extends from Europe to eastern Asia.

As Ruohoniemi explained the science, "The Earth's magnetosphere is immersed in the tenuous, fully-ionized outer atmosphere of the sun, which is responsible for the solar wind and its structured and dynamic magnetic field. In the aftermath of severe solar disturbances, such as solar flares, energized solar wind plasma impinges on the Earth's magnetic and plasma environment and initiates a broad range of interactions. These reactions lead to the onset of disturbances in the magnetosphere.

"During these events, the magnetosphere-ionosphere system passes through a range of states that can be described as quiescent, mildly disturbed, and storm-like. As each transition takes place, the effects of disturbance reach to ever increasing fractions of the Earth's plasma environment. The consequences of these solar-induced disturbances are often described as space weather and they can threaten harm to humans in space, perturb spacecraft orbits, damage spacecraft electronics, and disrupt radio, radar, and GPS operations."

Virginia Tech has operated a midlatitude radar at the University's Blackstone Agricultural Research and Extension Center since February 2008. Ruohoniemi and Joseph Baker are responsible for its daily operation and share in the responsibility for the operation of a radar at the NASA Wallops Flight Facility located at Wallops Island. Ray Greenwald, considered the "godfather" of the SuperDARN group, is now retired from JHU/APL, but continues to work as a research professor with Space@VT. The ECE group also manages two older SuperDARN radars located at auroral sites in Labrador and northern Ontario.

With the new midlatitude infrastructure, researchers will be able to observe substorm processes at lower latitudes than is currently possible. They will also be able to merge overlapping measurements from pairs of radars to map the structure within substorm flows at high spatial and temporal resolutions.

—by Lynn Nystrom

Kevin Stern

SuperDARN array at Blackstone, Virginia.

ECEs invent **world's smallest** UWB antenna

ECE researchers have developed an efficient compact ultra-wideband (UWB) antenna (CUA) for a range of home, automotive, medical, and military applications. The antenna has achieved a near optimal performance for size and bandwidth, according to inventor Taeyoung Yang.

Yang, a Ph.D. student, developed the antenna with professors William Davis and Warren Stutzman. "To our best knowledge, our invented antenna is the world's smallest with more than a 10:1 bandwidth. It has more than 95 percent efficiency for signal transmission and a fairly constant omni-directional radiation pattern," said Yang.

UWB antennas are designed for low energy, short-range transmission of lots of data. Wireless transmission of data from a cell phone or digital camcorder to one's computer is one potential use. A smaller antenna that can send large movies is easily appreciated. Wireless transmission from a DVD to a high-definition television (HDTV) offers a boon to room décor.

There are also complex and critical applications for such technology, said Yang. Examples are pulsed radar systems to prevent collisions between cars; medical imaging systems to detect tumors; and military applications, such as unmanned aircraft.

The inventors' strategy to reduce the size and increase the adaptability of the antenna was to configure it as a structure that can be printed on the inner side of the protective housing, which can be light plastic.

The design also makes it cheap and simple to produce. "The required material expense is low, the fabrication process is simple, and it is versatile for mounting on curved surfaces," said Yang. "It is convenient to install and disassemble."

— by Susan Trulove

Overcoming ignorance of terrain for predicting signal strength

Terrain affects communications signals and other electromagnetic waves, but topographical maps are simply not precise enough for planners to predict signal strength in many cases, according to Gary Brown, a remote sensing expert and director of ECE's ElectroMagnetic Interactions Laboratory.

"The loss of signal strength on a communications path that travels over terrain is currently unknowable, yet there are a number of users – commercial and military – who really need this information," he says.

Brown's team has developed a quick, memory-efficient method that helps solve this problem and is applying it to help the National Radio Astronomy Observatory (NRAO) in Green Bank, W.V. maintain its radio quiet zone.

Other users who need similar data include military patrols heading into unknown territory who need to stay in constant communication and military spectrum planners trying to avoid friendly radio interference over a given land region, he says.

The problem, Brown says, stems from the relatively low resolution of topographical information. Topographical data points are seldom closer together than 30 meters, he explains. The elevation in rough terrain can change significantly between 30-meter-apart measurements from features such as steep ravines, rock outcroppings, and small hills.

Brown's team quantifies the level of uncertainty in predicting the path attenuation. "Based on probabilities of what we know about the roughness, we can provide an average attenuation loss and a standard deviation. If we need more precision, we can target an area for gathering more topographical data."

Brown is working with federal agencies to help eliminate interference signals at the Green Bank Telescope from other locations in the National Radio Quiet Zone. "With more precise understanding of how signals travel in the zone, regulators can allow or prevent other radios from coming online," he says.

The Army Research Office and Naval Surface Warfare Center are providing funding for the effort.

Optical fiber sensors
for the next generation coal-burning power generation

Photonics researchers are developing fiber sensors to operate in the super harsh environment of coal generation systems that emit 30-35 percent less CO_2 than the conventional technology.

The fiber sensors will measure strain, temperature, and pressure at temperatures greater than current sensor capabilities.

The sensors will be capable of operating in a distributed network, providing the first such capability for ultra-super critical steam (USC) designs, according to Anbo Wang, director of the Center for Photonics Technology.

"Distributed sensor capability is critical for these new generators," he said. "The larger coverage will enable models to more accurately identify operating conditions that can impact boiler reliability and plant availability." USC boilers have an efficiency target between 45 and 47 percent – a 10 percent increase in efficiency that results in a 25-30 percent decrease of CO_2 emissions compared with current technology.

USC boilers are targeted for operation at 760° C and 5000 psi. These extreme conditions lead to accelerated degradation and places new challenges on all the materials and components. Increased and accurate monitoring is critical to keeping efficient and reliable operation, Wang said. "Our new sensors must perform in the boiler with the same or better accuracy and long-term operating reliability as their lower-temperature predecessors."

To meet the stringent requirements, the CPT team is developing a suite of sensors for a measurement network based on a technology recently demonstrated at Virginia Tech.

The project is funded by an $850,000 grant from the U.S. Department of Energy. For information: *www.photonics.ece.vt.edu*.

Photonics group selected to join Pratt & Whitney Center of Excellence

The Center for Power Photonics (CPT) has been selected as one of the first year five members in the Pratt & Whitney Center of Excellence established at Virginia Tech. CPT joins the other groups in applications, including combustion, materials, aerodynamics, heat transfer, structural analysis, design, and test. Specifically, CPT's objective is to develop single-crystal sapphire fiber based sensors for multiplexed measurement of high temperatures at multiple locations.

Pratt & Whitney, a United Technologies Corporation, has established strategic university partnerships with Georgia Tech and Penn State in addition to Virginia Tech.

The program supports the design and development of state-of-the-art gas turbine propulsion systems used in commercial, military and emerging technology, and environmental programs.

Extending fiber sensors
beyond temperature and strain

The Center for Photonics Technology (CPT) is developing sensor technology for long-span, fully-distributed measurement of pressure and transverse stress – two parameters that cannot be measured by any available conventional technology, according to CPT director Anbo Wang. The technology will extend fiber-optic distributed sensor technology beyond its traditional functions for temperature and longitudinal strain only.

The breakthrough technology is expected to find a wide range of applications in oil and gas production and delivery, real-time highway assessment, earthquake prediction, volcano monitoring, and structural health evaluations.

The research team is combining specially designed optical fibers with a novel technology recently developed at Virginia Tech: grating-assisted polarization-optical time-domain reflectometry (GA-POTDR). GA-POTDR interrogates the fiber in a fully distributed manner with high resolution and high accuracy.

"The technology provides a large degree of freedom in system design, which can be exploited to achieve previously unattainable performance," Wang said. "By controlling the fiber reflections, we will achieve a uniform signal-to-noise ratio along the fiber regardless of the power consumptions from previous sensor sections. By optimizing the fiber design, we could greatly enhance the measurement sensitivity while maintaining its low temperature cross-sensitivity."

The project is funded by the National Science Foundation. For more information, visit *www.photonics.ece.vt.edu*.

PHOTONICS

Creating a visual environment

For safety-critical embedded software

A new process is needed for writing software for complex, distributed embedded applications such as flight-control, missile control, even automobile control, according to ECE's Sandeep Shukla. He has a research team working with the U.S. Air Force Laboratories to do just that.

Lemair Stewart (CPE '09) and Jason Pribble (CPE '10) spent the summer at the Air Force labs in Rome, N.Y.

"In these systems, the computation takes place in a distributed set of microcontrollers and microprocessors that are connected over a bus or an interconnection network. Based on inputs from sensors that are distributed throughout the system, or from the driver, the complex concurrent real-time computations take place." he says. "The concurrent real-time processing environment becomes too complex for a software designer to hold in mind and the software becomes error-prone and riddled with bugs that are hard to discover by traditional testing methods."

His team is tackling these issues by creating a visual environment, called CodeSyn, in which designers create the specifications through a graphical interface, use a visual debugging tool, and generate code automatically.

The implementation of the visual framework was developed this past year by two undergraduate research assistants, Jason Pribble (CPE '10) and Lemaire Stewart (CPE '09). Both students spent the summer with Shukla at the Air Force labs in Rome, N.Y., capturing the embedded control problems from a data-flow perspective using a mathematical model called Multi-Rate Instantaneous Channel Connected Data Flow Actor Network (MRICDF). In the model, the time to compute or communicate is assumed to be zero, and the only way time passes is by the arrival of a certain set of events. The next steps involve analyzing the MRICDF model of the problem, creating and analyzing the mathematical representation, creating XML models for storage and exchange of data with other tools, and developing sequencing of computations and the code generator.

There are several challenges in developing the code generator, according to Shukla. "The synthesized code must be optimal, clean code. It must be capable of handling the real-time constraints of multi-processors and operating efficiently in a mult-core, parallel processing environment."

Graduate students for this project are supported by an AFOSR funding. Bijoy Jose, Bin Xue, and Zeng Wu are the Ph.D. students working on developing the theory involved in the project.

VLSI chips for structural health monitoring

A group of computer engineering researchers, led by ECE's Dong Ha, is working on next-generation technology to monitor the health of the country's structural infrastructures, including bridges, plants, and buildings.

"The integrity of these structures is typically assessed by visual inspection, which is time consuming and requires seasoned experts," he said. "Most critical, however, these assessments provide mostly qualitative – and often subjective data."

The lack of quantitative assessment can lead to early replacement, which wastes funds and resources, or late maintenance, which can lead to failure, he said. "Cost-effective monitoring can save millions of dollars annually," he said.

Ha envisions a system where all critical structures are monitored continuously with tiny wireless sensor nodes that report the status of their structural health to central offices. The complexity and high installation cost of today's structural health monitoring (SHM) technology has been a stumbling block, according to Ha.

His team is developing an ultra low-power, wireless SHM sensor node with a tiny ultra wideband (UWB) radio. The sensor would be low cost, about the size of a quarter, and would operate for several years with a coin-sized battery or use energy harvested from ambient sources, he explained. "The UWB radio will have an antenna dimension of 2 cm x 2 cm and be able to communicate more than 50 meters, he said."

The sensor node is highly versatile and can be applied to virtually any SHM application, including bridges, buildings, wind turbine blades, airplane wings, and spacecraft. Ha's group has developed several previous generations of SHM sensor nodes, each one smaller and more energy efficient than previous ones.

Ant behavior may help semicon industry to verify design

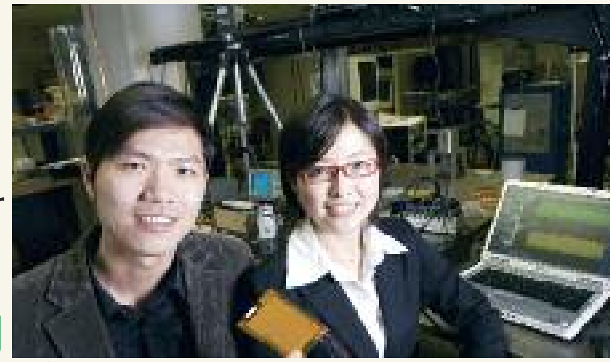
One of the hardest problems in validating designs is getting the system to reach all the possible states it will experience during use. The hard-to-reach "corner cases" are compared to finding a needle in a universe of haystacks – or finding a particular state within a space of more than 10^{3000} states.

Michael Hsiao's team has developed an approach that finds many of the hard-to-reach states where existing methods fail. Their heuristic is based on ant colony optimization, biologically inspired by swarm-intelligence.

In their model, artificial ants start from their nest (the initial state) and attempt to find a path to reach food (the target state). In so doing, all the ants will converge to the path most likely to reach the target state.

"This is an important problem to solve," Hsiao said. "Finding these hard-to-reach spaces will make design validation and verification more robust and more efficient." Up to 70 percent of the effort of the semiconductor industry is spent checking if the implemented circuit conforms to the design intent, he noted.

Circuits for Energy Harvesting



ECE researchers are designing power conditioning circuits for a system, in which a piezoelectric patch harvests energy from vibrations in a bridge. Dong Ha's team is collaborating with Dan Inman, Director of Virginia Tech's Center for Intelligent Material Systems and Structures (CIMSS) on a project to develop a suite of new technologies to provide continuous, energy-independent monitoring of the structural integrity of bridges. CIMSS is partnering with Physical Acoustics Corp. of Princeton Junction, N.J. on the $14 million project funded by the National Institute of Standards and Technology (NIST).

Speeding up software testing by several orders of magnitude

A team of computer engineers has developed a scalable approach that can speed up testing of software to ensure software reliability by several orders of magnitude.

"With the increasing importance of software in our everyday life, software reliability has become a critical issue," said Michael Hsiao, who heads up the team. One method of testing software reliability is a formal verification method called model checking. This involves systematically exploring all the possible behaviors of the system to determine whether it satisfies a specific property in all cases, he explained. "If the property is violated, it also returns counter-examples to explain how."

However, the rapidly growing complexity and size of software could result in an exponentially growing state space, making static-only verification both infeasible and impractical, he said. "Abstraction techniques, which reduce system complexity by removing irrelevant information, hold tremendous promise in this situation."

He and his students, Xueqi Cheng and Nannan He, are exploring first-of-their-kind hybrid approaches that integrate both dynamic and static techniques for efficient program abstraction. "We are leveraging the lightweight, dynamic techniques that are usually associated with program execution. Dynamic program execution, in combination with knowledge/pattern discovery mechanisms, such as data mining and swarm intelligence, provides means for extracting extremely useful information regarding program behaviors with respect to the property under verification." The approach is also being applied to validate cognitive radio software.

Power line communication goes mini

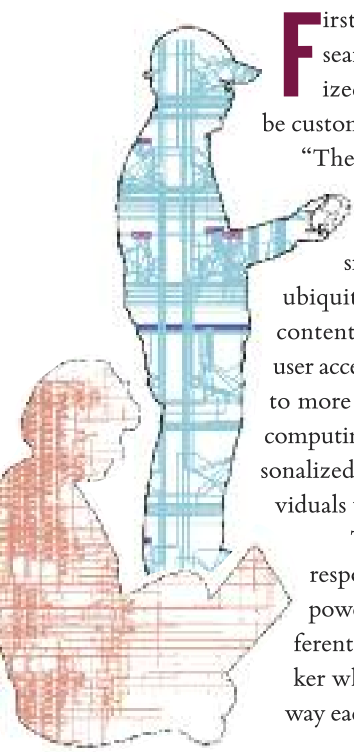
While most people think of power line communications in the context of home networks or communication over thousands of miles of the electric power grid, embedded systems researchers are applying the technology at the micro level – on an integrated circuit (IC).

"An IC has a mesh of power lines to supply power to underlying circuits," says Dong Ha, who leads the effort. "These power wires can deliver data as well as power." The technology could be used for various applications, such as on-line testing, system debugging, fault diagnosis, monitoring transient logic values during a built-in self test, he notes.

Power line communication at the IC level and wireless communications systems face essentially the same challenges, according to Ha. His group is working with methods adopted for wireless communications, such as DS-CDMA (Direct Sequence – Code Division Multiple Access) combined with UWB signaling.

The work has been supported by Intel through the Semiconductor Research Corp. (SRC) and is currently funded by a grant from the National Science Foundation (NSF).

Personalizing computer architectures

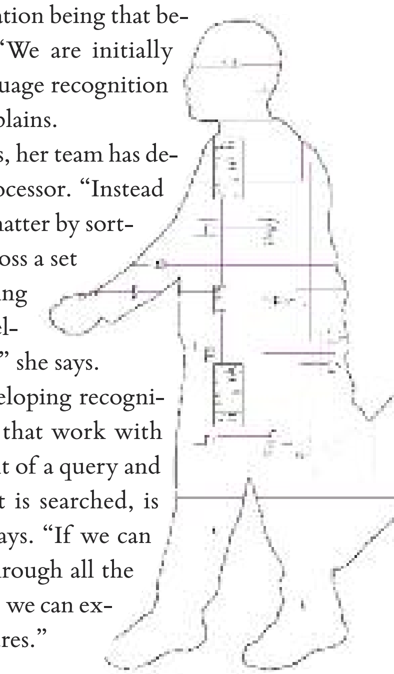


First there was personal computing; now ECE researchers led by JoAnn Paul are exploring personalized computing – how computer architectures can be customized to individual usage patterns.

"The relationship between users and computers has changed dramatically in recent years, due to the combination of wireless communications, smaller computer sizes, longer battery life and the ubiquity of Web pages," Paul says. "At the same time content – particularly Web content – has changed and user access to it has become more individualized. The need to more efficiently access the Internet from ever-smaller computing devices suggests that the time has come for personalized computer architectures, based on the way individuals use their computers."

The research team envisions devices that are more responsive to user needs and are faster while using less power. "A lawyer who follows baseball could use a different cell phone architecture from that of a stock broker who enjoys travel and fine dining, just based on the way each would interact with their device (language processing) and the dominant websites they follow," she explains.

Most people use their computers for different reasons at different times, the most dominant separation being that between work and play, she says. "We are initially investigating how to optimize language recognition for those specific contexts," she explains.



With a nod to chemical analysis, her team has developed what they call a spectroprocessor. "Instead of identifying the composition of matter by sorting according to concentrations across a set of elements, we identify the meaning of data by sorting according to its relevance across a set of user interests," she says.

In a first step, her team is developing recognition algorithms for search queries that work with personalized contexts. "The content of a query and the context in which that content is searched, is strongly related to the user," she says. "If we can develop search methods that cut through all the data depending on context and user, we can extend that to personalized architectures."

Speeding up FPGA application development

Field Programmable Gate Arrays (FPGAs) are ubiquitous in systems requiring high-speed communication, video, cryptography, or digital signal processing. While off-the-shelf FPGAs avoid the fabrication costs, delays and risks incurred by custom chips (ASICs), application development time is escalating.

An ECE team led by Cameron Patterson is investigating methods to speed up implementation of large-scale FPGA designs. The work is supported by a grant from the Defense Advanced Research Projects Agency (DARPA).

"The size of available FPGAs – well over 2 billion transistors – is adversely affecting productivity due to the time required for the FPGA tools to generate a new configuration after a design change," Patterson says.

Current FPGA tools often require complete re-implementation of a design when a module change affects other modules, he

says. "In the software domain, this would be analogous to recompiling all libraries whenever a change is made to application code. Unfortunately, the conventional approach does not exploit the inherent ability of FPGAs to rapidly update portions of the circuitry while other parts remain unchanged and even operational," he adds.

The team is investigating the use of run-time reconfiguration (RTR) to add a software-like module linkage step, reducing the time required to add or replace a module by up to three orders of magnitude. "RTR has not previously been used in this way," Patterson adds. The new tools will proactively generate a variety of new layouts to quickly accommodate module changes, much like chess-playing programs anticipating the human player's future moves.

Ensuring the trustworthiness of cognitive radio networks

As the national discussion progresses on spectrum access and reallocation, many options under consideration require technological advances in cognitive radios (CR) and related dynamic spectrum access technologies. ECE's Jung-Min "Jerry" Park is working to make sure cognitive radio devices remain trustworthy and operate within the boundaries set by regulatory frameworks.

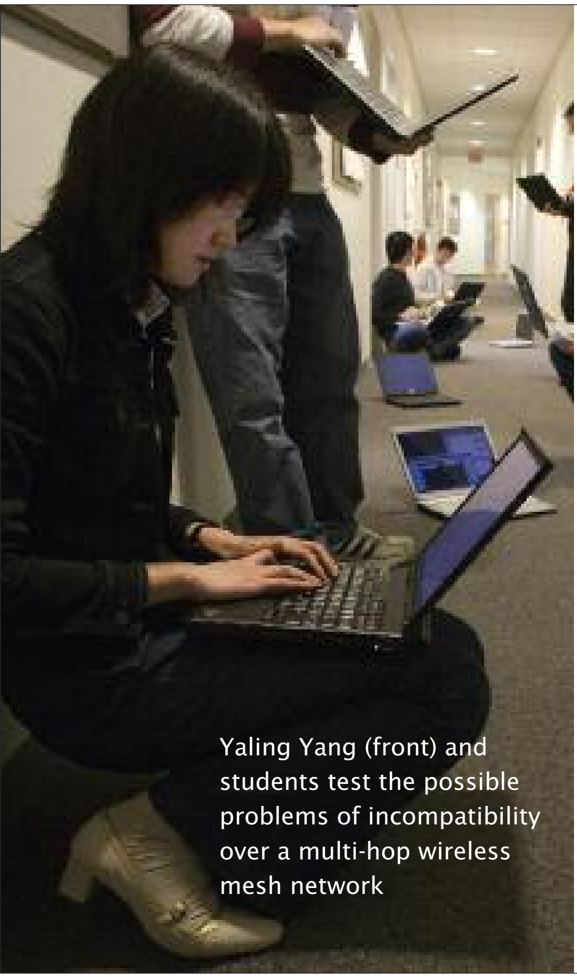
"Cognitive radios are frequency-agile devices that can adapt their operating characteristics based on local observations," he said. "To ensure that cognitive radios can coexist with existing wireless infrastructures and devices in a harmonious way, a number of security solutions are needed."

One project Park and his graduate research assistants are investigating involves a tamper resistance scheme that is designed to thwart unauthorized tampering of CR software. Their approach uses code encryption and branch functions to obfuscate the target program while enabling the program to meet its performance requirements.

The challenge in developing security solutions for CR software is to operate within stringent real-time constraints, Park says. "To deal with such constraints, our scheme uses a technique called the random branch function call, which enables a user to control the tradeoff between the integrity checking frequency and the overhead," he says.

The team is also devising a CR policy reasoner that assists in policy enforcement and carries out policy analysis and processing. The policy enforcement function monitors the channels that the CR is attempting to use and pro-actively applies enforcement mechanisms to ensure that the transmissions originating from the radio conform to the regulatory and system policy requirements. The policy analysis and processing function is based on a graph-theoretic approach and carries out conflict detection and resolution. "It is critical to avoid policy conflicts," Park says. "They can cause serious security breaches or degrade network performance."

Park's work is sponsored by the NSF, SCA Technica, and Samsung Electronics. For more information, please visit *www.arias.ece.vt.edu*.



Yaling Yang (front) and students test the possible problems of incompatibility over a multi-hop wireless mesh network

Too many routing choices can lead to catastrophe

When choosing paths to send traffic in a wireless network, designers can select from a wide selection of routing metrics, depending on specific goals and constraints. This rich collection, however, creates significant compatibility issues that can lead to disaster, according to Yaling Yang, an assistant professor of computer engineering and a networking expert.

"A combination of arbitrary, incompatible designs of routing components can create a catastrophe on a network's normal operations, such as instability, network isolation, management difficulties, routing loops, and performance degradation," she says. The plethora of routing designs arose when multiple organizations developed independent wireless network designs at the same time.

"It was a rich time of creativity and problem solving," she says, "but now with our layers of networks and growing interconnections we need to understand the compatibility issues and develop theory and practices to avoid problems."

Yang and co-investigator Thomas Hou have been awarded a $350,000 grant from the NSF to investigate the issue and establish a theoretical foundation for the design of compatible routing systems.

Current network compatibility knowledge is based on several IP routing protocols deployed for the Internet, she notes. The ECE team plans to move beyond traditional linear wireless routing metric design into non-linear modeling and understanding.

"We hope our work will lead to methods of developing flexible wireless routing architectures so that engineers can avoid designs that put too many restrictions on the development of routing metrics," she says.

Improving GPS performance indoors

Undergraduate researchers Jerry Towler and Bryan Farley worked last summer with Michael Buehrer on improving performance of GPS-based position location for indoor sites when other information such as WiFi signals and accelerometers are available. The project builds on recent work by doctoral candidate Swaroop Venkatesh and two previous undergraduate projects on indoor position location that mitigates multipath propagation effects.

GPS is the primary source of position location information, with an accuracy up to 3 meters in environments with an open view of the skies and access to satellite availability. However, in many indoor environments, GPS performance is degraded due to an obstructed view of the sky and propagation effects such as attenuation and multipath fading.

The students developed techniques for exploiting additional information (such as WiFi signal strength and range data between multiple devices, etc.) for improving position location indoors. Graduate assistants Haris Volos and Tao Jia provided assistance.


Jerry Towler (left) and Bryan Farley

ECEs are 2-time winners in Smart Radio Challenge

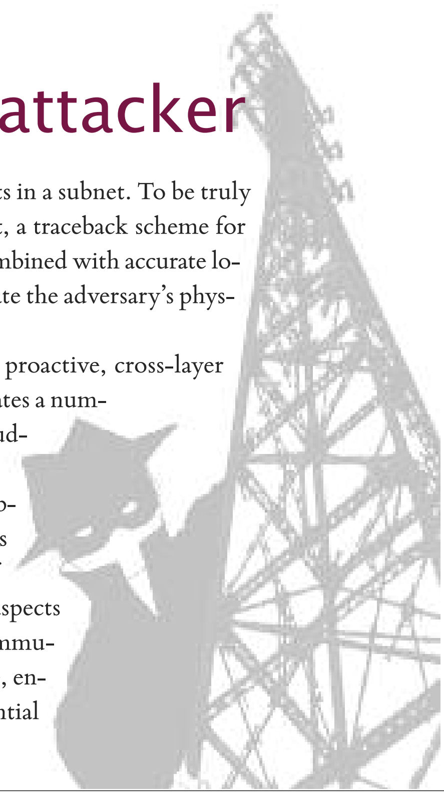
ECE students took first prize for one of three problems at this year's Smart Radio Challenge competition at the annual Software Defined Radio in October. The team was last year's grand prize winner in the competition.

The students successfully developed a smart radio system that will automatically create an ad-hoc extension to an existing communications network, so that voice communications can be relayed between the incident site and existing communications systems along a path like a subway tunnel where signals can travel only short distances.

The team is led by Ph.D. student Mark Silvius and advised by Charles W. Bostian. Members are Terry Brisebois, Qinqin Chen, Al Fayez, Feng Andrew Ge, Bin Phillip Li, Gladstone Marballie, Sujit Nair, Rohit Rangekar, Yongsheng Sam Shi, Ying Wang, and Alex Young.

For information, visit: *www.cognitiveradio.wireless.vt.edu*.

HUNTING the hidden wireless network attacker



The widespread deployment of wireless networks and the increased availability of attack tools on the Web have enabled adversaries – from "script kiddies" to experienced hackers – to launch sophisticated network attacks against remote critical infrastructures with relative ease and anonymity. A team of ECE researchers wants to unmask these adversaries, help bring them to justice and prevent others from trying such attacks.

Yaling Yang, with co-investigators Michael Buehrer and Jung Min Park are developing a system to trace back to the true sources of wireless network attacks. Supported by a $330,000 grant from the NSF, they are seeking a method of finding an adversary that is actively trying to disguise its location in a wireless network by distorting its signal features.

Most existing approaches for finding network adversaries were designed for tracing back to the edge routers in wired networks, according to Yang. "These approaches are ineffective for wireless networks, since the attacker can be anywhere in the unified coverage area of all wireless access points in a subnet. To be truly effective as an attack deterrent, a traceback scheme for a wireless network must be combined with accurate localization techniques to estimate the adversary's physical location," she says.

The team's approach is a proactive, cross-layer localization design that integrates a number of diverse disciplines, including localization, security, wireless networking and distributed system design. The results will help ensure the security of cyber applications in critical aspects of the society, such as telecommunications, banking and finance, energy, transportation, and essential government services, she says.

Digital Extravehicular Activity Radio aimed for space

Carl Dietrich and Jeff Reed are leading a project for AeroAstro, Inc. to develop a digital extravehicular activity radio (DEVAR) for manned space exploration.

Doctoral student Sahana Raghunandan is developing infrastructure and application software that runs on the general processing module of the radio to interface with signal processing and radio frequency modules under development. Other Tech students contributing to the project are: Hoda Darwish, Dileep Kumaraswamy, and Lillian Le.

A byproduct of this effort is Open Space Radio, an open-source implementation based on NASA's STRS standard for software defined radio (SDR). Availability of this software is expected to foster SDR education, research, and prototyping similar to that of ECE's OSSIE open-source implementation based on the U.S. Department of Defense Software Communications Architecture.

Global MANIACs compete in futuristic wireless network

With inspiration ranging from information theory to mongoose behavior, university teams from seven countries and three continents tested network cooperation – and noncooperation – strategies in March at a competition organized by a group from ECE.

The MANIAC Challenge 2009 (Mobile Ad-hoc Networking Interoperability And Cooperation) investigates cooperation and selfishness in ad hoc networks. These networks of the future are expected to be established anywhere on demand and could involve thousands of phones, radios, and other mobile devices.

The competition was held in Galveston, Texas, in conjunction with the IEEE PerCom conference. It is funded by the National Science Foundation (NSF) to better understand cooperation and interoperability in ad hoc networks – and to encourage student interest in solving the complex issues involved.

Each student team participates in the competition with two laptops, which act as nodes in the network. Teams program their participation strategies, deciding when to forward data packets for others and when to seek more favorable routes that avoid selfish nodes.

The team from the Freie Universitaet Berlin, Germany won the Performance Award and received a set of pervasive computing sensor platforms donated by Sentilla Corporation. Marcello Caleffi, from the Universita di Napoli Federico II, Italy, sought inspiration in information theory to design his strategy, which applies concepts of diversity and mutual information to the problem of whether and when to forward packets for one's neighbors. His strategy won the Design Award.

The team from the Arab Academy of Science and Technology in Egypt was inspired by the behavior of the mongoose to design their strategy. Just as a mongoose will act as a sentinel, "climbing to a vantage point and scanning to surrounding area," their strategy used a node that scanned neighbors to assess who was dropping packets. The youngest team to compete in MANIAC was composed of three third-year undergraduates from the University of Cyprus.

Other teams came from the Charles University of Prague, Czech Republic; the Technical University of Kosice, Slovakia; the University of North Carolina at Charlotte; the University of Detroit Mercy; and Virginia Tech.

The MANIAC Challenge 2009 was organized by Luiz DaSilva and Allen MacKenzie. They were joined by Michael Thompson (Ph.D. 2007), an assistant professor at Bucknell University. Student travel grants were provided by the College of Engineering. For more information, visit *www.maniacchallenge.org*.

Michael Thompson

Heiko Will, from the Freie Universitaet Berlin tries to get a stronger wireless signal to improve his data throughput during the MANIAC Challenge competition. His team won the Performance Award.

Tightening trip protection in spite of information delay

As power systems across the country operate closer and closer to maximum capacity, the strategies that control operation and protection must be enhanced, or blackouts and brownouts will become more common.

Protecting power system equipment requires high-speed decision making that is incompatible with delays of even tens of milliseconds. Protection decisions are weighted in favor of protecting the millions-of-dollars worth of equipment and long-term power capability over keeping the lights on in the immediate moment. This means that sometimes local and widespread blackouts may occur unnecessarily.

The phasor measurement unit (PMU) technology that was first built at Tech in the 1980s is becoming the global standard for power utilities to get wide-area, real-time data across their grid. However, there is a milliseconds-long delay, or latency, involved in getting remote or distant phasor measurements and relaying stations do not have the complete information for their decisions.

Led by the developers of the PMU, a power engineering research team is working with California utilities to overcome this issue and to determine optimum protection policies and settings for critically located relaying stations. The team is developing adaptive relaying technology with slow speed-protection in which the delay in remote phasor measurements is not an obstacle. Adaptive relaying systems use digital relays that can change their setting to adapt to changing system conditions, either automatically by sensing the proper parameters, or in response to a control signal.

The team is attacking the problem on four fronts. They are devising schemes for supervising back-up zones with remote phasor measurements so that back-up protection is not allowed to operate when it is not appropriate.

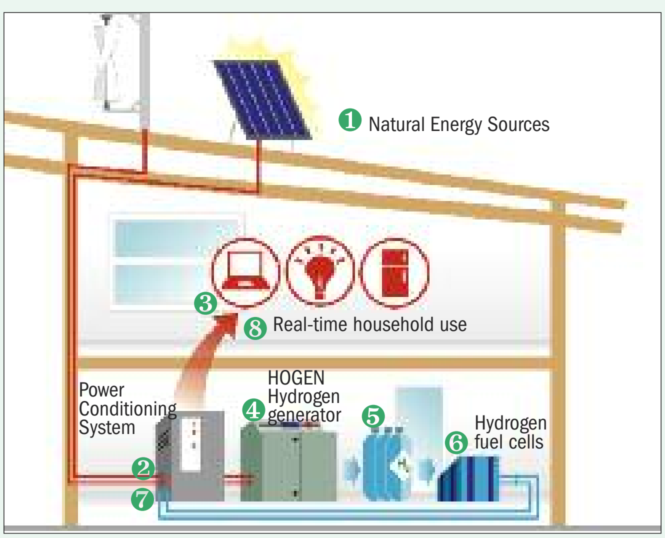
"Instead of letting a single protection relay open a circuit at its first hint of trouble, we're saying, 'Let's vote: if two relays say open, we'll open,'" said ECE Department Head James Thorp, who is working on the project. "Using data-mining and other analysis, we've determined that this concept works remarkably well."

The team is also devising algorithms and simulations to produce recommendations on load shedding, as well as techniques to adjust loss-of-field relay settings automatically. Finally, they are also designing a robust damping controller using remote phasor measurements to control dc-power lines to damp ionter-area oscillations. "All of these measures are within the capabilities of today's technology," said Thorp.

Virgilio Centeno is the principal investigator on the project. He and Thorp are joined by Arun Phadke, an emeritus university distinguished professor and Jaime De La Ree. The project is funded by the California Institute for Energy and the Environment (CIEE) and is being done in conjunction with Pacific Gas & Electric Company and Southern California Edison.

Fuel Cells for Sustainable Homes

Researchers in the Future Energy Electronics Center (FEEC) are developing a demonstration unit for an energy independent home using an integrated fuel cell power system based on renewable energy sources.



The heart of the system is a high-efficiency advanced power conditioning system that can convert power from either variable ac or dc sources to a clean sinusoidal ac that can power a hydrogen generator. The power conditioning system achieves efficiencies higher than 98 percent.

The demonstration unit will take solar and wind energy sources and convert them into 120 V ac power for real-time use and convert any extra power into 240 V ac to power a "reversed" fuel cell that can produce hydrogen with 99.9995 percent purity at a rate of 40 ft^3/hour of gas. The hydrogen can be stored for later use in an attached fuel cell power system when the demand exceeds the power supplied by the solar and wind energy sources. The same power conditioning system will convert the fuel cell output to 120/240 V ac for household use.

Funding for the demonstration unit was received from Tech's Institute for Critical Technology and Applied Sciences (ICTAS) and through the College of Engineering SHEV competition.

Battling cancer

Understanding signaling networks

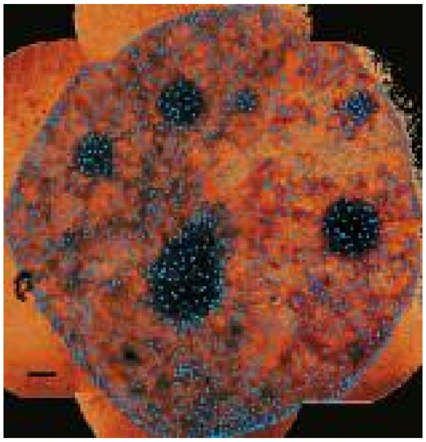
In 2008, more than 41,000 American women died of breast cancer and almost 173,000 others were newly diagnosed with the disease, according to Jason Xuan, an associate professor who is working on breast cancer research.

One of the major therapies to combat this cancer is the administration of antiestrogen drugs. Although most patients with hormone-responsive breast cancers will respond positively to this treatment, many of these cancers will recur and become resistant to antiestrogen drugs, requiring alternative treatments.

Xuan and ECE's Yue Wang are working with colleagues in molecular biology and clinical oncology at Georgetown University Medical Center to understand why cancer cells become antiestrogen resistant. It has long been known that estrogen can bind to estrogen receptors within cancer cells and initiate a signaling cascade that ultimately causes proliferation. Accordingly, antiestrogen drugs work by binding to estrogen receptors and preventing estrogen from binding, but many details of the signaling network remain unknown as does the cause of antiestrogen resistance.

Xuan and Wang are developing new computational methods that can be applied to gene expression data to unravel the functioning of the estrogen receptor signaling network for both antiestrogen responsive cells and resistant cells. The ultimate goal of understanding this network is to identify new drug therapies for estrogen resistant cancers, which would have a major impact on breast cancer mortality and improve the quality of life for breast cancer survivors.

The work is funded by a $350,000 grant from the National Institutes of Health.



A human mammary cell

U.S. Department of Energy Genomes to Life Program

RNA MOLECULES

Noise model overturns accepted notions

Modeling the effects of noise on a system helped a Virginia Tech team of biologists and engineers discover an inconsistency in two commonly accepted notions about single cells: how many messenger RNA (mRNA) molecules are in a cell, and how long they live. Their results affect the understanding of how cells process information and were published this spring in the *Proceedings of the National Academy of Sciences (PNAS)*.

In a cell, information is processed through a molecular network of genes and proteins. Messenger RNA is the molecule that carries information from the gene to the cell's ribosomes, where proteins are made. Because of their small size, cells are sensitive to random fluctuations in the number of molecules being created or destroyed at any given moment. Yet, despite the noise in the system from variations in mRNA molecules, cells typically have reliable communications for essential processes such as DNA replication and cell division.

Because of the randomness of the mRNA numbers, the team investigated the system through a stochastic modeling perspective. For yeast cell-cycle genes, the literature reported, on average, only one mRNA molecule per gene per cell and that each mRNA molecule lives, on average, for 15-20 minutes before it degrades.

ECE's Bill Baumann worked on the model with John Tyson, University Distinguished Professor of biology, Mark Paul of mechanical engineering, and Sandip Kar, a postdoctoral associate. "When we looked at the effects of noise on our calculations, we found a tradeoff," Baumann said. "If the mRNA molecules are short-lived, then a small number of them are sufficient for the cell to function. If they are long-lived, however, small numbers are a problem: they create too much noise." The team concluded that since experimental data revealed long lifetimes, there had to be higher numbers of mRNA molecules than conventionally accepted.

"We came to our conclusion based on our model of a yeast cell, and recent experimental work agrees that the numbers of molecules had been underestimated in the past," Baumann said.

Electrical engineers typically model the effects of noise for radio receivers and other communications applications.

"This is a different application of the same theory, except that as a biological system, it's highly nonlinear," he said.

Tyson, Baumann, and Paul are investigators on a National Institutes of Health (NIH) funded research project to build more elaborate and more accurate models of noise in the control system of yeast cells.

2008 2009 BRADLEY FELLOWS

William C. Headley
BSEE '06;
Virginia Tech
Advisor:
Claudio R.C.M. da Silva
Research: Classification and parameter estimation of asynchronously received PSK/QAM modulated signal in flat-fading channels. He developed a classifier and the necessary signal parameter estimators for classifying asynchronously received PSK/QAM modulated signals in flat-fading channels.

Ryan Irwin
BSCPE '07,
Mississippi State
Advisor:
Luiz DaSilva
Research: Cognitive networks. He is involved in development of a MAC protocol for a dynamic spectrum access (DSA) environment, related to the Wireless Network after Next (WNaN) project. He is investigating the tradeoffs and techniques of merging these traditionally independent functions in a cross-layer cognitive networking scheme.

Nathan Kees
BSEE '08
Virginia Tech
Advisor:
Hardus Odendaal
Research: Railgun energy recovery. He is developing a method of capturing energy wasted in the use of a large-scale railgun. Application would be applied to U.S. Navy new ship-based indirect fire railguns to improve the efficiency of future defense systems.

Evan M. Lally
BSEE '03,
MSEE '06,
Virginia Tech
Advisor:
Anbo Wang
Research: Development of a high-resolution particle imaging system and a sapphire pressure sensor for ultra high-temperature, harsh environments – operating up to 1500°C. Investigating a new method of sensor construction through a novel combination of etching and bonding techniques applied to single-crystal sapphire components.

BRADLEY ALUMNI

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

Robert J. Adams (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 Engineer
Advanced Design Group, Intel
Portland, Ore.
Designing mixed-signal circuits for test chips on Intel's newest process technologies.

Carrie Ellen Aust (BSCPE '98)

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

Mark W. Baldwin
(BSEE '93, MSEE '05, Ph.D. '08)

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
Redmond, Wash.
Working in Microsoft Research on topics spanning FPGAs to portable devices.

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)
Argon ST, Inc.; Fairfax, Va.

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. '02)
Electronics Engineer, FBI

Scott C. Cappiello (BSCPE '94)
Senior Director
of Program Management;
MicroStrategy, Inc.
Carlsbad, Calif.

J. Matthew Carson (BSEE '98)
Engineer, Engine Dept.
Joe Gibbs Racing
Huntersville, N.C.
Team won 10 races last year.

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

Eric Caswell (Ph.D. '02)

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

Cas Dalton (BSCPE '03)

Phillip Danner (BSCPE '91)

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

Daniel Davis (BSEE '03)

Scott Davis (BSCPE '00)
Vice President of Operations
Exodus International
Davis operates a program for troubled youth and their families and oversees organization's technical infrastructure.

Brian M. Donlan (MSEE '05)

Joel A. Donohue (MSEE '94)

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

Former Bradley Fellow R. Matthew Gardner (back), an electric transmission planner, was one of three Dominion Power employees and Virginia Tech alumni who visited campus this semester to present a contribution from Dominion that included funding for a fellowship and state-of-the-art equipment for the power engineering laboratory. See the story on p. 25.

Parrish Ralston
BSEE '06,
MS '08
Virginia Tech
Advisor:
Sanjay Raman
Research: Design and verification of liquid metal vertical interconnects for RF flip-chip assembly. Develop consistent techniques to build, model, simulate and perform testing on vertical RF flip-chip assemblies that use a gallium-based alloy, which is liquid at room temperature. Such assemblies do not experience thermo-mechanical stresses of typical solder joints.

David Reusch
BSEE '04,
MSEE '06,
Virginia Tech
Advisor:
Fred C. Lee
Research: Study of alternative power electronics topologies and designs that improve the current practice and capability of future electronics to operate more efficiently and with higher power density. Current research is a three-level converter that can offer improved performance in point of load applications by the use of smaller magnetics and better performing low voltage devices.

Ben York
BSEE '08
University of Alabama
Advisor:
Jih-Sheng Lai
Research:
Investigation of highly efficient power conversion techniques for renewable energy applications. Currently developing adaptive control algorithms for use in photovoltaic installations.

Phillip A. Zellner
BSEE '07,
Virginia Tech
Advisor:
Masoud Agah
Research:
Previous work on mechanical and electrical property differences between cancer cells and healthy cells. Using common MEMS fabrication techniques, a low power, high-yield separation device may be conceived. Currently investigating three dimensionally independent buried channels for microfluidic networks and dielectrophoresis for the separation of cancer cells from blood.

W. Ashley Eanes (BSEE '95)
Duke Energy; Burlington, N.C.

Richard B. Ertel (Ph.D. '00)

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

Kevin P. Flanagan
(BSCPE '00, MSCPE '01)
Design Engineer, Numonyx
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)
Ph.D. Student Carnegie Mellon

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

Timothy Gredler (BSCPE '03)

Christopher R. Griger
(BSCPE '02)
Senior Digital Hardware Engineer
National Instruments
Austin, Texas

Daniel Michael Hager (CPE '08)

Alex Hanisch (BSCPE/Math '03)
Simulation and Modeling Scientist
Joint Warfare Analysis Center
Dahlgren, Va.
Developing analysis and modeling capability to solve problems for the warfighter.

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)
Plant Engineering, Coal Gasification
Eastman Chemical Co.
Kingsport, Tenn.
Became registered PE in 2006.

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)
Software Engineer
Hatteras Networks
Research Triangle Park, N.C.

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.
Became team leader this past year.

Russell T. Holbrook (BSCPE '03)

Andrew Hollingsworth (BSCPE '02)

Ryan Hurrell (BSEE '03)
Electrical Engineer
Northrop Grumman/Remotec
Clinton, Tenn.
Currently completing program to provide remote operated, explosive ordinance disposal vehicle to Yuma Proving Ground.

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)

2008 2009 BRADLEY SCHOLARS

Benjamin A. Beasley
EE/Music '09
Kernersville, N.C.
J.B. West Scholarship; National Merit Scholar; Robert C. Byrd Scholar; Sam Walton Community Scholar; BPO Elks Walter "Buddy" Green Scholar; Guilford County Schools/Harris Teeter Scholar; New River Valley Symphony; Horn Ensemble.
Why ECE: "Electrical engineering is the ideal combination of math, science, and tinkering. It manages to be both abstract and practical in a very appealing way."

Ross Benjamin Clay
CPE '09, Minor in Economics
Raleigh, N.C.
Pratt Scholarship; Dept. of Energy Student Undergraduate Laboratory Internship Fellowship; IEEE; Outstanding Poster Presentation in Engineering, Los Alamos National Lab Student Symposium 2007; ECE tutor.
Career aspirations: partner in/owner of a diverse set of software startups. "My interests have gravitated to software, but I am pleased to have been trained as an engineer. I enjoy the problem solving and application..."

Brittany Clore
CPE '10
Fairfax, Va.
Gamma Beta Phi; Hypatia Engineering Community; HKN Honor Society Secretary and Climate Committee Chair; Gamma Beta Phi Honor and Service Society.
Career goals: working as a systems engineer with embedded systems.
Why Virginia Tech: "I love the campus atmosphere, and even after three years the food still doesn't get old. It's the only place I could see myself and I have no regrets."

BRADLEY ALUMNI Continued

Paul A. Kline (Ph.D. '97)

Gregory Kozick (BSCPE '03)

William B. Kuhn
(BSEE '79, Ph.D. '96)
Professor, EECE
Kansas State University
Research projects include Mars Microtransceiver radio.

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

Mark A. Lehne
Graduate student, Virginia Tech

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)
Research Scientist
Bellcore, Red Bank, N.J.

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

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

Andrew Love
Graduate student, Virginia Tech

Cheryl Duty Martin (BSEE '95)
Head, Cyber Information Assurance and Decision Support
Applied Research Laboratories
University of Texas at Austin

Stephanie Martin (BSEE '04)
Associate Professional Staff
Johns Hopkins University Applied Physics Lab; Columbia, Md.
Provide 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 Electronic Engineer
U.S. Department of Defense

David McKinstry (MSEE '03)

Garrett Mears (BSCPE '00)
Head of Software Development
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.
Currently leading a team working on R&D for Army weapon systems.

Carl Minton (MSCPE '99)

John Morton (MSEE '98)

Stephen Nash (BSCPE '03)
Senior Software Engineer
Lockheed Martin; Rockville, Md.

Troy Nergaard (MSEE '02)
Senior Electrical Engineer
Tesla Motors; San Carlos, CA
Manages the Charging Systems group for electric car development.

Michael H. Newkirk
(BSEE '88, MSEE '90, Ph.D. '94)
Assistant Group Supervisor in the Air and Missile Defense Dept.
Applied Physics Laboratory
Johns Hopkins University
Laurel, Md.
Newkirk is involved in analysis of environmental effects on RF systems, particularly radar and communication systems, as well as testing, upgrading radars, and RF propagation modeling.

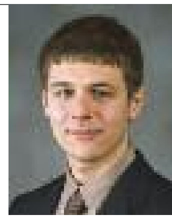
Paul Erik Nguyen
(BSCPE '98, MSCPE '99)

J. Eric Nuckols
(BSEE '97, MSEE '99)
Communications Engineer
Zeta Associates
Fairfax, Va.

Thomas Alan Cooper

EE ’10
Oak Ridge, Tenn.
Galileo Engineering Community; HKN Honor Society; IEEE; Student Engineers’ Council; Video Problem Solving Editor; Intramural soccer.
Career goals: Communication systems.
Why ECE: “I’ve been intrigued by circuits, computers, radios, and other electronic systems...”

Zachary La Celle

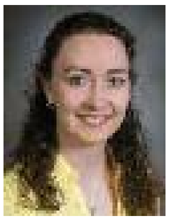


CPE ’09
Lansing, N.Y.
IEEE; Intramural soccer.
Study abroad: Spring 2008, Lorraine, France.
Career goals: Robotics and AI navigation and decision making.
Most memorable: Embedded System Design. It was exciting to take a concept and work on every aspect, coming up with a fully working product.

David C. Mazur

EE ’11
Pittsburgh, Pa.
IEEE; U.S. Soccer Refereee.
Career aspirations: My own engineering firm.
Why ECE: “I was interested in the different electronic components... This sparked my passion for electronics.”
Why Virginia Tech: “The EE power program is very strong and competes with the best in the nation.”

Chelsy Wynn Smidler

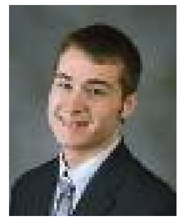


EE ’11
Lafayette, Ind.
Career goals: “I would enjoy an electrical engineering career that allows me to travel the world.”
Most memorable: “One of my most memorable moments at Tech was enjoying the musical tribute at “A Concert for Virginia Tech.”

Jerry A. Towler

EE ’08
Greenville, S.C.
Hillcrest Honor Community; Student Technology Council.
Career goals: Graduate school to explore complex robotics and automation.
Why ECE: Wanted to develop robotic devices, but then discovered an interest in combining mechanical development and software-based automation.

Matt Welch



EE ’09
Richmond, Ky.
IEEE; HKN Honor Society Vice President; TBP; SEC; Galileo Learning Community.
Career goals: Completing the Edison Engineering Development Program at General Electric Energy and working internationally.
Why Virginia Tech: “Being in a university that has such a dedicated and close-knit community.”

Bradley Scholar Jerry Towler worked on an undergraduate research project with improving indoor reception of GPS. See p. 34.

Neal Patwari
(BSEE ’97, MSEE ’99)
University of Utah

Joseph Allen Payne (BSEE ’00)

W. Bruce Puckett (MSEE ’00)

Yaron Rachlin (BSEE/Math ’00)
Researcher
Accenture Technology Labs
Chicago, Ill.

Christian J. Reiser (Ph.D. ’05)

Steve Richmond (MSEE ’01)

Jamie Riggins (BSEE/BSCPE ’04)

Pablo Max Robert (Ph.D. ’03)

Thomas W. Rondeau
(BSEE ’03, MS ’06, Ph.D. ’07))
Research staff, Center for Communications Research
Princeton, N.J.

Thomas M. Rose (MSEE ’96)
Radar Analyst
Electro-Optics and Physics Group
Boeing Company
University City, Mo.

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)
R&D Engineer
GE Global Research Center
Niskayuna, N.Y.

Raymond A. Sharp (BSEE ’02)

Rebecca Shelton (MSEE ’08)

Jacob Simmons (CPE ’08)

Roger Skidmore
(BSCPE ’94, MSEE ’97, Ph.D. ’03)
Distinguished Innovator
Wireless Broadband Group
Motorola; Austin, Texas

Jeff Smidler (BSEE ’98)

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

Graham Stead (BSCPE ’93)

Douglas R. Sterk (MSEE ’03)
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

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

Daniel Tebben (Ph.D. ’06)

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.
Responsible for designing equipment and controls for remote operation.

Michael L. Webber (MSEE ’03)

Jason Wienke (BSEE ’02)

Thomas Williams (BSEE ’00)

William J. Worek
(BSCPE ’99, MSCPE ’02)
Senior Engineer
SAIC, Arlington, Va.
Focus on network optimization for RF communications pathways to include routing, reliable data, and network management.

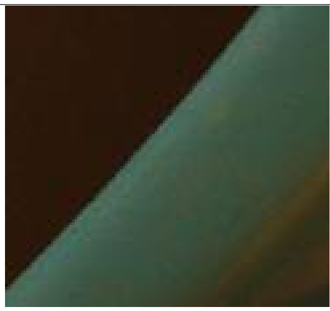
Kai Xu (BSEE ’95)

Jason Jon Yoho (Ph.D. ’01)

Gregory A. Zvonar (MSEE ’91)

Richard Zimmerman (BSCPE ’07)
Applications Programmer
Virginia Tech Transportation Institute
Blacksburg, Va.

2007 2008 PH.D. DEGREES AWARDED



Baldwin, Mark Walter
Modal Analysis Techniques in Wide-Area Monitoring Systems
Committee Chair: Lui, Y.

Blumer, Aric David
Register Transfer Level Simulation Acceleration via Hardware/Software Process Migration
Committee Chair: Patterson, C.D.

Chen, Chen
Electron Temperature Enhancement Effects on Plasma Irregularities Associated with Charged Dust in the Earth's Mesosphere
Committee Chair: Scales, W. A.

Chen, Ruilang
Enhancing Attack Resilience in Cognitive Radio Networks
Committee Chair: Park, J. M.

Craven, Stephen Douglas
Structured Approach to Dynamic Computing Application Development
Committee Chair: Athanas, P. M.

Fan, Dawei
Synchronized Measurements and Applications During Power System Dynamics
Committee Chair: Centeno, V. A.

Fang, Lei
Exploring Constraint Satisfiability Techniques in Formal Verification
Committee Chair: Hsiao, M. S.

Gardner, Robert Matthew
A Wide-Area Perspective on Power System Operation and Dynamics
Committee Chair: Liu, Y.

Kim, Jina
Low-Power System Design for Impedance-Based Structural Health Monitoring
Committee Chair: Ha, D. S.

Le, Bin
Building a Cognitive Radio – From Architecture Definition to Prototype Implementation
Committee Chair: Bostian, C. W.

Lee, Kisun
Advanced Control Schemes for Voltage Regulators
Committee Chair: Lee, F. C.

Mathaikutty, Deepak Abraham
Metamodeling Driven IP Reuse for System-on-chip Integration and Microprocessor Design
Committee Chair: Shukla, S. K.

Raymond, David Richard
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International & national service

Saifur Rahman has been appointed by the NSF to serve on its Advisory Committee for GPRA Performance Assessment to determine whether NSF-sponsored programs are meeting the foundation's strategic outcome goals.

William Davis was elected as the international vice-chair of the URSI/Commission A.

Conference chairs

Thomas Hou is serving as technical program co-chair of IEEE INFOCOM 2009. He also served as technical program co-chair of IFIP International Conference on Network and Parallel Computing (NPC), October 2008 and technical program chair of the International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM), September 2008.

Scott Midkiff served as general chair of the International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities (Tridentcom), April 2009.

Sandeep Shukla is program committee co-chair for the 4th International Workshop on Formal Methods in Globally Asynchronous and Locally Synchronous Designs (FMGAL), April 2009.

Honors & awards

Jaime de la Ree received one of three 2009 Virginia Tech Wine Awards for his record of teaching excellence.

Tom Hou received best paper awards for papers presented at IEEE INFOCOM 2008 and the 2008 IEEE International Conference on Communications (CC) – Wireless Networking Symposium.

Krishnan Ramu won the *IEEE Industrial Electronics Magazine* 2007 Best Paper Award. He and co-authors C.W. Lee and N. Lobo won second prize for their paper from the IEEE Industry Applications Society Electric Machines Committee.

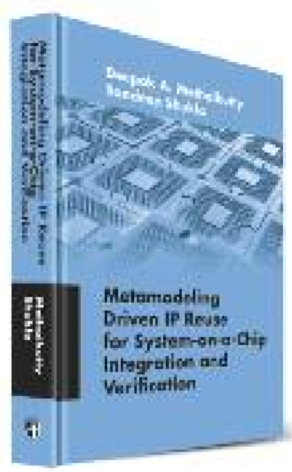
Sandeep Shukla received a Friedrich Wilhelm Bessel Fellowship for lifetime achievement within 12 years of completion of Ph.D. from the Alexander von Humboldt Foundation of Germany. He will be spending the summer of 2009 at the University of Kaiserslautern in Germany as a fellow. He also served as an invited professor at the French National Institute for Computer Science and Automation (INRIA) from August 2008-April 2009.

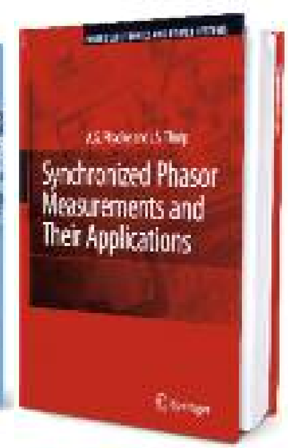
Dushan Boroyevich gave the keynote address at the 2nd IEEE International Power & Energy Conference, December 2008. He also gave the keynote address at the AIST Symposium on Network Society and Energy, January 2008.

Books published

A.G. Phadke and **James S. Thorp** published *Synchronized Phasor Measurements and Their Applications*, Springer, 2008.

Sandeep Shukla published the following books this year:
H.D Patel and S. K. Shukla, *Ingredients for Successful System Level Automation and Design Methodology*, Springer, 2008; D. A. Mathaikutty and S. K. Shukla, *Meta-Modeling Driven IP Reuse for System-on-Chip Design*, Artech House, 2009; and S. S. Ravi and Sandeep Shukla, eds., *Fundamental Problems in Computer Science: Essays in Honor of Daniel J. Rosenkrantz*, Springer, 2009.





Patents awarded

"Nonlinear Observers in Electric Power Networks," R. Broadwater, C. Wells.

"Location Determination of Power System Disturbances Based on Frequency Responses of the System," R. Gardner, Y. Liu, Z. Zhong.

"Process for Forming an Electronic Device Including Semiconductor Fins," M. Orlowski and S. Venkatesan.

"Semiconductor Process for Forming Stress Absorbent Shallow Trench Isolation Structures," M. Orlowski, M. Foisy, O. Adetutu.

"Method for Forming a Semiconductor Device Having a Fin and Structure Thereof," M. Orlowski.

"Dual Surface SOI by Lateral Epitaxial Overgrowth," B. Winstead, O. Zia, M. Sadaka, M. Orlowski.

"Method for Forming an Electronic Device," M. Orlowski, B. Goolsby.

"Laterally Grown Nanotubes and Method of Formation," M. Orlowski, S. Rauf, P. Ventzek.

"Method of Making a Multi-Bit Non-Volatile Memory (NVM) Cell and Structure," M. Orlowski and S. Goktepelli.

"Multi-channel Transistor Structure and Method of Making Thereof," M. Orlowski.

"Semiconductor Process with First Transistor Types Oriented in a First Plane and Second Transistor Types Oriented in a Second Plane," M. Orlowski, B. Nguyen

"FinFET Structure with Contacts," M. Orlowski and T. Stephens.

"Discharge Lamp Lighting Control Device," F.C. Lee, J. Zhou, Y. Jiang, M. Okawa, D. A. Tran, H. Eriguchi.

"PMBDCM and Two Phase SRM Motor, Two Phase SRM Rotor and Stator, and Coil Wrap for PMBDCM and SRM Motors," K. Ramu, A. Staley.

"Method and Apparatus for Identifying an Operational Phase of a Motor Phase Winding and Controlling Energization of the Phase Winding," K. Ramu, A. Bhanot.

"Apparatus for Drive Control, Power Conversion, and Start-Up Control in a PMBDCM or Two-Phase SRM Drive System," K. Ramu.

"Method and System for Identifying Essential Configuration Bits," C.D. Patterson

Editorships

Tamal Bose is associate editor for *Research Letters in Signal Processing, IEICE Transactions on Fundamentals of Electronics,* and *Communications and Computer Sciences*.

R. Michael Buehrer is associate editor for the *IEEE Transactions on Wireless Communications*.

Luiz DaSilva is associate editor for *IEEE Communications Letters* and on the editorial board of *Computer Networks*.

Thomas Hou is technical editor of *IEEE Wireless Communications* and editor of *IEEE Transactions on Wireless Communications, ACM/Spring Wireless Networks (WINTET)*, and *Elsevier Ad Hoc Networks Journal*.

Michael Hsiao is on the editorial board of *IEEE Design & Test of Computers; the Journal of Electronic Testing: Theory and Applications*; *and the Journal of Embedded Computing*.

T.-C. Poon is associate editor for *IEEE Communications Letters*, focus issue editor of *Chinese Optics Letters*, and feature issue editor of *Applied Optics*.

Sandeep Shukla is associate editor for *IEEE Transactions on Computers, IEEE Design & Test*, and *IEEE Embedded Systems Letters*. He was guest editor for a special issue of *ACM Transactions on Emerging Technologies in Computing*, and a co-guest editor for a special issue of *IEEE Transactions on Computers*.

Alumni honors

James M. Russell III (BSEE '62) was named a 2008 Virginia Outstanding Scientist. He is a Hampton University professor and co-directs the Center for Atmospheric Sciences.

His career has ranged from performing ground and rocket reentry tests of heat shield material used on the Gemini and Apollo capsules to instrumentation for characterizing the Martian atmosphere during entry. He is currently the principal investigator on the SAVER experiment on the TIMED satellite as well as PI on the AIM mission to study noctilucent clouds.

Thomas Rondeau (Ph.D. '08) was awarded one of two distinguished dissertation awards by the national Council of Graduate Schools for his 2007 Ph.D. dissertation on "Application of Artificial Intelligence to Wireless Communications." This is the nation's most prestigious honor for doctoral dissertations.

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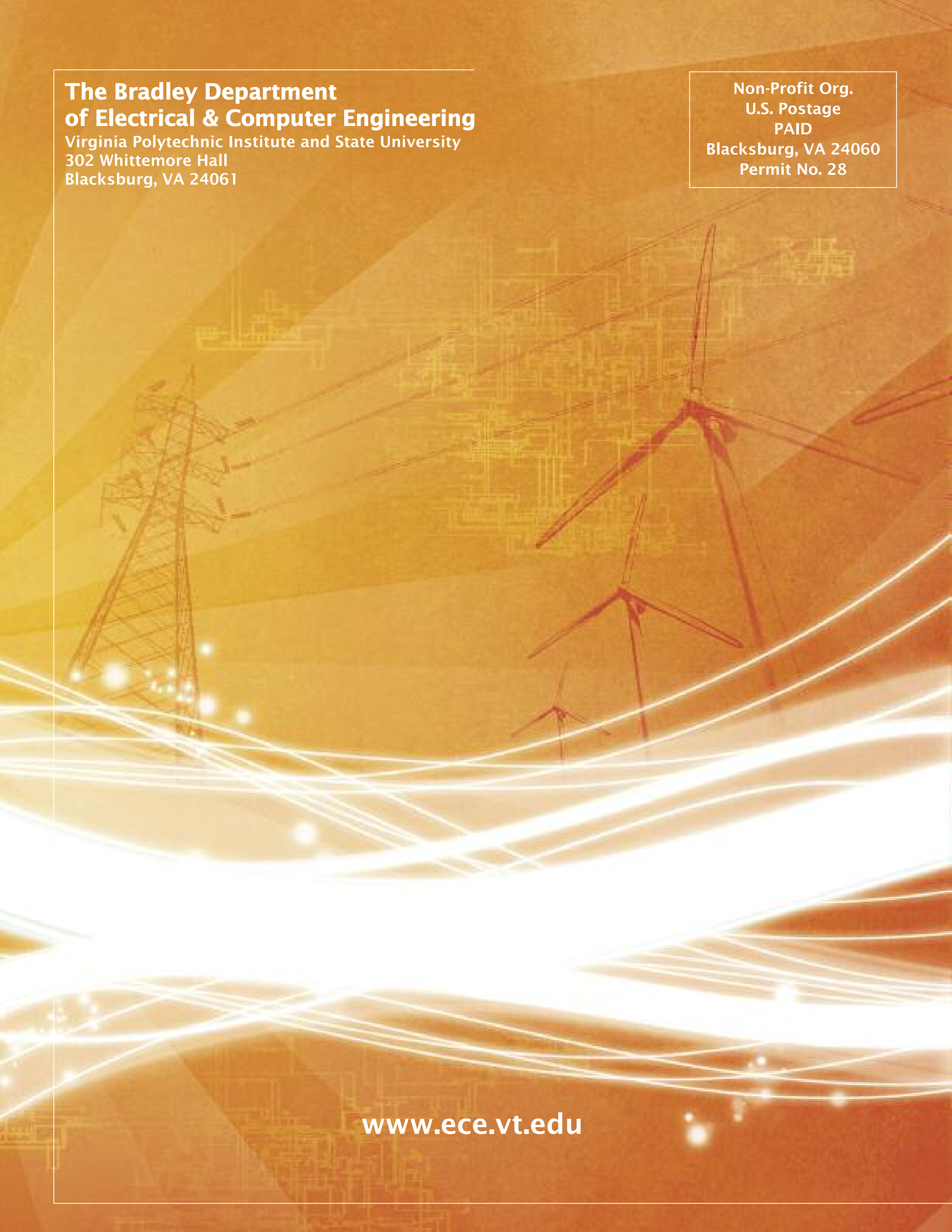

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