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Prof. Talghader is creating enhanced research tools for field research in Antarctica

Next year, ECE Prof. Joseph Talghader will go where few people have had the privilege to go—Antarctica. Working on a three-year project funded by the National Science Foundation (NSF) – Office of Polar Programs, Talghader and his team will develop optical tools for glaciological research that will analyze annual layers of dust content and crystalline structures in their natural state within the polar ice sheet.

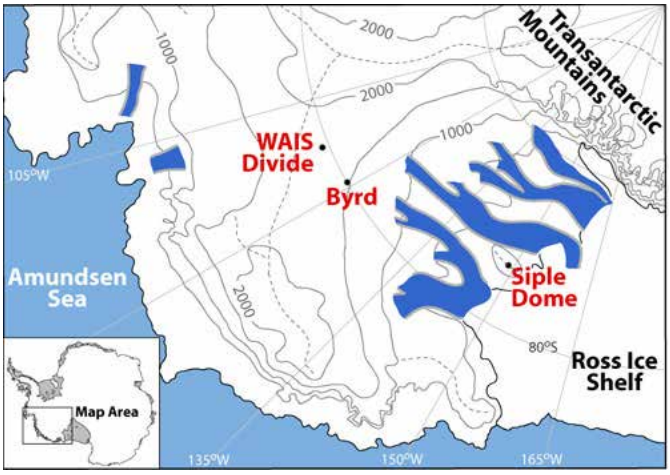
Talghader is collaborating with University of California-Berkeley Professor Ryan Bay. Other team members include ECE graduate students Wing Chan and Merlin Mah. Three members of the team will visit two sites: WAIS Divide Bore Hole in West Antarctica and Siple Dome Bore Hole (see map).

"This expedition is an exciting opportunity and will allow us to use our electrical engineering and optical skills," says Talghader. "It's a different opportunity than one normally sees in an engineering curriculum, and we hope it is a fruitful one."

The team will attempt to create more compact optical devices to obtain data from boreholes that have been drilled over the years in Antarctica. Current data is taken by "borehole loggers" that require complex optical equipment including lasers, detectors, power supplies and optical elements that all are lowered into a borehole.

Talghader's team will create optical fiber-based tools to make the devices smaller and more lightweight, which will allow them to explore a wider range of drill sites.

They also will incorporate additional optics into the tools to obtain information about the crystal structure of the ice sheets. Up to now, measurements of crystal structure have been destructive, requiring



Prof. Joseph Talghader will travel to Antarctica to test research equipment at two sites: WAIS Divide Bore Hole and Siple Dome Bore Hole. *Map from WAIS Divide Ice Core Project Science Coordination Office Website, National Science Foundation http://www.waisdivide.unh.edu/about/site.shtml*

that ice cores be cut into many small slices which then could be analyzed using standard techniques.

Talghader's team will use polarized backscattering to extract the size and orientation of the ice crystals nondestructively from the borehole wall. One of the challenges they must overcome is the effect of frigid temperatures on instrumentation. Talghader's team must ensure that the optics will operate in the outdoors as well as in the rough and unpredictable conditions of polar field sites.

The NSF is conducting a large drilling project at the WAIS Divide; this is where the Talghader team will test their new equipment first. NSF has drilled a borehole on the site over the past few years. It was completed last year and is more than 3,000 meters deep. Other groups will begin drilling replicate cores at the original borehole to obtain multiple samples of particularly important core regions.

The second site Talghader will visit is a borehole site from the 1990s called Siple Dome. Currently, only equipment is stored at the site, so Talghader's team will have to set up a field camp.

Talghader hopes to have some ability to communicate visually daily while at the WAIS site or at the main Antarctic base at McMurdo and is planning some communication dates with local Twin Cities schools. However, once the team is at Siple Dome, communication will be minimal.

In this issue

College of Science & Engineering
University of Minnesota

Puzzle-solving as a paradigm for research in computer engineering

When asked to put a label on his domain of research, **Prof. Marc Riedel** (left) avoids generic terms like "hardware" and "software." He studies computation in a broader sense, focusing on novel architectures and new domains, such as nanoscale and biological systems, in which to deploy computing. "I look at my work as inductive rather than deductive, and conceptual as opposed to applied. I am not seeking ways to improve existing computer designs; I am seeking entirely new paradigms for computing," Riedel says.

Riedel, in self-defined mid-career, has renewed his zest for research as he revisits conventional areas in computer engineering. Although he will continue to work on bio and nano computing, Riedel's top-of-mind topic area is "Revisiting Logic Synthesis." He will be applying expertise from fields of mathematics such as combinatorics, as well as from fields of electrical engineering such as coding theory, to the very basic problem of logic synthesis: how to organize logic gates such as AND, OR, and NOT to compute useful functions.

"We engineers are puzzle solvers at heart. The puzzle of how to organize logic gates was solved early in the history of computing, when computer engineers were working with mere hundreds of logic gates. It has not really been revisited since. However, computer engineers are now working with millions or even billions of gates. The rules have changed; it's time to tackle the puzzle again."

To date, Riedel is most proud of the work done with his student Weikang Qian (Ph.D.'11), now a professor at the Shanghai Jia Tong University, and ECE colleagues Kia Bazargan, David Lilja, and Ramesh Harjani. Riedel and his collaborators created a new paradigm for computing based on probabilities instead of fixed values. "Since grade school, we've all learned to count in a positional number system, namely in base 10. Most digital systems operate on a positional representation of data, namely binary radix. This is a compact way to encode values. However, if you stop and think about it, operating in binary radix requires complex logic," says Riedel. "In each operation such as addition or multiplication, the signal must be decoded, with the higher order bits weighted more than the lower order bits."

Riedel and his collaborators advocate an alternative representation: random bit streams where the signal value is encoded by the probability of obtaining a one versus a zero. This representation is much less compact than binary radix. However, complex operations can be performed with very simple logic. Also, the resulting circuits are highly tolerant of noise and errors. "If some of the bits accidentally get flipped from 0 to 1 or vice-versa, the circuits do not fail catastrophically; they continue to operate seamlessly, just with a little less accuracy," Riedel says.

Riedel's research interests also include molecular computing. "Just as electronic systems implement computation in terms of voltage

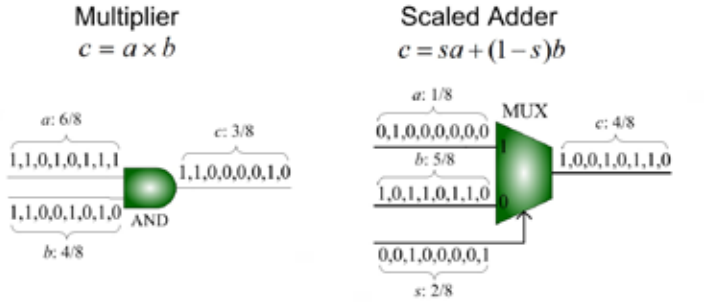


Figure 1: Logical computation on stochastic bit streams. A real value x in the unit interval [0, 1] is represented as a random bit stream. For each bit in the stream, the probability that it is one is x. The circuit on the left illustrates multiplication (with a single AND gate!). Here the inputs are 6/8 and 4/8. The output is 6/8 × 4/8 = 3/8, as expected. The circuit on the right illustrates scaled addition (with a single MUX gate!). Here the inputs are 1/8, 5/8, and 2/8. The output is 2/8 × 1/8 + (1 − 2/8) × 5/8 = 4/8, as expected.

(energy per unit charge), molecular systems compute in terms of chemical concentrations (molecules per unit volume)," Riedel says. His group is studying techniques for implementing a variety of computational constructs with molecular reactions such as logic, memory, arithmetic, and signal processing. "The impetus for this research is not computation per se. Molecular computation will never compete with conventional computers made of silicon for tasks such as number crunching. Chemical systems such as DNA are inherently slow and messy. Rather, the goal is to create embedded controllers—viruses and bacteria that are engineered to perform useful molecular computation where it is needed, for instance for drug delivery and biochemical sensing," he added.

Funding

Riedel's work is supported by three concurrent National Science Foundation (NSF) grants. The first is an NSF CAREER Award titled "Computing with Things Small, Wet, and Random—Design Automation for Digital Computation with Nanoscale Technologies and Biological Processes." The second, titled "Digital Signal Processing with Molecular Reactions," funds joint research with ECE Prof. Keshab Parhi. The third, titled "Digital Yet Deliberately Random: Synthesizing Logical Computation on Stochastic Bit Streams," funds joint work with ECE Professors Kia Bazargan, David Lilja, and Ramesh Harjani.

Students

"I've graduated three Ph.D. students; two of them have landed tenure-track positions at prestigious universities," says Riedel. Qian (mentioned above) is a professor at one of the top universities in China. Mustafa Altun (Ph.D.'12) is a professor at the Istanbul Technical University, the top university in Turkey. "My third graduate, Hua Jiang (Ph.D.'12), was lured away from academia to Silicon Valley," Riedel says. His fourth Ph.D. student, John Backes, is expected to graduate in 2013. Backes has interned at NASA and has obtained a Doctoral Dissertation fellowship for his final year.

Prof. Kim pushes the envelope for chip speed, efficiency, and reliability

Prof. Chris Kim (left), whose VLSI Research Group in the Department of Electrical and Computer Engineering, does research in the cyclical environment of chip design development, from planning and designing to testing and characterizing. This challenging research provides opportunities for his graduate students to learn the fundamentals, to invent new ideas, to lead projects, and often to intern in major businesses; for Kim, it provides much satisfaction.

Kim divides his research into two areas: designing new silicon chips that push the envelope for increased speed, efficiency, and reliability; and designing non-silicon devices for yet-to-be developed systems—for example, using magnets as computational devices or designing flexible electronics.

"We work on designing chips that will be part of computing in five to ten years and others of a more experimental nature that may be in use in ten to twenty years," Kim says. "This is a risk-intensive business. We make sure we are working on high-risk high-payoff type projects that industry won't necessarily attempt in their own development labs."

An eco-system is required to accomplish the completed working assembly of an electrical computer system. Research teams with expertise ranging from material development, device fabrication, circuit design, testing, and systems coordination, create the design eco-system.

"The system complexity is such that no single individual can handle the project," Kim says. "That is why we work closely with the system level teams and the device teams.

With a grant from the National Science Foundation (NSF), Prof. Kim works with Prof. Jian-Ping Wang, Prof. Steve Koester, and Prof. Paul Crowell on magnet-based computing. "By replacing silicon transistors with nanometer dimension magnets and playing some circuit tricks, we can have a processor with zero standby leakage current which could lead to significant energy savings," he says. The team is exploring ways to bring this nascent device concept closer to reality.

Since 2008, Kim has been working with Chemical Engineering Prof. Dan Frisbie through joint grants including one from the Office of Naval Research (ONR) consisting of 10 principal investigators across five institutions. "I am the only one in the group who is not on the fabrication side," Kim says. "I guide them in designing good devices through my perspective on the circuits level." The goal of this five-year project is to design a flexible brain sensor prototype with local sensing circuitry achieving a very high signal to noise ratio. Brain sensors available today are cumbersome, susceptible to noise, difficult to wear, and expensive. Our multidisciplinary team spanning ECE, BME, and CEMS aims at overcoming these limitations through flexible electronics technology.

(Left) Die microphotograph of a test chip. (Right) Measurement workbench setup and test program graphical user interface.

In the more traditional design area working on silicon chips— silicon is the work-horse of the $300 billion semiconductor industry— Kim works with ECE Prof. Sachin Sapatnekar. Together they collaborate on ideas involving fast computer algorithms and computer-aided design. In a joint project, funded by the NSF, they are designing compact on-chip sensors, called "silicon odometers" for monitoring the health of a chip, and looking at ways to deploy them in a massive processor system.

Graduate student experience

Kim provides an excellent learning environment for his graduate and doctoral students providing them with opportunities to lead at least two to three chip designs by the time they complete their Ph.D. degree. First, the new graduate students spend time learning to design circuits and to use the tools required. They move on to "shuttle-runs" or mobilizing plans that have hard deadlines of two to three months and require sequencing multiple project timelines of four to six months.

"When doing this type of work, we want to be designing for multiple projects to be cost effective overall," Kim says. "It also takes team work and communication so that two people are not working on redesigning the same block. It's a real group effort. Our design reviews sometimes last for hours."

"When our students leave, they are well-prepared and have few problems finding jobs—industry loves them," he says.

When Kim's team has completed its design work, the project is handed over to a chip manufacturer. "Then the wait begins," says Kim. "It can take six months to a year depending on the complexity and process required in the new design. The timing is very fluid depending on how many updates the company has to make to the processing flow. If our project involves more mature technology, the process may take only three months." In addition to the waiting, Kim spends six months to a year on legal paperwork and planning the efforts with help from the University's Sponsored Projects Administration (SPA).

Once the chip returns, Kim's team begins testing the new device. (see illustration.) "It can take months to finally see the fruits of our labor as some experiments involve long-term endurance tests," Kim says. "The ultimate goal is to make chips perform better, burn less power, and last longer."

Algorithm engineering career brings breakthroughs to cognitive radio and wireless systems

Steve Bruzzone (MSEE'78, Ph.D.'82) Director of Advanced System Techology, Tarana Wireless

ECE alumnus Steve Bruzzone (MSEE'78; Ph.D.'82), Director of Advanced System Technology at Tarana Wireless in Santa Clara, Calif., develops beamforming solutions for advanced broadband wireless internet networks by creating and refining algorithms. Bruzzone also is the originator of the breakthrough nonlinear resonance classification (NRC), a transformation that detects subtle modulation differences, thus solving a problem that had caused inefficiencies in military signal classifiers. His discovery, made during his previous position at ArgonST Radix, significantly simplified the classification logic required to achieve a robust capability.

"A couple of years into this program, a U.S. Government laboratory pronounced NRC as the top ranked classifier in detailed laboratory tests that compared the available defense contractor offerings," Bruzzone says. "This caused NRC to 'go viral' as much as an algorithm product can in the defense industry."

Radix entered into licensing agreements with several companies, most notably being branded as the "ModRec" (Modulation Recognition) software option to the Agilent E3238S Signal Intercept and Collection System. Today NRC is running at hundreds of installations throughout the world, and continues to be considered the performance standard in the defense industry.

Advancements in engineering through Bruzzone's eyes

Today, the enormous increase in processing power and memory density has made it possible to develop systems powerful enough to implement highly complex algorithms and to run them at real-time rates. "Many of the ideas we researched back in the early 1980s were simply not attainable in real-time systems, at least not without a lot of patient financial backers," says Buzzone. "Now, a modest-cost machine can run complex simulations and exhaustively characterize the performance of nearly any concept or algorithmic idea worth testing."

For example, Tarana Wireless, Bruzzone's current employer, has a simulation capability that runs on a standard desktop or laptop computer, and, in minutes, is able to model the impact of algorithm changes on the operation of a communication network covering a township or urban area.

"For system and algorithm design, it is not far from the truth to say that your imagination is the limit," Bruzzone says. "This is what makes algorithm engineering fun. I like to consider wide-ranging ideas when initially approaching a problem, and in several instances what began as an off-the-wall association of ideas ended up as an outstanding approach to a solution."

New types of tools have been developed in recent years to help engineering teams accomplish parallel development and version control. "Engineers today are more geared for these tools, and have a tendency to set up wikis, sandboxes, and the like on their own initiative for information sharing, file sharing, and collaboration," Bruzzone says. "In particular I think the wikis and sandboxes have accelerated the rate of learning, especially for engineers starting out at a company."

When Bruzzone entered the working world, he was surprised by the "sink or swim" environment of smaller companies. "It's not that the environment deliberately is adverse, but rather that nobody has the time or bandwidth to do meaningful training or mentoring," he says. "I quickly discovered a new found relevance for my old textbooks, and a day or two of review was often enough to gain traction on a given assignment. Today, online resources such as Google and Wikipedia have taken over the textbook role to some extent, because they are so fast and easy to access. But I still find the textbooks useful, better at jogging my memory, and in fact amazingly prescient in how accurately they anticipated where the fields of communication and control theory were going."

Limits of the radio spectrum

Bruzzone says he never expected the radio spectrum to get "used up" in his lifetime. As the demand for broadband wireless devices and services continues to accelerate, technology and service providers are attempting to push into increasingly high-frequency bands.

"The best inherent radio propagation and efficiency characteristics for suburban and urban coverage are found in the lower frequency bands (not long ago defined as "microwave bands" signifying their high-frequency nature) in which cellular and WiFi signals operate today," he says. "Providers are jamming as much data rate as possible into a given radio frequency bandwidth. This is a rich area for algorithm origination and development in the effort to maximize the data rate per Hertz of radio spectrum consumed. The goal is to transform highly dynamic and interference-laden, non-line-of-sight channels into high-fidelity radio frequency links rivaling a cable connection."

As data rate demands increase, the power required for modulation density and complexity over even moderate distances is becoming impractical. To compensate, companies are building cells smaller, with some service providers now deploying microcells and picocells in areas of heavier internet usage. This causes an increase in interference density, requiring the use of adaptive beamforming in each cell to null out unwanted signals from neighboring cells.

"In my current position at Tarana Wireless, I am working in this tradespace, developing next-generation wireless non-line-of-sight microcell and picocell backhauls to reduce deployment costs for

continued from page 4 - Bruzzone

service providers," Bruzzone says. "But eventually, further shrinking of cell sizes will increase interference densities beyond levels that adaptive beamforming can reasonably address without a counterproductive draw-down on the bandwidth available for data transmission. At that point, a paradigm shift will be needed, and it will be interesting to see the evolution of new ideas and possibly disruptive concepts that will arise from this need."

A lookback to University of Minnesota classroom days

"The research assistantships provided by my academic advisor Mos Kaveh, and the associated interactions with Mos throughout my time at University of Minnesota, were critical for my chosen career path," Bruzzone says. "I have pursued a purely technical career path as an algorithm engineer, a term that translates roughly to system engineer with an 'inventor' focus.

"I developed an affinity for algorithm origination during my student years working with Mos. Our earliest interactions generally involved my coming up with bad ideas, and Mos gently instructing me on how to define meaningful metrics by which to quickly discern the differences between those and good ideas. The skills he taught have served well over the years," Bruzzone says.

Advice to current ECE students

Communication skills, both written and spoken, turned out to be more important to an engineering working environment than Bruzzone had anticipated. "While these skills are obviously critical for the researcher looking to publish his work in the IEEE and other engineering journals, they are no less important in the project team environment," he says.

"In system and algorithm engineering, I would estimate that more time is spent writing than in actual technical design activities. This is due in part to the fact that requirements and design approaches must first be documented before the detailed technical work is begun. These documents form the common baseline critical to coordinating the efforts of a team of engineers," Bruzzone says.

"Spoken communication is equally critical, especially in working groups. Answering a question with just enough detail to get the message out without expending the team's time on digressions or excuses that are generally not needed seems to be an art that some engineers have mastered. The most effective meeting participants operate in a time-division duplex (TDD) mode: They transmit, then receive, then transmit, then receive, as opposed to one-way broadcast. Everyone on the team appreciates the TDD participants," he added.

STEM Education

U of M STEM Education Center receives $8 million grant from National Science Foundation

The University of Minnesota's STEM Education Center/CEHD received an $8 million, five-year grant from the National Science Foundation, to partner with 200 Twin Cities metro area teachers to increase science and math learning through engineering for 15,000 students in fourth through eighth grades.

Tamara Moore (CEHD) is the Principal Investigator (PI) and **ECE Prof. Paul Imbertson (left)** is one of four co-PIs on this project. He is the Content Director, and responsible, along with Gillian Roehrig (CEHD), the Pedagogy Director, for the Professional Development activities with area teachers.

The STEM Education Center, with the largest grant it has ever received, will lead an engineering, design-based approach to teacher professional development that will help teachers design curricular units for science topic areas within the Minnesota State Academic Science Standards.

The project will include summer professional development and curriculum writing workshops, paired with a cognitive and content coaching model, to allow teachers to design curricular units focused on science concepts, and meaningful data analysis and measurement. Each unit will go through an extensive design research cycle to ensure its quality and then will be submitted to TeachEngineering.org, an online peer-reviewed digital library, for use across the United States and beyond.

The project name is "EngrTEAMS: Engineering to Transform the Education of Analysis, Measurement, and Science."

Project partners include the University's Center for Compact and Efficient Fluid Power and Center for Applied Research and Educational Improvement, the St. Paul Public Schools, the North St. Paul-Maplewood-Oakdale School District, the South Washington County Schools, the Metropolitan Cooperative Service Unit, and the Grants and Research Office of Intermediate Districts 287 and 916.

The school districts involved cover a diverse student population. In St. Paul, for example, many students come from immigrant or refugee families and 45 percent live in homes where English is not the first language. Teachers in the project who work with high-need students will not only implement the curriculum modules, but also will document the learning outcomes of underrepresented populations. The project research findings are aimed to help practitioners, administrators, and policymakers discover the best ways to improve student achievement and develop student interest in STEM careers.

Part of the College of Education and Human Development (CEHD), the STEM Education Center includes researchers from five U of MN colleges, with core faculty from CEHD's Department of Curriculum and Instruction. The Center for Compact and Efficient Fluid Power is part of the College of Science and Engineering at the University. The Center for Applied Research and Educational Improvement is part of CEHD.

Prof. Massoud Amin was elected president of the International Association for Management of Technology (IAMOT), after having served the last two years as vice president of IAMOT public affairs. He will oversee plans for IAMOT's 2014 international conference.

In addition, Prof. Amin conducted a number of media interviews including: Public Radio International (PRI), WNYC-New York Public Radio/BBC, *New York Times*, and WGBH/WBZ Radio Boston, *The Globe and Mail*, *USA Today*, *Forbes*, IEEE's *Today's Engineer*, Pacific Standard, Australian Broadcasting Corporation, *The Government Technology Magazine*, among others.

Prof. Emad Ebbini has been named president of the International Society for Therapeutic Ultrasound (ISTU), a non-profit organization founded in 2001 to increase and share knowledge of therapeutic ultrasound with the scientific and medical community.

In addition, Office of the Vice President of Research's MN Futures Grant Program approved funding for Prof. Ebbini's dual-mode ultrasound work. This grant funds a collaboration with Prof. Efie Kokkoli (CEMS), Dr. Erik Cressman (Radiology), and Dr. Raj. Aravalli (Radiology), to investigate the use of a dual-mode ultrasound array (DMUA) system for both image guidance and controlled release of a peptide functionalized thermo-sensitive liposome (TSL) with specific binding to target cells such as liver cancer cells. If successful, this approach will allow for the use of the most powerful agents to fight the disease with minimum adverse systemic effects.

Prof. Rhonda Franklin was appointed to a three-year term as Associate Editor for the IEEE Microwave Wireless Component Letters (MWCL), a journal of the IEEE Microwave Theory and Techniques Society, starting October 2012.

In addition, Prof. Franklin was named one of five fellows representing the University of Minnesota in the 2012-13 Committee on Institutional Cooperation (CIC) Academic Leadership Program (ALP). Established in 1989, this intensive experience develops the leadership and managerial skills of faculty who have demonstrated exceptional ability and academic promise. Many of the program's nearly 1,000 Fellows have gone on to serve with distinction as college presidents, provosts, and deans.

Prof. Franklin also was awarded a three-year NSF collaborative research grant titled "Polymer RF Electronics with Co-integrated Tuning and Thermal Cooling Using Microfluidics." With a colleague at Georgia Institute of Technology, her group will develop RF fluidic circuits for use in radar applications.

Correction: *Signals* 2012 Summer issue, page 5. Photo caption is incorrect. The identity of the person is unknown and not Sri Latha Ganti as published.

Prof. Ramesh Harjani was selected TPC Chair for IEEE Custom Integrated Circuits Conference (CICC). He will be serving one year as TPC chair, one year as conference chair, one year as general chair, and three years on the steering committee.

Prof. Paul Imbertson, one of four co-PIs and assigned to be the Content Director, along with Gillian Roehrig assigned to be the Pedagogy Director, will be responsible for Professional Development activities with area teachers in the University of Minnesota's STEM Education Center $8 million, five-year grant from the National Science Foundation (NSF). The grant's purpose is to partner with 200 Twin Cities metro area teachers to increase science and math learning for 15,000 students in fourth through eighth grades.

Prof. Mihailo Jovanovic (left) and **Prof. Jian-Ping Wang** (below) have been appointed as Resident Fellows within the Institute on the Environment (IonE) at the U of MN. IonE's resident fellows program provides support for creative faculty members from a range of backgrounds with the objective of generating a new cadre of world-class environmental leaders and problem solvers. Prof. Jovanovic will be involved in research, teaching, outreach, and leadership activities in the area of renewable energy. In conjunction with his ongoing work, Prof. Wang will bridge spintronic and nano magnetic technologies with environment monitoring and research.

Prof. Chris Kim's "An Embedded Flash Memory in a Generic 65nm Logic Process for Zero-Standby-Power System-on-Chip Applications" was invited by the ISLPED 2012 Design Contest Program Committee to present at this year's conference. From a field of 16 submissions, only four were selected for the design contest award.

Prof. Steven Koester's research on building an artificial pancreas, a collaboration with the Mayo Clinic, was highlighted in the Minnesota Medical Foundation's *Discoveries in Diabetes* newsletter.

Prof. Ned Mohan organized a highly successful Department of Energy-supported workshop to discuss power and energy related curricular reform. Nearly 120 national faculty, department heads, and engineering deans attended the University of Minnesota workshop in August.

Prof. Marc Riedel gave the keynote address titled "Logical Computation on Stochastic Bit Streams" at The International Workshop on Power and Timing Modeling, Optimization, and Simulation (PATMOS) in Newcastle, U.K., in September.

Prof. Beth Stadler was invited to teach at the IEEE Magnetics Society Summer School in Chennai, India during summer 2012. The school is held annually during summer holidays and is designed for graduate students studying magnetism and related areas. It consists of lectures by international experts and includes poster presentations by participating graduate students. The program covers fundamentals and advanced topics in magnetism. Support is typically provided for approximately 100 students based on a competitive application. Awardees are provided with free room and board and are reimbursed for most of the cost of transportation to and from the school. Students from all parts of the world are accepted.

Prof. Bruce Wollenberg was interviewed by Associated Press (AP) to comment on the power outages in Washington. The article was picked up by a number of affiliated media organizations through the U.S.

News Briefs Alumni

ECE alumnus Taehyoun Oh (Ph.D.'12) received the Best in Session award at Techcon 2012 for his paper "Adaptive Calibration Algorithm for MIMO Channel Equalization and Crosstalk Cancellation" authored by Oh and his advisor Dr. Ramesh Harjani. Techcon 2012 was conducted by Semiconductor Research Corporation (SRC) and was held on September 10-11 at Austin, Texas.

ECE alumnus Ted Brekken (Ph.D.'05) was chosen as the 2011-2012 Oregon State University Electrical Engineering and Computer Science "Professor of the Year." (Ned Mohan, advisor)

Prof. Georgios Giannakis's former advisees met with College of Science and Engineering Associate Dean and Professor Mostafa Kaveh (center) during a small alumni gathering in San Diego on Sept. 13. Prof. Kaveh provided updates from the college and the department. ECE alumni include (from left) Yingqun Yu (Ph.D.'07), Pengfei Xia (Ph.D.'05), (Kaveh), Xiliang Luo (Ph.D.'06), and Wanlun Zhao (Ph.D.'05).

ECE Alumni awarded Outstanding Achievement Awards

In October, the University of Minnesota Board of Regents announced that the highest honor for alumni—the Outstanding Achievement Award—was bestowed upon two former ECE graduates **Mark Kroll** (top left) (BEE'75, MSEE'83, PhD'87 and MBA'90 University of St. Thomas) and Prof. **Yannis Tsividis** (lower left) (BEE'72 and MSEE'73 and PhD'76 University of California-Berkeley.)

Kroll, Principal of Mark Kroll & Associates, LLC, is the developer of the biphasic, implantable cardioverter defibrilator (ICD); every ICD today uses Kroll's technology. With more than 350 patents, Kroll is one of the most prolific inventors of medical devices in the world.

Tsividis, Professor of Electrical Engineering at Columbia University, is the inventor of the first fully-integrated MOS operational amplifier. His results were widely adopted by the industry in the first massively produced mixed-signal MOS integrated circuits which incorporated both analog and digital functions on the same chip providing vastly higher levels of circuit integration than bipolar analog devices. His work has been widely used in wireless communications equipment, consumer electronics, computer disk drives and biomedical devices.

In Memoriam
Emeritus Professor Mahmoud Riaz

Emeritus Prof. Mahmoud Riaz of Minneapolis, a past professor in the University of Minnesota's Department of Electrical and Computer Engineering from 1959 to 1999, passed away on Aug. 10, 2012. He was 87. Riaz is best known for his solar energy research in the 1970s.

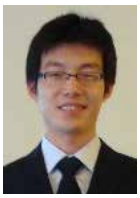
Riaz was born Feb. 27, 1925, in Paris, France. He received his L.L.B. (Bachelor of Laws) from the University of Paris in 1944, a Bachelor of Science from the University of Cairo in 1946, a Master's in electrical engineering from Rensselaer Polytechnic Institute in 1947, and Doctorates in Electrical Engineering and in Science from the Massachusetts Institute of Technology in 1952 and 1955, respectively.

In 1979, Riaz presented a six-week invited lecture series about Solar and Electrical Energy Systems in the People's Republic of China. For many years, Riaz, together with colleague Prof. Jack Judy, organized and taught multi-week refresher programs in math, science, computing, and engineering for engineering managers from companies like IBM and 3M. Riaz also had an extensive consulting career serving major industries such as Boeing, Honeywell, NASA Electronics Research Center, and Sundstrand Aviation.

He was a senior member of IEEE, Life Fellow of the Franklin Institute, an associate member of IEE, and a member of the International Solar Energy Society and Sigma Xi.

Undergraduate **Ken Condon** accepted an electrical engineering internship at SpaceX in Los Angeles and works on the Dragon Capsule project. SpaceX hopes to get the Dragon certified for human transport. Dragon is a free-flying, reusable spacecraft developed by SpaceX under NASA's Commercial Orbital Transportation Services (COTS) program. Initiated internally by SpaceX in 2005, the Dragon spacecraft is made of a pressurized capsule and unpressurized trunk used for Earth to Low Earth Orbit satellite transport of pressurized cargo, unpressurized cargo, and/or crew members. In May 2012, SpaceX made history when its Dragon spacecraft became the first commercial vehicle in history to successfully attach to the International Space Station. Previously only four governments—the United States, Russia, Japan, and the European Space Agency—had achieved this challenging technical feat.

Ph.D. student **Mohammad Elbadry** (left), alumnus **Bodhisatwa Sadhu (Ph.D.'12)** (below), Joe Qui (Army Research Labs) and Prof. Ramesh Harjani were nominated for a best paper award for "Dual Channel Injection-Locked Quadrature LO Generation for a 4 GHz instantaneous Bandwidth Receiver at 21 GHz Center Frequency" at IEEE RFIC held in Montreal. **Bodhisatwa Sadhu (Ph.D.'12)**, Bodhisatwa Sadhu, Ramesh Harjani: (University of Minnesota); Mark Ferriss, J-O Plouchart, A.V. Rylyokov, A Valdes-Garcia, B. D. Parker, Scott Reynolds, D Friedman, J Tierno, A. Natrajan : (IBM TJ Watson Center); A Babakhani: (Rice University); and S. Yaldiz, L Pilleggi: (Carnegie Mellon University) were nominated for a best paper for "A 21.8-27.5 GHz PLL in 32nm SOI Using Gm Linearization to Achieve 130dBc/Hz Phase Noise at 10 MHz Offset from a 22 GHz Carrier" at the IEEE RFIC conference. Both papers were nominated from a field of 123 accepted papers. The RFIC Symposium is one of the foremost IEEE technical conferences in RF circuits, systems, and devices. (Ramesh Harjani, advisor)



Ph.D. students **Zhe Zhang** (left) and **Nohhyun Park** (center), and former post doc **Weijun Xiao** (right)—now assistant professor of ECE at Virginia Commonwealth University—and Prof. David Lilja received the Best Paper (testing and verification track) award for "Memory Module-level Testing and Error Behaviors for Phase Change Memory" at the IEEE International Conference on Computer Design (ICCD), September 2012. (David Lilja, advisor)

Ph.D student **Morteza Mardani** (left) and alumnus **Gonzalo Mateos (Ph.D.'12)** (center) received a Best Student Paper Award for "Distributed Nuclear Norm Minimization for Matrix Completion" authored with G.B. Giannakis at the 13th IEEE Workshop on Signal Processing Advances in Wireless Communications (SPAWC) held in Cesme, Turkey. (Georgios Giannakis, advisor) In addition, Ph.D. student **Omar Mehanna** (right) received a Best Student Paper Award at SPAWC for "Multicast Beamforming with Antenna Selection," authored with N.D. Sidiropoulos and G.B. Giannakis. (Nikos Sidiropoulos and Georgios Giannakis, advisors)

News Briefs New Faculty

Ulya R. Kapuzcu received the B.S. degree in Electronics and Telecommunications Engineering, and the B.S. degree in Computer Engineering (double major) from Istanbul Technical University and the M.S. degree in Electrical and Computer Engineering and the Ph.D. degree in Computer Engineering from University of Illinois, Urbana–Champaign (UIUC).

Her research interests include computer architecture, impact of technology on architecture, energy-efficient architectures, near-threshold voltage computing, variation-aware architectures, and hardware reliability.

John Sartori received a B.S. degree in electrical engineering, computer science, and mathematics from the University of North Dakota, Grand Forks, and an M.S. degree in electrical and computer engineering, and the Ph.D. degree in electrical and computer engineering from the University of Illinois at Urbana-Champaign (UIUC). His research interests include stochastic computing, energy-efficient computing, and system architectures for emerging workloads.

Sartori's research has been recognized by a best paper award (CASES 2011) and a best paper award nomination (HPCA 2012) and has been the subject of several keynote talks and invited plenary lectures. His work has been chosen to be the cover feature for popular media sources such as BBC News and HPCWire, and also has been covered extensively by scientific press outlets such as the IEEE *Spectrum* and the *Engineering and Technology Magazine*.

Working to fulfill a dream, student enters Disney ImagiNations Design Competition

Ever since junior high school, ECE senior **Lucas Kaeding** has dreamed of working at Disney. When he learned of Disney's ImagiNations Design Competition, he set out to prove his skills.

The Disney competition is a way for students and recent graduates to showcase their talents and for Disney to identify new talent. This year's competition received 120 entries. "Although Disney staff is willing to answer some questions in general about the projects, they do not provide project-specific mentoring," Kaeding says. "I had to be self-motivated to participate. It really is a test of creativity and skill."

Beginning in summer of 2011, Kaeding began searching for fellow students who might be interested in joining his team. "It's hard to create a team," he says. "It's difficult to find people who are willing to put the time into a project you really are motivated about and get them to want to do it, too."

In September 2011, he recruited ECE senior Allison Howard and they began working on the project: to create a ride experience located on the Moon in the year 3012. "We first had to envision what it would be like living on the Moon, what the cities would be like, and what people would miss most about no longer living on Earth," Kaeding says. "We decided we would make a ride based on the Disney Channel's "Phineas and Ferb" cartoon. Our machine takes the riders through an experience of Earth's four seasons. We particularly wanted to create the impression of an endless blue sky above and hide the workings of the ride's track mechanism below. Fall has leaves and an apple orchard, winter has ski slopes and mountains, spring has a thunderstorm, summer is pleasant and the end of the ride. "

Kaeding and Howard researched cutting-edge 3-D projection technology currently being done in Japan. Kaeding says they believed that by 3012, 3-D projection would be a profoundly sophisticated technology that would create the illusion of Earth's endless sky and the ability to shield the ride's track from view. Kaeding envisioned a control system that would allow the vehicle to sway and to bounce atop a sphere eliminating the need for a lot of actuators to cause movement. For the blue sky, he envisioned a dome-like construction that would make use of the 3-D video projection system.

The team was allowed to submit only eight PowerPoint slides to Disney. "The first two were already spelled out: Slide One must present the description, Slide Two must present the cartoon characters in the ride. Kaeding and Howard filled in the last six slides with pictures, maps and specific technology components. Kaeding built and painted a wooden model of the car atop its sphere.

At the end of December, Kaeding and Howard were told they were semifinalists. They kept their fingers crossed. The field of competition had been reduced to 40 teams during the evaluation. But in the second round of reviews in February, they learned they had not placed among the 16 finalist. "We did get a good feedback review, though," says Kaeding. "Using the suggestions Disney staff made, plus some other ideas, I'm doing the competition again this year."

To view past projects, go to: disneyimaginations.com/flash/bloom.html

continued from page 11 - Franklin

• *Specific curriculum materials may not be available.* "The only limits are that the variety of texts available depends on the vendors' course load catalogs," Franklin says. "As I observed the lists, some of the books would not have worked. Some books may have worked for my 5000 level class but not my 3000, for example."

Some of the advantages include:

• *Student interactions are encouraged.* "eText allowed more interaction than the earlier PDF versions of just the text," Franklin says. "This will be an enhancement and will encourage creative thinking. In our classroom, the eText information raised good questions. We covered topics we had not covered in past courses."

• *Instructor has an idea of students' interaction with the material.* "The instructor can see the highlighting and questions posed before class time," Franklin says. "The instructor can see what the overall class is choosing as important information and what information they are having difficulty understanding."

• *Cost is much less than text book purchase.* "Students really liked that the eText was cheaper than a printed book," Franklin says.

• *eText learning presents a new direction in active learning and can make working in groups easier for beginning students.*

More information is available at: http://elearning.umn.edu/etext/

Hybrid approach to classroom learning prepares students for careers and develops faculty to offer next–generation teaching methods

Shuffling into class, picking a seat, and listening to an instructor lecture for 50 minutes no longer constitutes the university class experience. Words like "flipping," "clickers," and "etexts" are common. Today's college students listen to online lectures, take quizzes and file their answers with their professors via linked applications, read and discuss chapters from etexts outside of class, and use class time to participate in group discussions.

Bringing change to power systems engineering

During 2000-2005, universities cut back on power engineering programs because industry was not hiring those program graduates—industry believed they had all the power engineers they needed. Then, when many life-long power engineers began retiring, the landscape changed. In addition, the country was experiencing a growing need for alternative energy sources. New power system engineers were needed, and fast.

According to Zenna Berg, Program Manager, Kelly Services in Minneapolis, "From 2000 to 2010, STEM jobs (science, tech, engineering, and math) grew at three times the rate of other fields. From 2010-2020, demand for STEM professionals is expected to increase 16.8 percent, adding more than one million new STEM jobs to the workforce."

To meet this need, the Office of Naval Research (ONR) and the Department of Energy (DOE) provided grants to the University of Minnesota to create a new curriculum. The University was chosen because **Prof. Ned Mohan's** (left) power engineering program was one of the few still in operation.

Mohan produced the new power curriculum consisting of three texts, labs and lab kits, video tutorials, and quizzes. Mohan, Prof. Bruce Wollenberg, and Prof. Bill Robbins began providing new curriculum workshops around the country for university professors, deans, and other administrators. The ECE team also invited these participants to join a national consortium—Consortium of Universities for Sustainable Power (CUSP ™)—that would meet one to two times per year, provide access to any additional materials created, and assure access to a network of resources. CUSP funding was provided through National Science Foundation, National Aeronautics Space Administration, ONR, and Electric Power Research Institute (EPRI.) Since the consortium's inception, more than 120 universities have implemented the new curriculum and used the labs.

Mohan's curriculum included a hybrid class technique, referred to as "flipping," that has changed the traditional classroom sequence. Students now watch lectures and take quizzes online before class time. In class, students discuss problems and answer questions via the use of Clickers (hand-held response devices). The in-class, real time Clicker answer tally helps the professor assess the classes' understanding of the concepts presented. "This method has increased class attendance and participation from 60 percent to 90 percent," Mohan says. "Currently, ECE provides three undergraduate power electronics classes in this format; we hope to add five new graduate-level courses before the end of the year."

Report from an Early Adapter

Prof. Allison Kipple (left), Northern Arizona University at Flagstaff, was one of the first professors to join the consortium; she also was one of the 120 attendees at the recent DOE Workshop hosted at University of Minnesota, Department of Electrical and Computer Engineering on Aug. 7-8, 2012.

"When I first received word that I would be teaching a power class at Northern Arizona, I was worried," Kipple says. "It was outside my area. Without the University of Minnesota's program, I would have muddled through on power education, and probably stopped after one class. I jumped at the chance to go to the new workshops. We practiced using the labs, shared teaching ideas, and solved problems. It was invaluable. Now I have colleagues from across the country with whom I can confer."

Kipple, who has a minor in education, says there was a learning curve but enjoys the new curriculum now. "It's become one of the most popular electives on campus and we've been fortunate to receive grant money from Arizona Public Service that helped us implement the curriculum and supports the program."

Kipple particularly appreciates the online math quizzes. "They are randomized so each time a student logs on the numbers change," she says. "Students spend time helping each other with the material and it keeps them in a continuous learning mode rather than the 'cram-before-the-test' mode."

The new curriculum also offers immediate hands-on lab projects. "Hardware labs are becoming rare at many universities due to cost of setup and maintenance," she says. "But they're so important for students' education. Prof. Mohan's hardware labs are truly outstanding, and students enjoying working with these modern, advanced labs."

As a result of the new curriculum, Northern Arizona has had a dramatic increase in students seeking and being successful in senior capstone projects, undergraduate research projects, internships, and full-time employment in the area of power engineering. "One of our students created an electric bicycle as an independent study project," she says. "He rode it to and from school. That student is now employed by a wind turbine manufacturer."

Kipple's Northern Arizona University Power System Engineering students and classroom in Flagstaff.

eText: A collaborative approach to a pilot project

In November 2011, Indiana University invited several institutions to participate in a 2012 spring semester pilot using eText learning in the classroom. Five institutions agreed: University of Minnesota, University of California–Berkeley, Cornell University, University of Virginia, and University of Wisconsin. The eText pilot project gave the participant universities an opportunity to quickly implement the pilot while taking advantage of Indiana University's negotiated publisher and software provider contracts.

The eText pilot had three major goals: 1) Conducting a pilot for a limited number of classes during spring semester 2012 using a multi-unit project team approach; 2) Collaborating with other Internet2 members to explore the impact of the pilot in different higher education settings; and 3) Exploring and understanding how students with disabilities (including those who use screen readers) access and navigate material through the Courseload application.

The pilot integrated the Courseload eReader software and the McGraw-Hill content with the University's Moodle course management system and single sign-on to provide access to eTexts. Faculty and students were able to read, to annotate, and to print eTexts via most browsers on laptops, desktops, and tablets.

U of MN participating faculty included Sehoya Cotner, Biology, CBS; David Fan, Genetics, Cell Biology & Development, CBS; **Rhonda Franklin** (left), Electrical and Computer Engineering, CSE; Donald Liu, Applied Economics, CFANS; Helen Moser, Finance, CSOM; Nathan Springer and Peter Tiffin, Plant Biology, CBS; Teresa Swartz, Sociology, CLA; and Henriette Warren, Child Development, CEHD.

Franklin chose her EE5613 "RF/Microwave Circuit Design Laboratory" course students to participate. This course is the lab complement to the theoretical course EE5601 "Introduction to RF/microwave engineering," also taught at the same time. The class consisted of 14 students. Because the format required no texts, Franklin was comfortable applying the eText experiment as the lab project assignment for the class.

Franklin chose *Antennas for Base Stations in Wireless Communications* by Profs. Zhi Ning Chen and Kwai-Man Luk as the eText from the McGraw Hill catalog. "I decided to focus on two chapters in the eText that involved introduction to antennas and applications that could be integrated into the group project assignment in the lab course.

At the beginning of the semester, each student was given the eText to download. Students then read sections, highlighted information, and posed questions in their eTexts. Specific permissions are granted among the class members for global views while they were interacting in the classes.

Franklin required each student to generate 1-2 questions for each section studied. Then student teams were assigned a section to present to the class as a tutorial peer-instruction segment. The questions for a particular section were integrated into the presentation of the lab team scheduled to present a tutorial of their topic. Open discussions would follow during the presentations as a result of the questions posed.

"As the class progressed through the semester the students became more proficient with their presentations and were able to address the subject matter and questions in a more coherent manner," Franklin says. "They could refer back to previous items and include them in the discussion. They became interested in learning and didn't feel they had to know all the information going into the discussions. The goal of the pilot was to see how they communicated, how they understood the information, and how they accomplished the interface with the electronic communications."

"In the past, students had been passive observers of a lecture, now they are active learners through presentations and discussions. I think this type of learning will become an expected part of the classroom of the future.

"Both presentations and the questions asked in class were considered in the project grade. Students were not evaluated on how much they interfaced with the eText book," Franklin says.

Franklin identified some of the challenges of using eTexts:

• *Certain functions, like flipping back and forth to specific sections of the book, were not available.* "Most engineers don't read whole books cover to cover; they go back and forth," Franklin says. "Although the eText has allowed page turning, more adaptation is needed as to how people use real books."

• *Tailor-made programming for different subjects will have to be developed.* "There will be a large learning curve when the eText companies discover what techniques are appropriate for specific subject areas," says Franklin. "What works in physics class may not work for a literature class."

• *Discipline cultural differences will have to be taken into account when developing the methods in eText.* "Ask an EE student to interact in the classroom when they barely talk to each other…. It will change the culture of the classroom," says Franklin.

• *Instructional methods will have to change.* "Professors must be ready to teach fluidly," says Franklin. "Whole curriculae may have to change, and that will require time and coordinating efforts," Franklin says. "So far eText focuses only on the user and not the instructor. I found it took 3-4 weeks of prep to do the program well. Unless instructors are required to adopt this manner of teaching they will not be anxious to use it. For me, I wanted to understand this challenge. I love books and learning from that medium, but it may not always be the best solution. It needs to be evaluated. I appreciate the participation class for being so cooperative. I would like to run a pilot for a year with my current text but I would also need a year to develop it appropriately."

Continued on page 9 - Franklin

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