IOWA STATE UNIVERSITY
COLLEGE OF ENGINEERING

RESEARCH HIGHLIGHTS

August 2006

Electrical and Computer Engineering

2005 2006

MISSION STATEMENT

Provide an outstanding educational program that enables our graduates to become leaders in their professions by imparting fundamental principles, skills, and tools to innovate and excel.

Pursue the discovery of fundamental knowledge and its applications to position the department among the leaders in research.

Respond to the needs of the state of Iowa and the nation by building a strong outreach program that serves industry and the engineering profession.

Published by The Department of Electrical and Computer Engineering

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Prepared by Engineering Communications and Marketing
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A Message from the Chair

It is my pleasure to present to you the highlights of the tremendous progress we are making in fulfilling our mission and achieving our goals in electrical and computer engineering at Iowa State University (ISU). We have hired nine high-caliber faculty members during the last two years, awarded a record number of PhD degrees during the academic year 2005–06, maintained an excellent undergraduate degree program, and awarded a near-record number of undergraduate degrees. We are starting a new degree program in software engineering. Our PhD population has increased to four per tenure-track faculty member. We have acquired significant computing power. Our faculty is well recognized. From the report, you will see how our faculty is contributing and achieving recognition for themselves, the department, and Iowa State. These are all very powerful indicators of progress at ISU.

To meet the challenge of the future and to carry out the cutting-edge research for the betterment of society, we have identified five strategic areas in which the department will invest and spend its energy. We believe that this will allow us to adapt and respond in a timely manner. These areas are: bioengineering, distributed sensing and decision making, cyber infrastructure, energy infrastructure, and small-scale technologies. You will see an article on each of these topics describing the challenges and the contributions our students and faculty are making in these areas. We strive to continue to make an impact on society.

—**Arun Somani**

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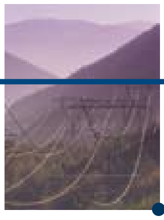


Combining engineering with life sciences

Biology, once largely an empirical science, is rapidly changing as physics, mathematics, and engineering concepts become integral to the field. The Department of Electrical and Computer Engineering (ECpE) at Iowa State University is making a concerted effort to bring engineering and the life sciences together, thus making ECpE a leader in changing the way we look at combining these two areas of study.

At the heart of this effort are discoveries like gene-regulation mechanisms and the enhanced ability to investigate bioprocesses at molecular and cellular scales. ECpE is set to play a significant role in these areas.

Bioresearch at the small scale

The discovery of the DNA structure by James Watson and Francis Crick laid the foundation for the present framework in molecular and cellular biology. And now ECpE is leveraging that work in a high-profile project.

Iowa State is one of four institutions participating in a $32-million, three-year project funded by the National Science Foundation (NSF), the U.S. Department of Agriculture, and the Department of Energy to sequence the maize genome. Led by ECpE Professor **Srinivas Aluru**, the team, which includes **Arun Somani**, Jerry R. Junkins Professor and ECpE chair; **Patrick Schnable**, director of the Center for Plant Genomics; and **Robert Jernigan**, director of the Laurence H. Baker Center for Bioinformatics and Biological Statistics, is currently working on multiple projects in plant genomics and systems biology.

The maize genome is nearly 2.5 billion nucleotides long, making it the most complex to be sequenced to date. Because 65 to 80 percent of the genome consists of repeats, sequencing it has proven to be a challenge. When the sequencing is complete, however, scientists will be able to more effectively develop corn with traits like enhanced nutrient composition, which means better food for humans and feed for livestock. The enhanced corn also will have higher energy content for renewable fuel production and improved characteristics for use in industrial raw material. That, in turn, will create new uses for corn, benefiting both consumers and farmers.

This group of researchers also received a major research instrumentation grant from NSF. With additional allocations from the President's Office, the Office of the Vice Provost for Research, the Office of Information Technology, and the Plant Sciences Institute, the research group has purchased an IBM BlueGene/L supercomputer with 2,048 processors. Iowa State is just the fifth major U.S. university to have this supercomputer, and one of the few universities using such a powerful computer for plant sciences research.

Aluru and Schnable teamed up to develop specialized algorithms and figured out how to use parallel computing to assemble genome sequences quickly. With the new equipment, Aluru estimates that his lab will be able to assemble 30 million short genomic sequences in a day, enabling the Iowa State team to solve large-scale computational problems in just days instead of months.

In addition to solving the maize genome, Aluru is working on a project to cluster expressed sequence tags (ESTs). At present, more than six million human ESTs and more than four million mouse ESTs are known. The computational challenge is to cluster the ESTs into groups so that the sequences that come from the same gene fall into one group. Once that's done, researchers can figure out where the clusters come from on the genome and be able to identify the gene.

With the new supercomputer, Aluru's group will use software they developed to cluster one million ESTs in a single run. "That's significantly more than any other program can do," Aluru says. "We'll use BlueGene/L to develop a catalog of all the human genes and all of the mouse genes."

Because computations in applications like maize genome assembly and EST clustering require an immense amount of data to be broken down in order to find a solution, Somani is leading another group that's looking at directly implementing these algorithms using field programmable gate arrays (FPGAs). FPGAs and other types of reconfigurable logic, Somani says, can be programmed to map the computation, which accelerates the process and provides much faster computation than do processor-based systems.

Iowa State is just the fifth major U.S. university to have this supercomputer, and one of the few universities using such a powerful computer for plant sciences research.

But with that research, other questions are raised. For example, how will biologists studying genetic makeup use this newfound power? Associate Professor **Julie Dickerson** is working on that answer using a concept known as "fuzzy logic," a term pioneered in the 1960s to define data expressed within general ranges rather than as determinate values.

"There's a growing realization that we have to deal with uncertainty," Dickerson says. "Traditional probability has always asked, 'Did something happen?' But with fuzzy logic, we're modeling the degree to which an event occurs."

Modeling uncertainty, Dickerson adds, helps account for the greater variation of biological networks compared to man-made systems. "It's more than whether a given gene was expressed," she continues. "Was it highly expressed? Or was it expressed at a lower level? Those ideas must be considered in coming up with realistic models."

Such modeling has assumed increased importance as biologists have moved from studying single genes to analyzing 20,000 to 40,000 genes simultaneously using modern chip technology and parallel computing. Work by Dickerson and others in bioinformatics and pattern recognition has helped researchers make sense of these larger volumes of data by overthrowing some of their most cherished preconceptions.

"For example, we're getting away from the idea of everything as a pathway," Dickerson offers. "We had a convenient notion of plant metabolism as linear flow charts: something comes in at the top and goes out at the bottom. But then we learned more about the genes, that there's a lot of feedback and interaction. That makes a big difference."

By abandoning certainty in favor of uncertain parameters of probability, says Dickerson, bioinformatics can reduce the vast information locked inside plant genes to manageable proportions.

"I work in pattern recognition," she says. "There's a lot of signal processing—we pull signals out of very noisy data and figure out if anything consistent is happening. Then we put the information back together to reconstruct the 'black box.' It's unpredictable, and the problem domain is very different."

The gene sequencing and systems biology efforts in the department are well complemented by the bioinstrumentation and manipulation work being conducted in ECpE's NanoDynamics Systems Lab, founded by Associate Professor **Murti Salapaka**. Researchers in the lab are developing a new paradigm for bio-imaging at the nanoscale that employs systems concepts to significantly enhance related technology.

Until recently, manipulating and probing biological matter was limited to aggregate methods, where control and investigation could only be achieved at relatively large spatial scales. The atomic force microscope (AFM) and similar scanning-probe microscopes, however, have enabled investigation and manipulation at the molecular and cellular levels. But because existing AFM methods are slow, Salapaka's research group has invented a new method of imaging they call transient force atomic force microscopy, which has increased sample detection rates by two orders of magnitude. "Research to employ the new principles of imaging to bio-matter is being conducted," Salapaka says, "and the related methods are particularly suited to a combinatorial investigation setting."

To complement the high bandwidth imaging scheme, researchers in the NanoDynamics Systems Lab have invented a thermally driven non-contact (thNc AFM) imaging method that enables the main probe to observe a sample for relatively long periods of time from a distance of less than two nanometers (nm). Taking readings for a longer period of time translates into more reliable data for scientists, Salapaka notes. This research was highlighted in the September 2005 issue of *Nature* magazine. Salapaka wrote a short article for the publication, noting that it's difficult to produce and maintain forced vibrations of the subnanometer amplitude necessary for accurate imaging at the small scale. However, the thermal oscillation amplitude of Salapaka's probe was 0.6 nm. "This new imaging capability allows one to observe processes at the nanometer regime in a noninvasive manner with unparalleled resolution of one-quarter Angstrom," Salapaka wrote.

The article points out that these findings can be useful for documenting forces resulting from cell wall oscillations. "Now that we have a way to detect sub-nanometer changes," Salapaka says, "we can start thinking about using this for diagnostics in the future."

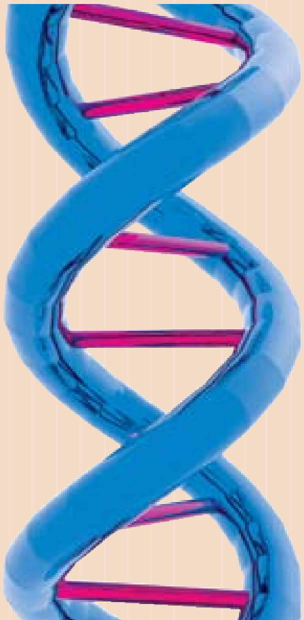
Equipment grants from Digital Instruments and Veeco, plus an NSF CAREER matching award, helped build the NanoDynamics Systems Lab, which houses two scanning probe microscopes and associated hardware. A collaborative effort with Asylum Research and Veeco, both in Santa Barbara, California, and Bioforcelab in Ames, is supporting several projects spearheaded by ECpE faculty members.

Supercomputing in ECpE

A team led by ECpE Professor **Srinivas Aluru** received a Major Research Instrumentation grant from the National Science Foundation (NSF) to purchase a BlueGene/L Supercomputer for research in assembling the maize genome and systems biology. This 5.7-teraflop supercomputer is among the 10 fastest, most powerful university-based supercomputers in the U.S.

The grant was primarily awarded to further the pioneering work conducted by Aluru and **Patrick Schnable**, director of Iowa State's Center for Plant Genomics, in making draft maize genome assemblies from NSF pilot sequencing projects. Aluru leads the group, which can assemble genomes using thousands to tens of thousands of processors. This technology is receiving the attention of other researchers working on genome sequencing projects, and the software is used by over 45 organizations around the world for other problems in computational genomics.

Iowa State is part of a consortium led by Washington University in St. Louis that was awarded a grant worth $29.5 million to sequence the maize genome. Jointly funded by NSF, the U.S. Department of Agriculture, and the Department of Energy, this project will generate a wealth of genomic data that will impact plant sciences researchers for decades to come. The Iowa State team will harness the power of BlueGene/L in all stages of the project to bring rapid analysis for the benefit of the molecular biology community.



Also working on the project are **Arun Somani**, Jerry R. Junkins Professor and ECpE chair, and **Robert Jernigan**, director of the Laurence H. Baker Center for Bioinformatics and Biological Statistics at Iowa State.

Research on biomedical issues

Another area in which ECpE faculty are conducting cutting-edge research is in biomedical issues.

On one project, for example, a group of faculty members is using high-intensity focused ultrasound (HIFU) waves to selectively remove cancer tumors. Their hope is to someday eliminate the need for surgery, chemotherapy, or radiation treatment, all of which have unwanted side effects for a patient. "Chemotherapy generally goes everywhere through blood and unnecessarily kills many normal cells, and radiation has a cumulative damaging effect on normal tissue," notes Adjunct Assistant Professor **Viren Amin**. Focused ultrasound waves, on the other hand, can precisely target and destroy tissue in an affected area without harming the surrounding tissues.

Patients with brain tumors could be the ones that reap the most benefit from this research. "Generally speaking, with certain tumors it may be OK to take a little bit of extra tissue out to make sure that the entire tumor is removed," Amin explains, "but that's not the case with the brain. If you take too much tissue out of a brain, the patient could lose motor function or even speech."

Most of the current research on ultrasound waves has used homogeneous (single-layer) substances. Iowa State's research team has started laboratory experiments measuring the interaction of HIFU with different types of inhomogeneous (multi-layered) tissues, including liver and muscle. "This is very challenging because ultrasound reacts differently to different materials," Amin observes. "Inhomogeneity gives rise to scattering and other phenomenon like phase aberration, but we're hoping to learn from the models developed for ultrasonic wave propagation in titanium, another inhomogeneous material."

And while medical ultrasound images have traditionally been presented two-dimensionally, this group's research has led to the construction of three-dimensional images, which makes planning the correct therapy dose for a specific tumor and location much easier. Amin and his team are using patient-specific imaging data to develop interactive tools to advance strategies for HIFU treatment.

Assistant Professor **Namrata Vaswani**, who joined the ECpE faculty in August, hopes her expertise in signal processing furthers the research being done in bioengineering at Iowa State. She's working with Amin's HIFU research group to help automatically locate tumor boundaries in a patient's brain. Locating the tumor region, she says, is the first step in analyzing its ultrasound transmission properties, and her goal is to develop fast algorithms that can be used to locate the tumor region accurately during HIFU therapy.

Vaswani hopes to be able to segment what she calls "interesting regions" of a patient's brain by tracking a sequence of MRI image slices. In current medical practice, much of this segmentation is done manually, but Vaswani is working toward detecting and locating tumors automatically, which, she explains, will help doctors look at the clearly segmented region of interest and detect abnormalities that may potentially be a tumor. Her plan is to extend some of her change-detection algorithms to identify a tumor, then track the tumor to locate it in sequential slices.

In yet another area of biomedical research, **Robert Weber**—the current David C. Nicholas Professor in electrical and computer engineering—is busy with a project focusing on implantable pressure transducers. This research will eventually help people suffering from high blood pressure or glaucoma.

Weber points out that it's easy to monitor peripheral blood pressure with a cuff, stethoscope, and sphygmomanometer. However, pulmonary blood pressure—the pressure between the heart and lungs—can be difficult to read. High pulmonary blood pressure can lead to heart failure, kidney failure, stroke, and other serious health problems.

Diagnosing and monitoring pulmonary pressure often requires catheterization in a clinical or surgical environment with a physician inserting a pressure sensor into the blood vessel between the heart and lung. "Leaving a sensor in that area would minimize the invasive character of a long-term measurement," Weber offers, "but traditional pressure sensors would need to be powered, and there's a chance the body would reject the sensor."

Weber is working on similar implantable transducers to measure pressure within the eye. Like his blood-pressure sensor, the device is an integrated circuit that requires microelectronic processing. However, this device is read by remote microwave sensing. Weber says that intra-optical pressure sensing in glaucoma diagnosis and therapy can be done with external pressure-measuring techniques. But, continuous monitoring of that pressure with an intra-optical sensor in a non-clinical environment would be of significant benefit to the long-term treatment of glaucoma.

In addition to eliminating materials the human body may reject, Weber is also trying to build a transducer that doesn't need a power source. "One of the difficulties with powered implantables is battery life," Weber acknowledges.

His goal, then, is to make a transducer that doesn't need a battery. "The technology is definitely there," he says.

The future

Over the next decade, researchers in ECpE will continue advancing ideas that combine biological, medical, and engineering expertise. One way to do that, department leaders say, is by hiring the best researchers in this expanding field, which is why the department is continually looking for the brightest leaders in bioengineering.

Advances in this arena also will be helped by the expansion and renovation of Coover Hall, which began in the spring of 2006. The new configuration will be ideal for both research and teaching and will lead to more student-faculty interaction. In addition, research labs will be updated, new bioexperimentation facilities will be built, and a state-of-the-art bioinvestigation lab to study single cells and single molecules will be added.

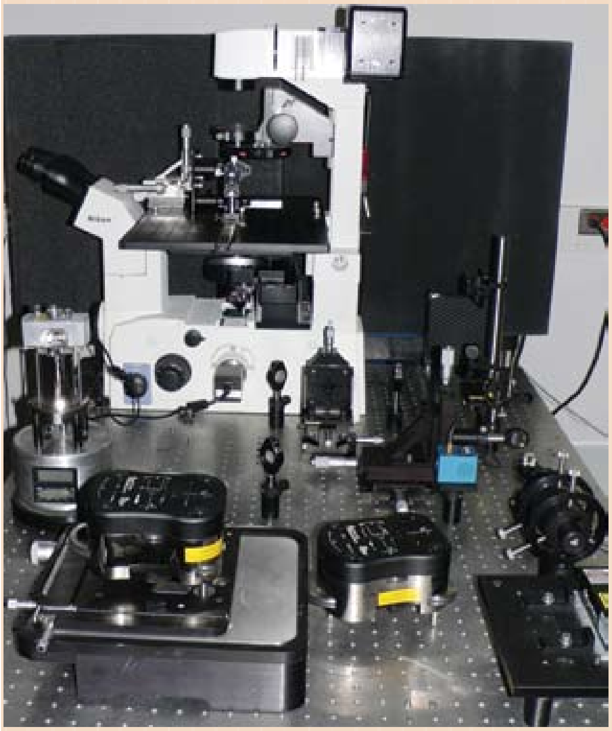
The new Coover Hall will also be the home of modern, flexible learning environments that can be adapted to meet the changing needs of the department. When the new building is finished, labs will be clustered together, and all ECpE faculty will work together under the same roof for the first time ever.

Hiring new bioengineering leaders and improving labs are just a few of the efforts ECpE is using to expand collaboration between researchers in both engineering and the life sciences from Iowa State, the University of Iowa, and other research institutions. It's that collaboration, after all, that will lead to the continued development of new technologies in bioengineering.

NanoDynamics Systems Lab

Under the direction of ECpE Associate Professor **Murti Salapaka**, researchers in Iowa State's NanoDynamics Systems Lab are developing new instrumentation for probing biological samples at the molecular scale. Related research is enabling temporal and spatial resolutions to monitor evolution of bio-phenomena in real time.

"We have used systems and dynamical systems perspectives in nano-bio investigation," Salapaka says. "These tools provide a unique advantage, and the proof is in the results of high-speed detection and high-resolution imaging."



Salapaka's group has established image detection at speeds that are two orders faster than other state-of-the-art work. They have used the transient force atomic force microscopy (TF-AFM) method invented at the NanoDynamics Systems Lab to image biological samples like DNA 20 times faster than conventional methods.

This group has also shown that it's possible to obtain sub-Angstrom resolution AFM-based interrogation under ambient conditions using the thermal non-contact AFM method invented in the lab. This work was published in *Applied Physics Letters* and highlighted in *Nature* magazine.

Please see the department Web page for more information.

Distributed sensing and decision making

Information technology platforms that have emerged in the last decade have enhanced the cost-effectiveness and speed associated with the processing, manipulating, storing, and transferring of large data sets. In addition, the expanding wireless technology has significantly increased functionality by making communication of data and information mobile. Finally, improved sensor technology has provided efficient, inexpensive sensors for diverse purposes. It's now possible to deploy a larger number of sensors while keeping costs low, yet still increasing performance standards.

The convergence of these technologies has given rise to complex system interactions; the large number of autonomous, heterogeneous entities working together toward a desired global behavior have made it imperative for researchers to coordinate and manage those complex interactions.

Related technologies that lead to and are governed by the advantages of distributed architectures will play a fundamental role in future engineering systems. This entails the ability to dynamically incorporate additional data into an executing application, and, in reverse, the ability of an application to dynamically steer the measurement process. Such capabilities promise more accurate analysis and prediction, more precise controls, and more reliable outcomes. The ability of an application to control and guide the measurement process and determine when, where, and how it is best to gather additional data has itself the potential of enabling more effective measurement methodologies. The ECpE department has determined the area of distributed sensing and decision making as a pivotal strategic area of interest.

Distributed algorithms

Large-scale sensor networks that can monitor an environment at close range with high spatial and temporal resolutions are expected to play an important role in various applications, including

- assessing the integrity of machines, aerospace vehicles, and civil engineering structures
- environmental, medical, food safety, and habitat monitoring
- energy management
- inventory control
- home and building automation

ECpE Professor **Ratnesh Kumar** and Assistant Professors **Aleksandar Dogandzic**, **Daji Qiao**, and **Srikanta Tirthapura** are playing pivotal roles in addressing the related challenges of these networks.

Sensors have been around for a long time, observing the physical world and tracking all sorts of information. Hospitals, for example, use sensors to monitor patients, while city governments can use them to direct traffic. Tiny sensors can also be thrown into a smoldering building to help firefighters measure the level of smoke and heat inside.

One of the challenges facing researchers is how to organize this vast amount of information in a single network. Traditionally, information gathered by sensors has been collected and sent to a central point of control. That method, Tirthapura observes, has two major hindrances: it consumes a great deal of energy, and it violates a fundamental principle of distributed system design called locality. "Informally, locality means information that changes frequently, such as an object's location, should only be stored at nodes that are close to the location of the change," he explains.

One way to fix those problems is through distributed estimation, says Dogandzic, who recently was awarded a CAREER grant to address these exact issues. He notes that each node in a network has limited sensing, signal processing, and communication capabilities, but if they cooperate with each other, the nodes can accomplish tasks that are difficult to perform with conventional centralized sensing systems.

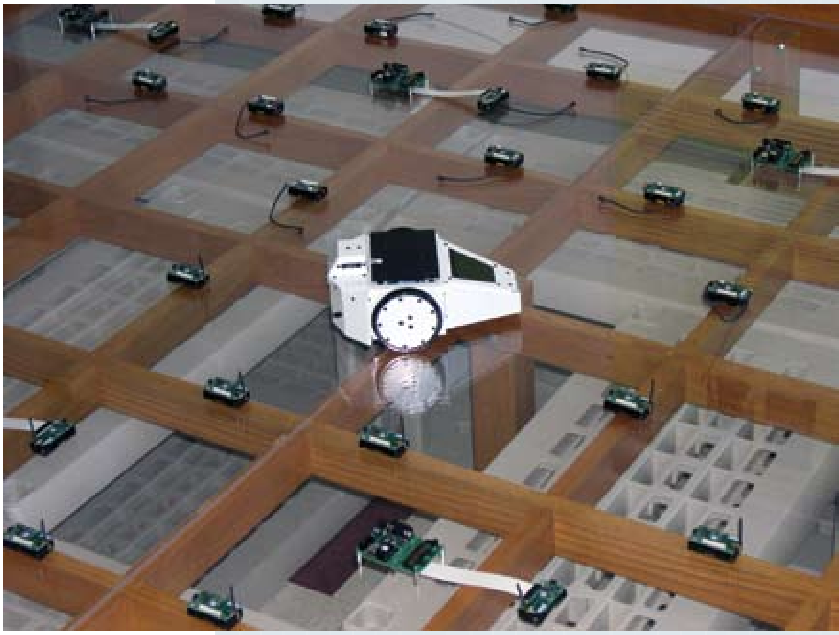
In his research, Dogandzic focuses on novel solutions for prominent signal-processing problems in network design. His solutions include efficiently extracting information through neighborhood-based distributed processing, conserving energy through active node selection, and mitigating practical difficulties, such as node localization errors and spatially correlated measurements. He's developing distributed algorithms for estimating physical phenomena in the presence of node location uncertainties because, Dogandzic warns, ignoring those uncertainties may lead to poor estimation and detection performance.

Sensor Networks Lab

ECpE Assistant Professors **Daji Qiao** and **Srikanta Tirthapura** have teamed up on a project that will build distributed directories to track mobile objects with the help of a wireless sensor network.

Although sensors have been tracking information for many years, this research asks different questions. Tirthapura's goal is to organize this information in a network. "We're looking at the coordination of that information and how to make the best use of it," he explains.

The finishing touches are still being put on the new lab, but when it becomes fully operational, the research group will be able to compare different distributed and centralized directories with respect to locality, scalability, fault tolerance, and energy efficiency.



Tirthapura recently secured a grant from the National Science Foundation to design and build distributed directories to track mobile objects with the help of a wireless sensor network. He received the grant in part because of a new wireless and sensor-networking lab funded by the department.

In December 2005, the lab was equipped with 100 sets of Crossbow MICA2 motes with generic and custom-made sensor boards. The motes will work with an Acroname Garcia robot (which looks like a mini-race car) that includes an embedded Stargate processor board. A distributed directory will be loaded onto each mote, and the motes will eventually be used to navigate the Garcia robot toward objects that can be detected by the sensors—objects such as other robots, magnetic fields, or even a fire. This lab is forming the catalyst for focused activities in distributed sensing and decision-making issues.

The distributed algorithms being developed in the lab will help Tirthapura's project. "Our network will lead to more efficient use of the information that's collected," Qiao says, "meaning the total energy required to answer queries will be much smaller using our distributed approach." Less energy required translates to longer battery life and less expense.

Costas Busch, a professor at Rensselaer Polytechnic Institute in Troy, New York, is also helping in the project.

Kumar, recently promoted to full professor at Iowa State, is working on several projects, many of which deal with distributed sensing and decision making. It's his concentration in designing controllers for discrete-event systems that is getting the most attention from colleagues. His work, in essence, focuses on building logic into automated control systems found in manufacturing facilities, power plants, communications networks, and embedded systems.

Workers in an automobile manufacturing plant, for example, might build two products—a sedan and a minivan. If a marketing promotion increases the demand for minivans, employees may need to switch gears quickly to get the right product onto the assembly line. Kumar's research enables the company's automated control system to handle the quick changeover.

The challenge, Kumar says, is to present mathematically what a system can do, as well as what a system should do. When the math is done correctly, control logic is computed and implemented to restrict a system so it performs only the functions you want it to perform, which, in this case, is configuring the system to build only minivans.

A related branch of Kumar's research enables system administrators to accurately predict when and where a system failure is likely to occur. Any system, he says, will have one of its components fail at some point. "The question," he asks, "is how do you determine which component has failed?"

The answer is found by monitoring the behavior of the network at multiple locations and then exchanging information about the health of the network to determine which components are experiencing problems.

The challenge, Kumar says, is to present mathematically what a system can do, as well as what a system should do.

ECpE Professor **Jim McCalley** works with Kumar on this research and says that even though using discrete-control capability is nothing new, Kumar's way of looking at the age-old problem is different. "Every power-plant generator has continuous-control capability to modulate response to power-system disturbances," McCalley explains, "but it's a new thing to say 'well, we can do this using discrete-control capability.'"

Kumar is also breaking new ground in the area of distributed diagnosis of event-driven systems. His research has attracted the attention of NASA and Argonne National Laboratory, where he has worked on the problem at its manufacturing facility and its Idaho Falls nuclear plant. He's also working with Penn State University's Applied Research Laboratory and the U.S. Navy on designing mission-control logic for underwater vehicles.

And if all of that weren't enough, Kumar is also collaborating with researchers in computer science on software verification. "Catching bugs in software early in the design phase results in huge savings in development cost, time, and labor," he says. Coincidentally, Kumar notes, the underlying mathematics for verification is the same as that for control or diagnosis.

Wireless technology

Wireless networks of sensors and machinery have long been utilized in tasks like air-traffic control, security surveillance, and environment monitoring. As technology continues to expand, these sensors can be used in more areas, such as deploying autonomous agents to perform search and exploration missions during natural disasters or guiding biomolecular behavior to a desired task. In the future, wireless networks will be able to reduce the costs of long-term health care, while at the same time improving response time in medical emergencies.

As this technology continues to advance rapidly, machines, computers, and sensors are communicating with each other at increasingly higher speeds without wires. Further research will likely have a significant impact on sensor/actuator node size, implementation cost, energy- and spectrum-efficiency, and the life expectancy of future wireless systems.

On one research project at Iowa State, Associate Professor **Sang Kim** has proposed a new cooperative-relaying technique for delivering data in mobile and ad hoc wireless networks, which will further increase the speed at which these wireless networks can exchange information.

Kim is starting with simple wireless devices—a cell phone, for example—that can send only a small amount of information. "Right now you can send only low-resolution photos," Kim notes, "but I want to improve that and eventually make it possible to send high-resolution pictures and maybe even video."

Instead of sending one huge file, Kim's research will allow a system using tiny relay nodes to split the pictures into thousands of different pieces. The nodes work together, each one taking a small amount of information and sending it to a final destination where, according to Kim, the hard work of putting the pieces back together will be done.

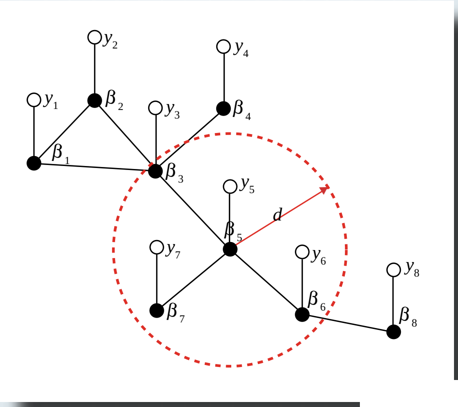
Dogandzic earns CAREER award

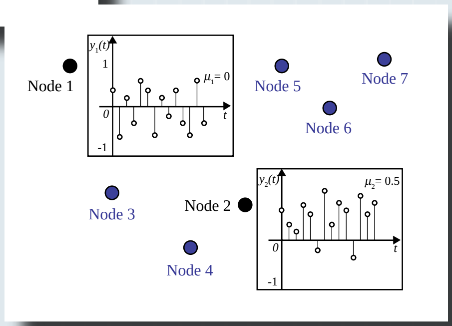
ECpE Assistant Professor **Aleksander Dogandzic** received NSF's prestigious Faculty Early Career Development Program (CAREER) award for his project "Distributed Space-Time Processing for Sensor Networks."

Highly competitive CAREER awards support the development of teacher-scholars who most effectively integrate research and education within the context of the mission of their organization.

Using funds received with the award, Dogandzic plans to study how large-scale sensor networks can monitor an environment at close range with high spatial and temporal resolutions. He expects this research to play an important role in various applications, such as assessing the health of machines, aerospace vehicles, and civil engineering structures. It will also be important for environmental, medical, food safety, and habitat monitoring, as well as energy management, inventory control, and building automation.

Each node in the network will have limited sensing, signal processing, and communication capabilities, Dogandzic notes, but by cooperating with each other, they will accomplish tasks that are difficult to perform with conventional centralized sensing systems.





That's just the near future, though. Looking further down the road, Kim says this type of research might someday even track the health of individuals. As our population continues to grow older, taking care of the elderly is becoming an expensive, labor-intensive job.

"It might not be that way in the future," Kim says. "We could put sensors in a person's body or on a person's clothes to check his or her medical status. We could monitor a patient's vital signs and continuously send that information to the doctor's office or hospital. This research could save millions of dollars in health-care expenses."

If a patient has a heart attack, the system can notify the hospital right away, Kim says, adding that the faster rescue personnel arrive to help a heart-attack victim, the greater the chances are of survival. The system also could be used to monitor blood pressure or take vital signs of someone with a bad liver or failing kidneys. The examples are nearly endless, he says. "As we do more research, we'll find more applications. Right now it's a big pie, but we'll cut it into pieces."

The distinctive benefit of this approach, Kim says, is the reduction of processing requirements on each relay node. He wants those nodes to cooperate so they can deliver a message. "I'm working on how the chosen nodes should collaborate," Kim says. "The more information you have, the more collaboration you need."

Assistant Professors **Yao Ma** and **Zhengdao Wang** are both working on research in communications with multiple antennas, which ties in nicely with the work Kim is doing. Modeled as multiple-input multiple-output (MIMO) systems, multiple-antenna channels can provide significant improvement in error probability performance and communication rates, says Wang, because of the additional degrees of spatial freedom.

Ma's recent research results have shown that, contrary to conventional thought, correlated antennas can bring about a significant power gain in certain channel setups. Performance gain results such as this, Ma notes, can provide guidelines for designing a distributed-sensing and decision-making system with MIMO technology.

Ma and Wang are also working on ultra-wide-band (UWB) communications, another emerging area in wireless technology. UWB communications—a competitive candidate for personal area networks, sensor networks, and military applications—use instantaneous bandwidth many times greater than the minimum required to deliver information. By spreading the radio frequency power over a wide bandwidth, Ma and Wang say, UWB signals can coexist with existing communication devices with minimal interference to each other. Because it uses spread-spectrum or multi-carrier modulations, UWB communication is promising as a physical layer enabling technology for energy-efficient, low-cost, and high-rate wireless sensor networks.

Ma is also working on cross-layer design and multi-user scheduling, which are also important issues in network design.

Complex networked systems

Understanding and designing large, complex, interconnected systems poses an incredible variety of challenges.

Cooperation is one central concept emerging in this context at many different levels. The question of how single nodes/agents in a network can be made to cooperate to transmit, share, retrieve, compute, and decide about the information more efficiently is being addressed by the research highlighted earlier. Examples of practical importance include air-traffic control, multiple vehicles coordination, and MEMS. These are more than just systems with large dimensionality; the limitations of these systems are as much due to the lack of time on a shared network as they are to the lack of computational power. In these situations, the separation of the control, the communication, and the computation tasks are not efficient, and the deep interaction between control and information and computations must be effectively exploited. Somewhat artificial boundaries existent in the present framework have kept these areas separate. Taking a more holistic approach, Associate Professor **Nicola Elia** is studying how the fundamental limitations of control communication and estimation interplay in networked control systems.

A big challenge in the area of distributed sensing and decision making is the emergence of global behavior and structures from local interactions. Examples include swarms, traffic systems, and self-assembly systems. Elia, Associate Professor **Murti Salapaka**, and Assistant Professor **Umesh Vaidya** are involved in different aspects of this challenging problem.

"Not only do we need to discover the design principles of collective behavior, but we also need to predict and alleviate unwanted or dangerous behaviors that can emerge in complex systems due to faults or other contingencies like large blackouts in the electric power network," Elia says.

Non-equilibrium dynamics will play an important role in understanding emergent global behavior. Analysis and control of non-equilibrium dynamics is a difficult problem facing engineers today, but Vaidya says the future technological impact in this area is promising. Hence, he's developing a mathematical framework for the analysis and control of non-equilibrium dynamics in these non-linear dynamical systems.

"The mathematical framework is inspired from the stochastic theory of dynamical systems and hence has the notion of uncertainty inherently built into it," Vaidya offers.

Because uncertainty analysis plays an important role in the design of complex interconnected systems, there's significant interest in the robust design of interconnected dynamical systems. Examples include power systems and sensor and communication networks, as well as groups of autonomous vehicles. "These types of systems are robust to uncertainty and external disturbance, but at the same time they perform very well," Vaidya says. "The proposed mathematical framework will help us better understand the role of uncertainty and better design these complex interconnected systems."

He adds that these systems can often be modeled as coupled nonlinear dynamical systems. "A steady-state behavior of coupled nonlinear dynamical systems is most often non-equilibrium dynamics," he adds. "Stable limit cycle is the simplest example of non-equilibrium dynamics, but complex non-equilibrium behavior like chaotic and strange attractor is typically observed even in lower dimensional nonlinear systems.

"Biological systems are known to operate away from equilibrium, where the living organism stays alive in a highly organized state by taking energy from the outside environment," Vaidya continues. "Oscillatory motion in molecular motors, oscillation in bacteria, and genetic oscillation are some examples of non-equilibrium behavior in biological systems. The phenomena of self-assembly in nanosystems and synchronization in complex interconnected systems are some other examples where non-equilibrium dynamics is the steady state."

Complex interactions

Claude Shannon, the father of information theory, has shown that mutual information captures a practical notion of successful transmission over a communication channel. Hendrick Bode, a pioneer of feedback control, has shown that feedback control systems are limited in their ability to reject disturbance, which is known as Bode's integral formula.

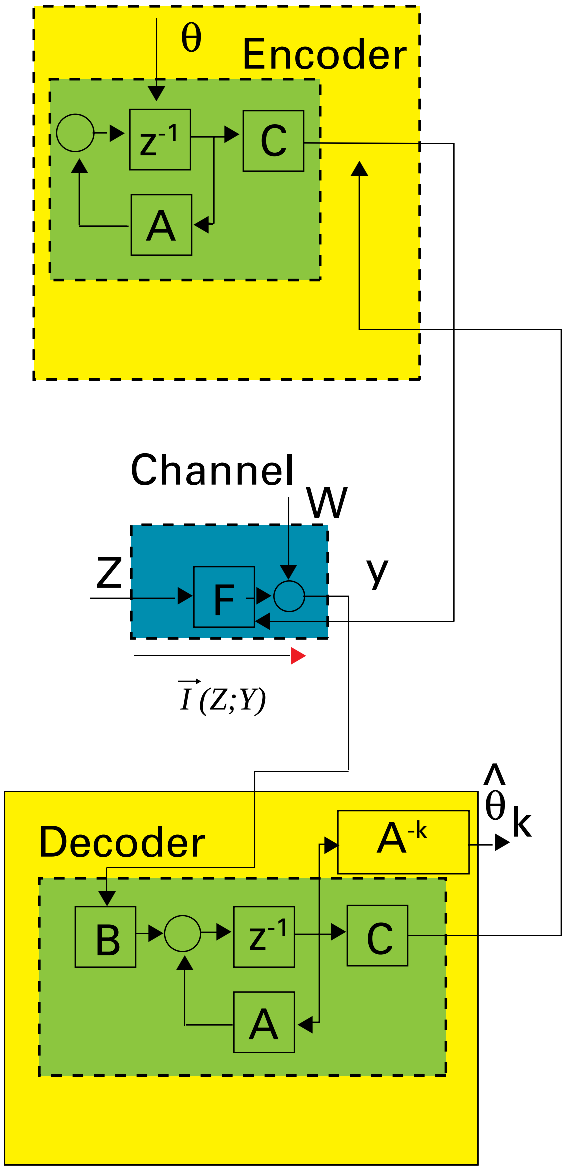
These two areas have developed independently, but ECpE Associate Professor **Nicola Elia**'s work is bridging these two great minds, making it possible to apply results from one area to another. He stresses that it's important to focus on the challenges addressed by both theories.

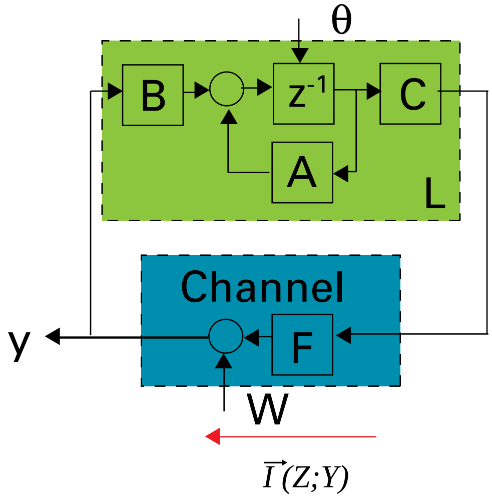
"For Gaussian channels in feedback loops, the mutual information and the Bode integral formula coincide, and they represent the same limitation," Elia explains. "This unification allows us to study feedback communication systems as feedback control systems and to analyze classical control problems from the information theory viewpoint."

Also working in this area is **Ratnesh Kumar**, an ECpE professor studying the nondeterministic control of discrete-event systems. Discrete-event systems, Kumar advises, have discrete inputs, states, and outputs, and a nondeterministic controller chooses its control action in a nondeterministic fashion from choices determined offline. Kumar and his research group have shown that certain control problems that are NP-complete under deterministic control become polynomially solvable when nondeterminism in control is allowed.

For a system with a nondeterministic model, its desired sequencing and branching behavior is naturally specified using bisimulation-equivalence (with a desired specification). The main result is a small-model theorem that proves the decidability of the control problem. Foundational notions of state-controllability and state-recognizability have been introduced as part of the solution.

Kumar's group is also developing existence/synthesis results for the enforcement of simulation equivalence, where a subclass of branching properties (besides all sequencing properties) can be specified.





The future

ECpE leaders and researchers are shaping the distributed sensing and decision-making area, as they continue to pursue and formulate new approaches. To facilitate new research, the department is updating its wireless communications lab.

It won't be long before radio devices capable of transmitting both digital and analog signals will be developed, and researchers at Iowa State want to be the first to provide those devices. In addition, point-to-point communication links that use multiple transmitters and receivers will be established, and ECpE researchers will lead the way in studying the performance of those multiple-antenna systems. The targeted application is high-rate wireless networks performing at unlicensed bandwidths of 5 to 60 GHz.

The new lab will also be a test bed for UWB applications, and the department's goal is to develop possible radio technology for future short-range, high-rate networks.

ECpE leaders have also proposed another new lab that will help investigate both biological and synthetic interactions at the molecular level. Biological systems organize themselves at the molecular level to perform various global tasks through local interactions, which means that monitoring, understanding, and eventually controlling these formations involves distributed sensing and decision making. With a new lab, researchers will be able to obtain a better understanding of these biological processes and be able to provide insights about how to synthesize or direct material toward a desired formation. It is a significant theoretical challenge to unravel the circumstances under which collective behavior occurs and triggers self-organizing behavior.

Cyber infrastructure

The computing and networking infrastructure, embodied in the Internet, has dramatically altered the technological, scientific, and sociological landscape. The full potential of this technology, specifically with respect to embedded devices, has yet to be realized. When computing oriented architectures are seamlessly embedded into a diverse set of applications that are seemingly unrelated to computing, the impact of the infrastructure will increase exponentially. Realizing the importance of real-time adaptive embedded computing architectures, the Department of Electrical and Computer Engineering has made this a strategic research area. The department also recognizes that focusing on the newer capabilities of the computing infrastructure must coincide with work on the demands and deficiencies of the existing infrastructure.

Robust information infrastructure

The information infrastructure, which is fast becoming the backbone of commerce and information exchange, must operate in a robust and reliable manner. Two looming challenges with the current infrastructure are security and the need to provide enhanced capacity and bandwidth to meet the demands of increased and diverse uses.

Reliable tools and investigative methods are needed to manage the information infrastructure. A team of ECpE researchers at Iowa State, one of the nation's first and leading institutes of digital forensics, has made significant progress in this field with projects ranging from programs to deter cyber-crime to technologies that can enhance the security of large networks.

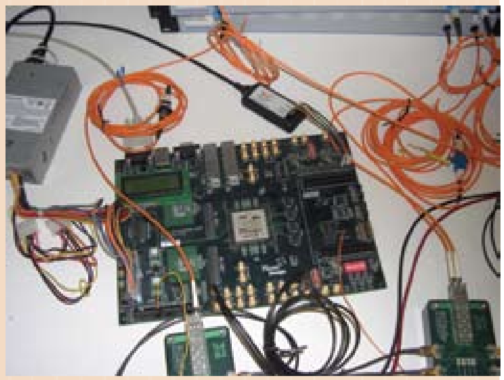
Assistant Professor **Yong Guan**, Associate Professor **Julie Dickerson**, and Assistant Professor **Tom Daniels** have received a $1.2-million contract from the Disruptive Technology Office (formerly Advanced Research and Development Activity) to develop software to "fingerprint" computer criminals. To that end, the team has created passive attack monitoring and analysis tools. Specifically, they have designed and developed software toolkits that allow experimental tests to be done reproducibly and be operated with user-friendly GUI interface. Experimental scenarios and environments can be easily reconfigured and expanded. The software provides a stable, open platform for further research in this area. The techniques have been tested at NSA, where various experiments demonstrated their effectiveness at managing complicated traffic perturbations.

"Attack traceback," the process of identifying the actual source(s) of attack traffic, can significantly deter cyber-crime. Users may be less likely to hack into a system if the threat of discovery and reprisal is real. Unfortunately, existing schemes suffer in one or more key metrics, such as the amount of time and resources (CPU cycles, buffers, and marking bits per packet) needed to perform successful traceback and the accuracy of the traceback itself. The research team, led by Associate Professor **Manimaran Govindarasu**, has developed a hybrid IP traceback that synergistically integrates packet marking and logging to achieve efficient and accurate traceback. In collaboration with researchers from Bell Labs, they developed a space-time encoding (STE) algorithm and novel spatial-reuse scheme that minimizes the number of marking bits required for a traceback.

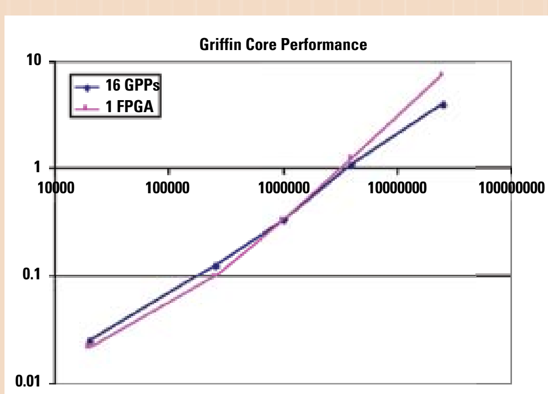
The schemes developed by Govindarasu's team have been subjected to performance studies with realistic topologies and

Distributed computing using COTS and FPGA components

Distributed architectures consist of large numbers of processor-based computing nodes working in concert to accelerate the solution of highly computational problems. However, as workloads and problem complexities increase, such computing clusters are becoming larger in size, causing power consumption, communication complexity, and monetary cost to increase while overall efficiency decreases. Smaller clusters made up of COTS and FPGA components with on-chip RISC-based microcontrollers reduce the need for larger, more complex systems. Iowa State's Griffin project uses Xilinx FPGA platforms connected with a custom-built high-speed 1.5Gbps ring network to tackle complex distributed computing problems.



The approach uses a good distributed algorithm, identifies parts that are best suited for reconfigurable components, and performs state management using simple RISC processors—a departure from standard clusters made possible only by reconfiguring FPGAs. In Griffin, the FPGA's dual on-chip 300MHz PowerPC microcontrollers provide state management capabilities to the system, while the reconfigurable logic executes the highly regular components of a given distributed algorithm. Communication between FPGAs is provided through a custom high-speed ring network. The goal is a high-performance COTS (processor and reconfigurable components) cluster that can be used for all traditional distributed applications at a fraction of the power consumption and monetary cost, while providing tools and methodologies to ease the migration from a software-only development approach to one involving both hardware and software. Current results indicate that for a demonstrative sequence alignment core, 1 FPGA can perform the work of 16 general purpose processing nodes working in parallel in the same amount of time.



attack traces. Results show that these schemes achieve more accurate traceback with fewer resources than current, state-of-the-art schemes. Realizing the importance of properly identifying the perpetrator of a cyber-crime, Guan is addressing new ways to overcome the deficiencies of existing schemes that are vulnerable to a new breed of attacks known as "collusion attacks." These attacks use a combination of multiple fingerprinted copies to create a new version of the multimedia artifact in which the underlying fingerprint is attenuated to render the colluders untraceable. Guan and his students have proposed a wavelet-based fingerprinting scheme and a clustering algorithm for collusion attack detection and colluder identification. Experimental results show that the scheme can identify colluders while maintaining low miss rates and false accusation rates. TraceDoS is a GUI-based software tool, developed by Govindarasu's team, for simulating traceback algorithms in conjunction with denial of service attacks.

Denial of service (DoS) attacks prevent regular Internet services from being accessed by legitimate users either by blocking service completely or by disturbing it such that users lose interest in the service. To effectively mitigate DoS attacks, which have escalated in recent years, Govindarasu and his students have developed concepts known as "victim assistance" and "router collaboration." Victim assistance refers to the direct role of the victim in identifying attack traffic before it reaches its target, and router collaboration refers to the means by which edge or overlay routers collaborate to detect low-rate attacks. The use of these concepts to mitigate other types of attacks is being investigated. The tool is also being extended to feature a cluster computing-based backend that will make it scalable for use with large-scale attack simulations.

Daniels is developing techniques that a forensic investigator can use to investigate computer crimes that occur across large enterprise networks. "Most work in this area has focused on the problem of fully automated analysis, yet this is not the common case for an investigation as people are involved," says Daniels. To address this problem, the group has developed a distributed architecture, a set of fuzzy reasoning models, and a flexible, graph-based correlation methodology. Together, these components provide a system that can identify attack scenarios crossing many sub-networks despite spurious attack traffic.

A project called DILON (Detecting Intrusions at Layer One) led by Daniels, Associate Professor **Steve Russell**, and Adjunct Assistant Professor **Mani Mina** uses measurements and characterization of signals from hardware (i.e., Ethernet cards, sensors, any communication-based system) to detect intrusions. This research has demonstrated that hardware can be uniquely identified based on analog measurements of the physical layer (layer one). This significant finding allows researchers to provide network security based on the hardware's signature instead of or in addition to conventional network protocols.

The department has several labs dedicated to diverse aspects of cyber-crime and security:

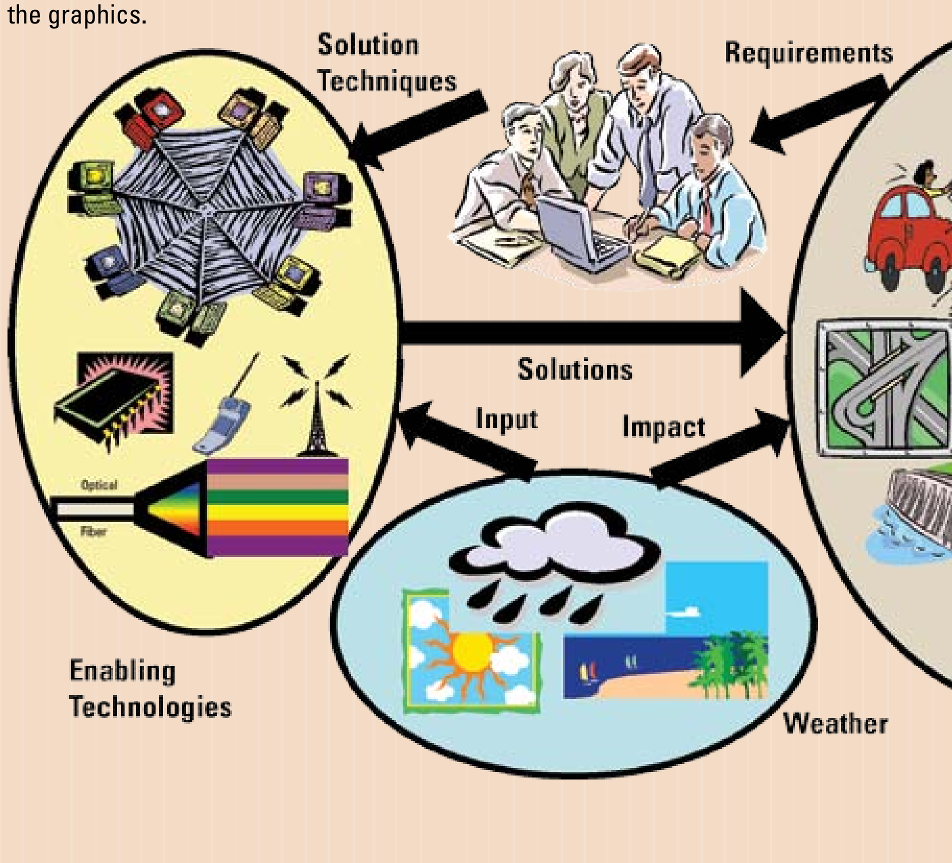
- Cyber Forensics Laboratory—Students receive hands-on training in the use of forensics tools and cyber-crime investigation theory and procedures.
- Cyber-Crime Lab—Led by Associate Professor **Doug Jacobson** and funded by the Department of Justice, the lab has served several law enforcement agencies since it opened September 1, 2003. Project Trident, a tool designed to locate child pornography on the Internet, works on about three pornography cases per month and also assists various Iowa agencies in recovering evidence relative to computer crime cases.
- The Internet-Scale Event and Attack Generation Environment (ISEAGE; pronounced "ice age")—Also led by Jacobson, this facility is dedicated

iCube initiative

In its infancy, Iowa State's Information Infrastructure Institute (iCube) initiative was envisioned to address the protection of critical national infrastructure that included energy distribution, public transportation, communications, food, water, agricultural production, and distribution systems. The goal of the initiative was also to gain an understanding of the common requirements of such protection and develop solutions through cross-cutting research where seemingly disparate applications can benefit from common overarching information technology techniques.

Professors **Arun Somani** and **Suraj Kothari** are directing ECpE's activity in the initiative, which is one of six proposed by Iowa State President **Gregory Geoffroy** four years ago as a challenge to university leaders in responding to critical needs in Iowa and throughout the country.

IT experts in the program work hand in hand with domain experts to develop tools and techniques to create solutions that are characterized by high computational efficiency, tailored algorithms, and accelerated turn-around times. The synergistic model of the various activities is depicted in the graphics.



A common example of the iCube activity is to make use of sensor technology, along with the appropriate algorithms, information collection, data fusion, and real-time decision making for various protection systems. For example, development of an in-situ soil sensor network for temporal and spatial monitoring of agriculture fields helps in identity preservation, food security throughout the agricultural production system, and precision farming. Incorporation of physical sensors to monitor the nation's electric grid or transportation network requires the same software technologies to manage the protection of those infrastructures. The same parallel processing technology can also be used for high-speed and timely analysis of massive national databases for genomics studies and data visualization for earthquake simulations.

iCube projects have motivated exploration of hardware and software technologies such as novel sensors, wireless technology, specialized microcontroller architectures, parallel algorithms, operational decision making, and tools for analyzing and transforming complex software. The research being conducted through iCube is of growing interest to a broad spectrum of companies and will foster further collaboration between the Iowa State researchers and industry leaders.

to creating a virtual Internet for the purpose of researching, designing, and testing cyber defense mechanisms as well as analyzing cyber attacks. The first of its kind in a public university, ISEAGE provides a mechanism to help solve cyber-crime. The creation of ISEAGE represents a new paradigm in the area of security research, cyber forensics, and will enable new and innovative research needed to solve the current security problems facing the world today.

In addition to security and cyber-crime issues, the information infrastructure is also challenged by the need for enhanced capacity and bandwidth to meet the demands of increased and diverse uses. Researchers in ECpE are investigating ways to meet this need with optical fiber-based technologies.

A significant challenge to enhanced capacity is the dimensioning, provisioning, and operation of optical networks to support services in a cost-efficient manner. It is important to accommodate all applications while utilizing resources efficiently. Providing differentiated and prioritized services in optical networks is also an important issue. The traffic that can be supported on a single channel of information exchange is outpacing the demand of a single or a few users. Thus it is important that traffic from multiple sources be appropriately groomed (multiplexed) to make efficient use of resources. With increasing deployment of such optical fibers in networks, the risk of losing large volumes of traffic due to failure of a single channel has also increased tremendously. Failure recovery is a challenging issue in the mesh network topologies. Capacity efficiency and recovery speed are two important aspects in designing protection mechanisms.

Professor and Chair **Arun Somani**'s group, together with Professor **Ahmed Kamal**, Mina, and Professor **Robert Weber**, has developed novel techniques for managing traffic, new architectures for access, local and metropolitan area network designs, and protection strategies for optical networks. They have also studied the tradeoffs among various protection and restoration techniques as well as the impact of network connectivity on the efficiency of protection/restoration schemes. Finally, they have built a state-of-the-art test bed prototype for traffic grooming architecture.

Kamal and his students are developing algorithms and analysis methods for cost-efficient multipoint service modes. It is recognized that the operation cost parameters of the optical network can change significantly with traffic granularities. Consequently, design strategies for optical multicasting and multicast traffic grooming have to consider the granularity of the traffic. The support for such services is being addressed by Kamal's group. His group is also studying differentiated and prioritized services in optical networks, including access networks and backbone networks with grooming capabilities. New strategies and network design methodologies are being developed to address this issue.

The Iowa State Optical Simulator (ISTOS), developed by Somani's group, is a powerful GUI-based simulation platform that helps network designers and researchers design and analyze various routing algorithms and operational strategies in optical networks. ISTOS consists of a front-end GUI that runs on Windows on a .NET framework and a back-end simulation engine that runs in both Windows and Linux environments. The GUI gives users the ability to draw a physical network topology and to set different link and node parameters in the network to be simulated. The ISTOS back-end simulation engine can run on the same Windows machine as its GUI or on a separate Linux machine. Users are also allowed to develop their own algorithms and supply them to the simulator as plug-ins.

Real-time embedded systems

Internet technology will significantly further its reach by using embedded systems where the system is designed with a processor that supports a function other than computing. Many of these functionalities pose strict upper bounds on the response time of the system to an external event, e.g., engaging a weapon when a lethal target is detected or dispensing an item from a vending machine immediately after depositing a coin. Real-time embedded systems produce results that are both functionally correct and timely.

Another orthogonal trend is "adaptive" systems that change in response to the external environment. For example, an automated vehicle pilot system can adapt its vision system control algorithm in response to a snowstorm. Real-time systems respond to stimuli (input) within a fixed timeframe and therefore need to

ISEAGE provides information assurance

For ECpE Associate Professor **Doug Jacobson**, it doesn't matter whether you're a high school student thinking about a career in information technology or an IT professional who wants to learn more about fighting off computer hackers. Jacobson simply wants to help with cyber defense, and he's doing that in the Information Assurance Center at Iowa State's Research Park.

Jacobson helped develop the Internet-Scale Event and Attack Generation Environment, or ISEAGE (pronounced "ice age"), to provide better research and education in information assurance.

Many vendors can provide products and services to help defend against cyber attacks, but companies that use these technologies are often unable to test the defense mechanisms. ISEAGE, however, provides a controlled environment where real attacks can be played out against real equipment. The exercise provides a vast warehouse of attack tools that can simulate point-to-point and distributed attacks against test configurations.

In May 2006, the IAC hosted Iowa's first High School Cyber Defense Competition. Twelve teams from around the state spent 15 hours playing the part of security crew members for a fictional dot-com startup company. The students were asked to design a computer network to keep hackers from attacking the company and then defend that network against a team of Iowa State University students posing as hackers.

Iowa State students have also been involved in similar competitions, and IT professionals from several companies have learned firsthand how ISEAGE works.

manage all the layers of system abstraction, i.e., architecture, operating system, application level algorithms, and software and its implementation.

Field-programmable gate array technologies (FPGA) can address the challenges of embedded systems by delivering certain functionalities that require significantly fewer resources than software implementations. This has greatly accelerated the growth in adaptive, real-time embedded systems. The main challenges facing embedded systems arise from the diverse domains of the applications, which require a variety of technologies, algorithms, architectures, operating systems, and software attributes. Moreover, when two embedded subsystems with overlapping resource constraints and performance specifications have to be designed, the design and verification of the composite system becomes significantly more challenging than the sum of the parts. Iowa State's ECpE department has core research expertise in reconfigurable and embedded computing architecture and real-time operating systems and is skilled at using it in real-world applications.

"This approach has the potential to improve performance by three orders of magnitude in certain applications."

A unique feature of embedded system design is the hardware-software co-design aspect, wherein the primary goal is to optimally partition the workload among hardware and software realizations in a hybrid implementation. The research led by Professor and Associate Dean **Diane Rover** is developing a comprehensive design flow framework to significantly reduce the design cost and time for FPGA-based embedded systems by exploiting the various architectural features and the tradeoffs between computations and communications.

The implementation of algorithms in FPGA meeting various constraints continues to be a challenging task as solution space grows with the complexity of the target architecture. Somani's group has developed FPGA implementations of core algorithms in diverse areas like vision and imaging, which has enabled high-speed, real-time use of these algorithms. "We are much closer to the vision of automatically piloted landing systems that are safer and more precise because of new emerging technologies," Somani says. Somani and his group are also integrating FPGA into parallel computing. A project, titled Griffin, has demonstrated that such approaches greatly increase computation speed in challenging and important applications like genome sequencing with less cost and power than traditional processor-only clusters.

At the system level, Associate Professor **Morris Chang** is working on improving the Java virtual machine by developing a comprehensive set of hardware and software algorithms for mapping, profiling, garbage collection, and static/dynamic optimizations for multithreaded applications. This research has made significant impact in the design of embedded systems for resource-constrained environments.

Although development continues in hardware resources, the needs of some embedded systems are outpacing these advances. Associate Professor **Akhilesh Tyagi** and members of his research group are developing hardware virtualization paradigms known as run time reconfiguration. These layers will allow transparent transitions between software and hardware versions of a sub-behavior. Tyagi says, "This approach has the potential to improve performance by three orders of magnitude in certain applications." Real-time scheduling of events and behaviors is of utmost importance to make such systems work. Govindarasu's group is investigating a variety of real-time scheduling algorithms that function across a range of time, space, and energy resources.

Embedded systems are required to operate in potentially unfriendly and unattended environments. This poses new problems with respect to the security of these systems. Even software intellectual property (IP) protection issues become challenging. On the other hand, embedded systems can facilitate security for an existing computing infrastructure.

Tyagi and Assistant Professor **Zhao Zhang** are addressing security and IP protection issues for embedded systems. Tyagi's research supports software protection with obfuscation and tamper resistance. He is also developing secure architectures for FPGAs where the hardware itself (captured by the configuration bit streams) is susceptible. The IP core protection problem in this domain, analogous to software protection, takes on new dimensions. The VLSI logic level design methodologies he is developing will prevent attacks based on other physical attributes such as current and electromagnetic radiation of the embedded devices. Zhang's research is also in architecture-level support against control flow attack, e.g., buffer overflow attack. Hardware-based methods can protect a system against a broad range of attacks with relatively low performance overhead. His group is developing a prototype system to demonstrate the idea using commodity computer hardware. They are also studying new hardware optimizations to improve the efficiency of such a system.

Realizing the importance of this emerging area, the ECpE department has hired a new faculty member, **Joe Zambreno**, from Northwestern University, who will join Iowa State in fall 2006. Zambreno uses FPGA-based coprocessors to increase the security of an existing infrastructure.

Energy infrastructure

The accelerating energy crisis continues to drive discovery in the Department of Electrical and Computer Engineering. Professors **Vikram Dalal**, **Chen-Ching Liu**, and **Jim McCalley**, as well as Assistant Professor **Venkataramana Ajjarapu**, are leading projects that will help answer the challenges we face as a result of growing energy demands worldwide.

Power systems

Ajjarapu leads a research team that hopes to prevent large-scale power outages like the one in August 2003 that plunged 50 million people in parts of the northeastern U.S. and eastern Canada into darkness. The blackout occurred when a segment of the vast network of power plants and transmission lines that comprises the North American power system failed.

The financial implications of a widespread blackout can be devastating: the 2003 power outage cost New York City alone more than a half-billion dollars in lost revenue. While preventing future blackouts is critical for economic and security reasons, it's also a very complex task.

Because electric power can't be easily stored, it's important to monitor and balance supply and demand. Protection systems are designed to disconnect generators or transmission lines when they sense overloads. As the lines carry more power, they get hotter, causing them to sag between towers. A sudden change in power flow can occur if a line comes into contact with a tree or other obstacle, causing the protection system to disconnect the line.

The outage of one line creates sudden increases in load to other lines, which can create significant problems for the overall system. "Under normal operating conditions, the system adjusts," says Ajjarapu. "However, if it's already stressed, the reaction time is longer. As seen in 2003, a delay can quickly lead to cascading failures, and eventually the power grid will fail."

While the U.S. power system works amazingly well most of the time, it's operating close to its limits, making it increasingly susceptible to outages. "We generate enough power," Ajjarapu explains, "but we're forcing transmission lines to take on bigger loads. That leaves little time to make adjustments when a problem occurs."

Ajjarapu is developing bifurcation-based computational and analytical tools that apply specifically to the period when the system is approaching its limits. "We may know what will happen in one scenario, but, since each problem impacts the system differently, our tool must be able to address a wide range of contingencies," he explains. "Our challenge is to model what will

Alternate energy sources

ECpE Professor **Vikram Dalal**, a proponent of solar energy usage since the early 1970s, is working with a team of three scientists, eleven graduate students, and four undergraduate students on low-cost solar panels that building contractors can use in residential and commercial structures. The state of Iowa, Iowa State's Microelectronics Research Center (MRC), the U.S. Department of Energy, and the National Science Foundation support the work, which is underway at the MRC.

happen and also to make the tool work online. Operators must be able to quickly grasp how close they are to maximum load so they can take appropriate action."

Ajjarapu is also part of a course, curriculum, and laboratory improvement project sponsored by the National Science Foundation that has helped establish a state-of-the-art power electronics lab at Iowa State. The lab is part of the $3.7-million Multi-University Research Initiative funded by the Office of Naval Research. Labs at the five participating institutions—Drexel, Iowa State, Mississippi State, Northeastern, and Texas A&M—will be interconnected via the Internet.

On another project, McCalley leads a team working on a computer model of the U.S. energy system that captures interdependencies among the electric, coal, natural gas, and hydroelectric energy subsystems. The project, supported by a three-year $600,000 grant from the National Science Foundation, began in September 2005.

The model uses information about the energy system's production, storage, emissions, and transportation infrastructure to predict variation in energy prices and its availability up to two years out. Although other models have been developed to predict production capacity, McCalley says this is the first one to also capture the various ways in which bulk quantities of energy may be transported, as well as the environmental influence of power plant emissions. Applications of the model include identification of more efficient modes of energy production and transportation, environmental impacts, and infrastructure weaknesses and related investment decisions.

The effort will illuminate influences on decision making associated with bulk energy production and transportation. "There are numerous financial and technical decisions involved in supplying energy, from the price of various raw fuel sources to the operating costs of the physical infrastructure that supports it," McCalley notes. "Providing reliable and affordable energy depends on our ability to manage all of this information, and our model provides a systematic means of analyzing, understanding, and improving this ability."

McCalley's research group is also targeting decision making associated with operations, maintenance, and planning of the high-voltage electric transmission system. As part of a project for a major power control center in Texas, he's developing software to estimate the likelihood of failure based on the condition of the equipment and variables such as consumer demand for energy. Transmission operators will be able to use the information generated by McCalley's software to respond more effectively to crises in real time, by shifting generation, changing voltage levels, or curtailing power transfers. In a third project, also funded by the National Science Foundation, McCalley is leading a large interdisciplinary team to deploy real-time condition monitoring of transmission equipment, with the data used in system-level decision algorithms. This project has the attention of a number of industrial partners who are interested in establishing a software system at Iowa State that continuously interacts with sensors in the Iowa power grid.

Another ECpE research team—this one led by Liu, ECpE's Palmer Chair Professor—is focused on improving the vulnerability of a power grid to equipment failure, natural disasters, and other forces. Because technologies to prevent catastrophic failures haven't been very effective in the past, Liu's team is studying how to improve wide-area protection and control for a power grid.

"The idea," Liu explains, "is to give a better system view of how you protect, operate, and control your power grid. When the system is unstable or vulnerable, there are wide-area control and protective actions you can take to bring it back."

Currently, power grids are operated as large interconnections, but Liu wants to know if, under extreme conditions, those large grids will be safer if they're divided into smaller groups that are self-sufficient. He also wants to know how to make the grids heal themselves in the event of interruption or failure.

"Can the grid be smart enough to actually come up with the correct actions and recover by itself?" Liu asks. "To do that, you have to collect data from a wide area, make good decisions about the situation, and then see how the system can take proper action without delay. It's an intelligent system that will take corrective actions quickly. It's not fully practical yet, but it's a great vision of the future that will require a lot of creativity."

Alternative energy sources

An attractive way to decrease our reliance on and use of traditional fossil fuels is to develop alternative sources of energy. Liu and Dalal are hard at work in this area.

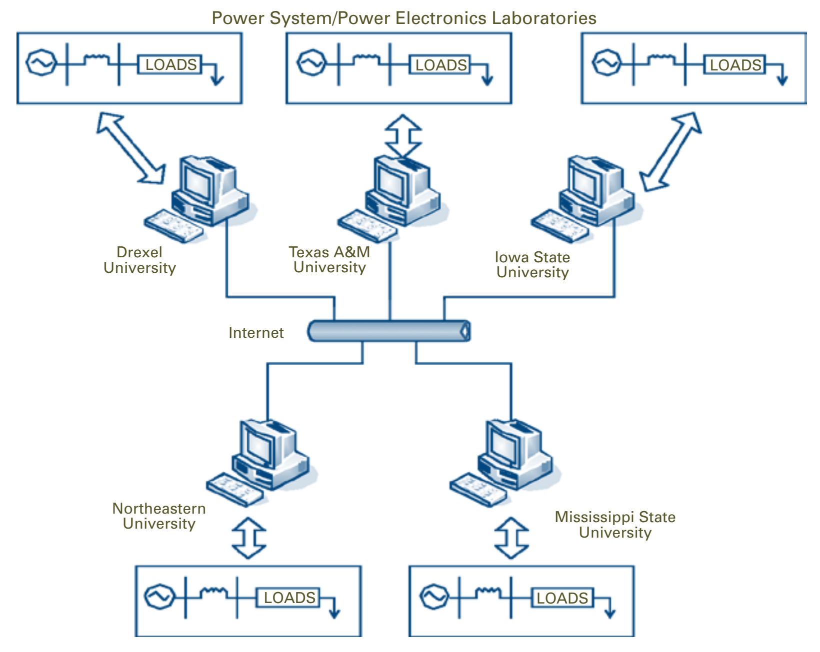
Liu is researching wind power and other renewable energy sources to see how they can be integrated into current and future power systems. "The new star of renewable energy is wind power," he claims. "Wind turbines are going up all over, and not just in the U.S. The turbines are large enough and the total production is significant enough to make wind power a serious player in providing energy."

He admits that we'll probably never get completely away from generating electricity using gas and oil, but wind, solar power, and fuel cells can all come together to help lessen the dependence on increasingly scarce nonrenewable sources. In fact, Liu says, some European countries are already generating 15 to 20 percent of their electric

Power infrastructure

A state-of-the-art power electronics lab established by ECpE Associate Professor **Venkataramana Ajjarapu** with initial funding from NSF is now part of a $3.7-million multi-university research initiative funded by the Office of Naval Research. In addition to Iowa State, researchers from Drexel, Mississippi State, Northeastern, and Texas A&M are working on the project. Labs from the five institutions are interconnected via the Internet.

Ajjarapu is principal investigator for Iowa State on the project, which has a goal of developing devices that will enable remote, nondestructive testing of power systems. This will allow researchers to test and measure processes that lead to system breakdowns, capturing the effects of communication delays on power system measurement and calculations. The remote testing capabilities will also allow Ajjarapu to demonstrate live laboratory experiments in the classroom, with video and audio feedback, to help prepare students for the lab. In addition, the project gives researchers the ability to conduct labs from other locations in real time via the Internet.



energy from renewable sources, and some states in the U.S. have regulations to increase the use of renewable energy. Everyone hitting that 15 to 20 percent mark, Liu adds, will have a significant impact on how we produce and deliver electricity in the future.

Another promising option is solar energy, which has been slow to catch on because of its price. It costs nearly twice as much to use solar power instead of gas and oil to produce energy. But Dalal is working to change that by reducing waste associated with the development of solar cells. The energy generated by a silicon chip is proportionate to the amount of silicon used. Current production methods use about one millimeter of silicon to make a half-millimeter chip.

"We believe we can reduce that amount to a micrometer, which is using 1,000 times less silicon," Dalal says. "The cost will then go down—not by a factor of 1,000, but certainly by a factor of three or four."

And that's the exact cost reduction needed to be competitive with gas and oil, he adds. "Our hope is that 10 years from now, solar energy will be half the cost of producing electricity with gas or oil."

Dalal, who does most of his research at Iowa State's Microelectronics Research Center, has been a proponent of using solar energy since the early 1970s. "I was bitten by the solar energy bug before the first energy crisis," he says. "I actually wrote an article predicting the emergence of solar power before Saudi Arabia imposed the first oil embargo in 1973. I said then that oil is getting scarce, and the only direction prices were going was up. That's certainly the case today as well."

Dalal's group consists of three scientists, eleven graduate students, and four undergraduate students. The state of Iowa, the Microelectronics Research Center, the U.S. Department of Energy, and the National Science Foundation support their work. The team's vision for the near future includes developing low-cost solar panels that building contractors can use in residential and commercial structures. Even though it's not standard practice everywhere, many homes in California are being constructed with solar panels in the roof and window panels.

Developing those low-cost solar panels is a booming industry, Dalal says. "Worldwide, it's about $10 billion a year," he offers, "and it's growing at a rate of about 50 percent each year. How many industries do you know that are growing like that?"

He suggests building large-scale power plants in western states like Arizona, Utah, and Nevada where the sun is plentiful and population is sparse. Dalal says even Iowa has enough sun to help power the nation, and building these large-scale solar power plants could provide 20 to 30 percent of the country's electrical needs. Iowa could become a leader in renewable energy production worldwide, he says, especially if the state combines its solar power capabilities with its potential in other renewables like wind and ethanol.

But for Dalal, it's more than helping Iowa become a leader in renewable energy production and more than helping the U.S. meet its soaring energy needs. His ultimate goal is to help underdeveloped countries use this power.

"Villages in India and China," he notes, "don't have any electricity. Most households rely on kerosene lamps, which are expensive and dangerous.

"A solar panel," Dalal continues, "can provide four to eight hours of power at night. What is the value of providing electricity and lighting to communities that haven't had it before? Think of the sociological implications—education for children, or providing refrigeration for vaccines. Solar energy can also be used in ultraviolet lamps, which can be used as water filters. Eighty percent of the world doesn't have clean drinking water, and this can help."

Dalal truly believes in what he's doing.

"Morally," he says, "this is the right thing to do. It will improve the quality of life."

Small-scale technologies

Small-scale technologies have significantly altered the way we lead our lives. These technologies have made computers and modern electronics, including cell phones, TVs, and digital music players, widely available and affordable. Although the impact has already been impressive, the story is far from over: small-scale technologies have found new impetus from the MEMS and nanotechnology initiatives. The Department of Electrical and Computer Engineering recognizes the need to more fully understand and exploit the full potential of small-scale technologies. The Microelectronics Research Center and Keck Lab are being utilized to meet this objective.

Fabrication and modeling of small-scale structures

Photonic crystals promise to revolutionize transmission and utilization of light and electromagnetic radiation in general. They can allow for very efficient light valves and bending of light waves around optical waveguides with very little loss. The devices rely on the confinement of photons to specific wavelengths, in a manner similar to confinement of electrons to specific bands in crystals. The photonic crystals are made by making a 2- or 3-dimensional periodic crystalline array of materials with different refractive indices. By deliberately introducing nano-defects within these photonic crystal structures, one can arrange for the formation of a narrow allowed pass band within an otherwise forbidden wavelength region where no photons can exist. Associate Professor **Gary Tuttle** and his group are working on designing and fabricating such narrow pass band photonic crystal waveguides. An important result of their research has been the development of a taxonomy of different kinds of photonic waveguides, each with a distinct wavelength transmission and loss property. By appropriately designing these photonic crystal waveguides, they can achieve a sharp bending of light in a waveguide with very little loss. The applications of such technology are in optical communications systems, in design of uni-directional antennas with very little loss. His group research has resulted in the first measurement of coupling between waveguides and defects in photonic crystal waveguides and has led to two new designs and fabrication of negative index materials.

Rana Biswas, an adjunct associate professor in ECpE, leads one research group focused on modeling advanced photonic structures using infrared sensors that detect carbon dioxide and other toxic gasses, such as carbon monoxide, methane, and nitrogen oxides. Each of these gasses has a unique absorption band in the infrared region; the tiny sensors that Biswas has helped develop can measure the absorption at a wavelength that is proportionate to the gas concentration.

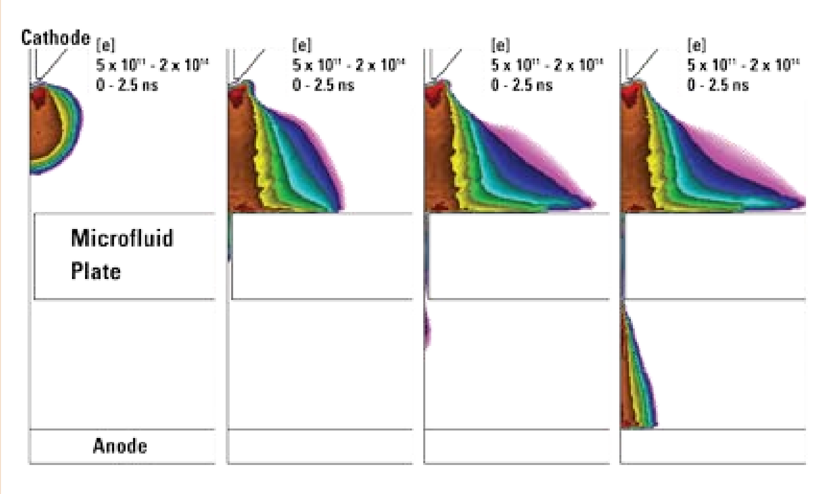
Biswas is working with Ion Optics, a company in Waltham, Massachusetts, which has developed patented photonic crystal technology that allows precise wavelength tuning of the emission and absorption of a silicon surface. When heated to a moderate temperature, the photonic crystals emit radiation in a narrow band of wavelength. That band can be tuned by simply varying the lattice space of the crystal, and when a gas passes through the

Computational Optical and Discharge Physics Group

The Computational Optical and Discharge Physics Group (CODPG), directed by Professor **Mark J. Kushner**, dean of the College of Engineering at Iowa State, develops computer simulations of low-temperature plasmas and technologically important devices that use them. These simulations provide a method of investigating the basic physical processes that occur in low-temperature plasmas and are also used as computer-aided design (CAD) tools for the design of plasma equipment and processes. The current focus of the CODPG includes plasma etching and deposition for fabrication of microelectronics and flat panel displays, profile evolution during plasma-surface interactions, microplasma devices, electrically excited chemical lasers, and plasma functionalization of polymers for biocompatibility. The simulations developed by the CODPG are standard CAD tools for designing plasma reactors and processes in the semiconductor industry.

The challenges in developing these simulations include the extreme dynamic ranges in space (10^6) and time (10^9) and the diverse range of physical processes required to address atomistic treatment of materials in meter-sized reactors. One such example is the functionalization of polymers using atmospheric pressure plasmas. There is need to provide biocompatibility to polymers (or other materials) that are used in applications such as tissue scaffolding or micro-fluidic labs-on-a-chip. These materials often have surface structures with sizes on the order of a cell or channels only tens of microns in size. The use of atmospheric pressure plasmas for this functionalization would greatly reduce cost.

An example of utilizing these comprehensive simulations for investigating functionalization of micro-fluidic channels is shown in the adjacent figure. The plasma density in an atmospheric pressure plasma sustained in humid air is shown penetrating through a 50-μm channel in a dielectric plate. The intent is to create radicals (such as O, OH) inside the channel to chemically treat the inner surface. The negative corona plasma pulse bridges the 2-mm cathode-to-anode gap in only 2.5 ns. The plasma achieves a density of $2 \times 10^{14}/cm^3$ that is capable of producing significant chemical reactivity inside the channel.



wavelength, it absorbs some of the emitted radiation. That, in turn, changes the temperature of the device and translates into a different voltage that can be easily measured and calibrated.

One emerging application of this work is with patients suffering from respiratory problems.

"Normally, carbon dioxide in the atmosphere is about 300 parts per million, or 0.03 percent," Biswas explains. "When a healthy person exhales air, he or she emits air with about 4 percent carbon dioxide—that's a huge change, which is easily recognizable."

To assist someone with respiratory problems, a doctor can place these sensors near a patient's mouth and record the amount of carbon dioxide being exhaled. "That tells us how the patient is doing and tells the doctor whether or not the treatment needs to be changed," Biswas says.

One of his main focus areas with the sensors is gaining a more thorough understanding of how the devices work. To do that, Biswas is using electromagnetic simulations to learn how changing the design can improve its performance. He's developed a scattering matrix method and standard equations of electromagnetic theory. "We're solving this in Fourier space, rather than real space," Biswas notes. "These simulations have been numerically intensive, but efficient enough to run on ECpE's parallel computing architecture."

Eventually, Biswas hopes to push the emissions to different wavelengths, not just infrared. That, he says, will enable the development of new devices that can be used in many different applications. He also expects to integrate his ideas on sensors into ECpE's wireless sensor network laboratory developed by Assistant Professors **Daji Qiao** and **Srikanta Tirthapura**. That integration, Biswas says, could benefit many people. Just one example he offers is detecting dangerous gasses in a mine. "A miner could wear a sensor on his helmet," he says. "If the level of gas in the mine is too high, the sensor will set off alarms that will inform the miner that he should leave the area immediately."

Professor **Vikram Dalal** is leading projects to fabricate sensors that complement Biswas' modeling expertise. Almost all biological and chemical agents have optical signatures (i.e., they emit fluorescence at specific wavelengths). The optical signature is affected by the presence of specific molecules that may represent toxic or harmful agents. For example, certain chemical analytes emit fluorescence, but the signal is quenched in the presence of glucose molecules. This quenching can be used to measure the concentration of glucose in fluids, a capability that will aid in monitoring sugar levels in diabetic patients.

Similarly, there is a need for precise, inexpensive oxygen detectors for use by firefighters and other rescue personnel. Dalal's group is developing a nanotechnology-based sensor to detect oxygen glucose, anthrax lethal factor, etc., using this principle. The device consists of an organic LED that emits at a wavelength suitable for absorption by the analyte, which then fluoresces at a different wavelength. The radiation is detected using a built-in photo-detector fabricated from nano-crystalline or amorphous silicon and silicon-germanium alloys. Dalal's team has integrated the entire arrangement into a single device.

VLSI circuits in small-scale technology

The semi-conductor industry has experienced tremendous growth in recent years. Memory doubles every two or three years on computers, and as performance gets better, costs are reduced.

To keep colleagues informed about these rapid advancements, industry experts have collaborated on a publication titled Information Technology Roadmap for Semiconductors. Used to identify major technology developments, directions, barriers, and challenges, the book is significantly revised every two years. The book was first published as the National Technology Roadmap for Semiconductors in 1992 by the Semiconductor Industry Association.

The "roadmap" has identified several grand challenges that must be met to keep the semiconductor industry moving forward. Professor **Randy Geiger** and Associate Professor **Degang Chen** are working on solutions to two of the most elusive challenges—analog and mixed-signal testing.

With the exception of the analog and mixed-signal areas, testing technology has kept pace with general technology advancements. Analog functionality is not on the same scale as other technology. As features become smaller, analog functionality distorts the signal. It's an

Jiming Song earns CAREER award

ECpE Assistant Professor **Jiming Song** received NSF's prestigious Faculty Early Career Development Program (CAREER) award for his project "Accurate and Efficient Electromagnetic Modeling Techniques for RF Integrated Circuits."

Highly competitive CAREER awards support the development of teacher-scholars who most effectively integrate research and education within the context of the mission of their organization.

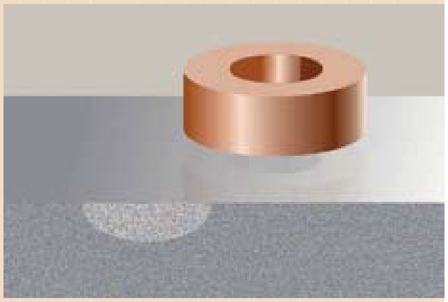
Song's grant of nearly $400,000 will be used on a project to develop next-generation accurate and efficient electromagnetic modeling techniques applicable to the design and analysis of mixed-signal radio frequency integrated circuits (RFIC). This research relates closely with educational and outreach activities, including curriculum development of electromagnetic courses at both the undergraduate and graduate levels.

Song is also working on creating a virtual electromagnetic experimental laboratory to provide viable, accurate, and efficient solutions for many key electromagnetic modeling issues in mixed-signal RFICs. He says the findings will lead to advances in developing efficient algorithms in areas such as landmine and underground facility detection and electromagnetic nondestructive evaluation.

Electromagnetic nondestructive evaluation

Professor John Bowler's work on electromagnetic nondestructive evaluation focuses on new and improved inspection methods for the detection of cracks and corrosion in aircraft and nuclear power plants. He has developed theoretical and computational models to support developments in eddy-current inspection hardware, introduced methods for estimating the accumulated damage in aging aircraft structures from eddy current inspection data, and developed techniques for measuring material properties of case-hardened steel.

Bowler has also studied electrically conducting composites in hopes of improving their ability to absorb microwave radiation. These studies are aimed at determining the conductivity of polymers loaded with conducting particles to find the best combination of materials to use for radar/microware absorption.



inverse relationship: as feature size, transistor, and voltage become smaller, noise levels become more significant.

Now circuits are becoming larger and larger. Whole circuits are integrated on one chip or an entire system onto a few chips, thus co-locating analog functionalities, analog-to-digital converters, digital-to-analog converters, etc. With an entire system resting on a chip, the chip must interface with the real world, which is always analog. CPUs are manufactured in the digital domain, but when you interface with the real world, you have to have analog functionalities.

"Traditional standards have emphasized the viewpoint that if you want to test a circuit that is 0.1 percent accurate, you should use a testing circuit that is 10 times better than that," Chen says. "That way you don't make testing errors. Your testing circuits have to maintain an accuracy of 0.01 percent."

But the problem is generating testing at that level. "You can't do it," Chen advises.

However, Chen and Geiger have discovered that the testing area can be considered from a system identification or signal processing perspective. Their pioneering work in this area shows that imprecise signals can be used to test those circuits and obviates the need for highly accurate testing signals.

For example, traditional wisdom holds that testing a 16-bit analog-to-digital converter requires 100-bit linear signals. Chen and Geiger have developed algorithms based on signals' error identification and removal, which lets them identify errors in the signal source that are then removed using digital-signal processing. "We separate the errors from the signal source, and once they're separated, we can accurately test the ADCs," explains Chen. "This allows us to use imprecise signals to test the high-precision ADC."

These new testing methods are a culmination of the successful interdisciplinary activity within systems and VLSI areas. The methods developed are leading to results that are several orders of magnitude better than previous state-of-the-art results."

This group is also incorporating testing results into a design flow. Algorithms that allow the use of low-cost instrumentation to test high-performance circuits enable the development of testing instruments on chips using a tiny area to build the instruments.

In turn, this enables the testing of high-performance circuits on a chip. The errors detected during testing can be used to calibrate the main circuit, thus enhancing the performance of analog and mixed-signal circuits and improving the yield to reduce the costs.

While Chen and Geiger have focused on facilitating testing methods for circuits, Assistant Professor **Jiming Song** is providing modeling tools that have become essential as the feature sizes in the semiconductor technologies become smaller and the frequencies faster. "Scientists want semiconductors that are smaller, faster, and cheaper," Song notes.

Song's work in electro-magnetic modeling for radio-frequency integrated circuit (RFIC) design was recently recognized with an NSF CAREER award.

Song's research will provide viable, accurate, and efficient solutions for key electromagnetic modeling issues in these mixed-signal RFICs. His goal is to make a significant impact on the design of new RFICs, and he hopes that his findings will also lead to advances in developing efficient algorithms in areas such as landmine and underground facility detection, as well as electromagnetic nondestructive evaluation.

In another project, Song is exploring ways to develop state-of-the-art, physics-based algorithms for electromagnetic modeling of nanoscale interconnects, embedded RF components, and high-speed circuits. Associate Professor **Chris Chu**'s group is focused on optimal placement strategies for VLSI circuits that are extremely fast and generate placements of comparable quality to state-of-the-art algorithms. Says Chu, "Our goal is to produce highly scalable algorithms that are capable of handling circuits with up to 100 million placeable objects." For circuits with 1 million placeable objects, the algorithms should be able to complete in a few minutes with solution quality within one-tenth percent of those generated by existing placement algorithms.

His group has developed a new placement algorithm termed FastPlace. "Experimental results show that FastPlace is on average 13.0 and 97.4 times faster than the state-of-the-art academic placers Capo and Dragon, respectively," Chu says. "The wire length, another performance metric, is just 1.0 percent and 1.6 percent longer than that of Capo and Dragon, respectively." That's a significant improvement over existing technology, Chu adds.

Chu's work was presented in a paper given at the 2004 ACM International Symposium on Physical Design. The paper, titled "FastPlace: An Efficient Analytical Placement Technique Using Cell Spreading and Iterative Local Refinement," won best paper honors.

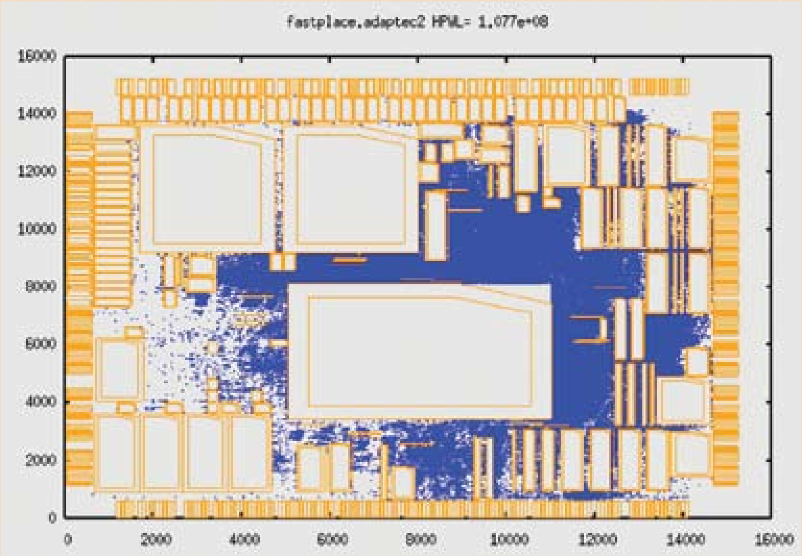
FastPlace called unbelievable

Computer engineers trying to fit millions of cells on a silicon chip the size of a strand of hair face a difficult two-dimensional problem: how to arrange the cells on a surface and how to accommodate the cells' interconnections. It's a time-consuming task, and dozens of software programs have been created to help carry it out.

But none is as fast as a program created by ECpE Assistant Professor **Chris Chu** and his former master's student **Natarajan Viswanathan**. In fact, their software, called FastPlace, is so quick that when they described it in a paper submitted to the International Symposium on Physical Design, the paper was almost rejected because no one believed its claims.

But after duplication and verification, the paper was named "Best Paper," and the software rocketed from obscurity to a prominent spot on the radar screens of the country's top computer companies.

FastPlace, a quadratic placer, reduces the time it takes to place cells from at least two hours to about 10–15 minutes.



Software engineering

The department's aggressive efforts to establish a strong education and research program in software engineering has resulted in a new undergraduate degree program, new lab, and cutting-edge research projects in key areas of software engineering and its applications. Expected to launch fall semester 2006, the new degree program will focus on practical aspects of software engineering. Working closely with industrial partners and an external advisory board, ECpE leaders developed the program to ensure that the curriculum has strong, real-life software process and practice components, in addition to the foundational principles component. The core curriculum, designed to follow the IEEE/ACM Computing Curricula guidelines, emphasizes all three key aspects of software engineering: principles, process, and practice. The elective focus areas, meanwhile, include the evolution of large-scale legacy software, embedded software, and software security. Cutting-edge research includes high-confidence software, software evolution maintenance, scientific computing, embedded software, and software security.

Two key areas of the department's research are summarized on this page.

High-confidence software development: Productivity and quality

This research addresses the human complexity of developing and maintaining high-confidence software. Its objective is to optimize the human resources required for developing software and ensuring its quality and reliability. The research provides a tool-centric approach with a focus on automating tedious mechanical aspects of software development and evolution. The research team, led by Professor **Suraj Kothari**, has pioneered a pattern-based approach for developing a variety of tools for different programming languages. The patterns are defined by experts in a particular domain (e.g., security, safety, real time, fault tolerance) using a pattern-specification language. Like human experts, pattern-based tools can apply context and avoid brute-force searches that lead to intractable problems. This research has led to the formation of a company at the Iowa State University Research Park that provides tools and tool-based services to multi-national companies.

Evolution and maintenance software and documents

Assistant Professor **Tien Nyguen**'s research focuses on online software maintenance. Software changes are often required to fix defects or to improve design or functionality. Online implies that software changes are implemented while the software application continues to run. Online changes are especially desirable for mission-critical applications, such as the flight-control software on spacecraft or the critical transaction processing servers. Another area of Nguyen's research focuses on integrating semantics of changes in configuration management and version control systems with application to software systems and Web.

ECpE faculty profiles

Venkataramana Ajjarapu
PROFESSOR

PhD, Electrical Engineering, University of Waterloo (1986)
MTech, Electrical Engineering, Indian Institute of Technology (1982)
BTech, Electrical Engineering, Jawaharlal Nehru Technological University (1979)

RESEARCH INTERESTS: Power system security (with emphasis on reactive power dispatch and voltage security), real-time control of power and power electronics systems

CORE AREA: Energy systems

STRATEGIC PLAN AREA:
Energy infrastructure

PUBLICATIONS

- Wen, X., and V. Ajjarapu. 2006. Application of a novel Eigenvalue trajectory tracing method to identify both oscillatory stability margin and damping margin. *IEEE Transactions on Power Systems* 1 (2, May): 817–24.
- Yang, D., and V. Ajjarapu. 2006. A decoupled time domain simulation method via invariant subspace partition for power system analysis. *IEEE Transaction on Power Systems* 21 (1, February): 11–8.
- Qin, W., H. Song, and V. Ajjarapu. 2006. Continuation based quasi-steady state analysis. *IEEE Transactions on Power Systems* 21 (1, February): 171–9.
- Zhou, Y., and V. Ajjarapu. 2005. A fast algorithm for identification and tracing of voltage and oscillatory stability margin boundaries. Invited paper for special issue of *Proceedings of IEEE Journal Publication for Energy Infrastructure Defense Systems* 93 (5, May): 934–46.
- Zhou, Y., and V. Ajjarapu. 2005. A novel approach to trace time domain trajectories of power systems in multiple time scales. *IEEE Transactions on Power Systems* 20 (1, February): 149–55.

Srinivas Aluru
PROFESSOR

PhD, Computer Science, Iowa State University (1994)
MS, Computer Science, Iowa State University (1991)
BTech, Computer Science, Indian Institute of Technology (1989)

RESEARCH INTERESTS:
Parallel processing, bioinformatics and computational biology, combinatorial scientific computing, applied algorithms

CORE AREA: Software systems

STRATEGIC PLAN AREAS:
Bioengineering and cyber infrastructure

PUBLICATIONS

- Kalyanaraman, A., S. J. Emrich, P. S. Schnable, and S. Aluru. 2006. Assembling genomes on large-scale parallel computers. In *20th IEEE International Parallel and Distributed Processing Symposium* (best paper award).
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- Rajko, S., and S. Aluru. 2004. Space and time optimal parallel sequence alignments. *IEEE Transactions on Parallel and Distributed Systems* 15 (12): 1070–81.
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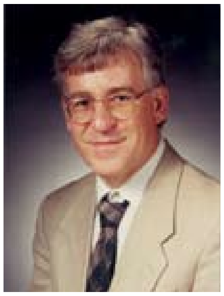
John R. Bowler
PROFESSOR



PhD, Physics, The University of Surrey, UK (1984)

MS, Science Education, Keele University, UK (1980)
BS, Physics, Leicester University, UK (1971)

RESEARCH INTERESTS: Analysis of electromagnetic fields, applications to nondestructive evaluation (NDE), computational methods in electromagnetics

CORE AREAS: Electromagnetics and NDE

STRATEGIC PLAN AREA: Small scale technologies

PUBLICATIONS

- Sun, H., J. R. Bowler, and T. Theodoulidis. 2005. Eddy currents induced in a finite length layered rod by a coaxial coil. *IEEE Trans. Mag.* 41 (9): 2455–61.
- Theodoulidis, T., and J. R. Bowler. 2005. Eddy current coil interaction with a right-angled conductive wedge. In *Proc Roy. Soc. Ser A*. 17 August.
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- Bowler, J. R. 2002. Thin-skin eddy-current inversion for the determination of crack shapes. *Inverse Problems* 18:281–91.

Nicola Bowler
ASSOCIATE PROFESSOR

PhD, Physics, University of Surrey, UK (1994)
BSc, Physics, University of Nottingham, UK (1990)

RESEARCH INTERESTS: Electromagnetic nondestructive evaluation, composite materials for electromagnetic applications

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA: Small scale technologies

PUBLICATIONS

- Youngs, I. J., N. Bowler, and O. Ugurlu. 2006. Dielectric relaxation in composites containing electrically isolated particles with thin semi-continuous metal coatings. *J. Phys. D: Appl. Phys.* 39:1312–25.
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Morris Chang
ASSOCIATE PROFESSOR

PhD, Computer Engineering, North Carolina State University (1993)
MS, Electrical Engineering, North Carolina State University (1986)
BSEE, Tatung Institute of Technology, Taiwan (1983)

RESEARCH INTERESTS: Embedded systems, performance in Java virtual machines, wireless communication protocol

CORE AREAS: Computing and networking systems
STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Peng, Y., Z. Abichar, and J. M. Chang. To appear. Roadside-aided routing (RAR) in vehicular networks. In *Proceedings of IEEE International Conference on Communications (ICC 2006)*. 11–15 June, Istanbul, Turkey.
- Lebsack, C., and J. M. Chang. 2005. System level perspective on object locality. In *Proceedings of ACM Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA)*, 244–5. 15–18 October, San Diego, California.
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Degang Chen
ASSOCIATE PROFESSOR

PhD, Electrical and Computer Engineering, University of California, Santa Barbara (1992)
MS, Electrical and Computer Engineering, University of California, Santa Barbara (1988)
BS, Tsinghua University, Beijing (1984)

RESEARCH INTERESTS: VLSI testing, nonlinear control

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA: Small scale technologies

PUBLICATIONS

- Wang, X. Z., and D. Chen. Submitted. An inversion-based iterative learning control algorithm for a class of nonminimum-phase systems. *IEE Proceedings Part D Control Theory and Applications* 152 (1, January): 7–8.
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Chris Chong-Nuen Chu
ASSOCIATE PROFESSOR

PhD, Computer Science, University of Texas at Austin (1999)
MS, Computer Science, University of Texas at Austin (1994)
BS, Computer Science, University of Hong Kong, China (1993)

RESEARCH INTERESTS: Performance-driven interconnect optimization, fast circuit placement algorithms, efficient rectilinear Steiner tree construction for VLSI design

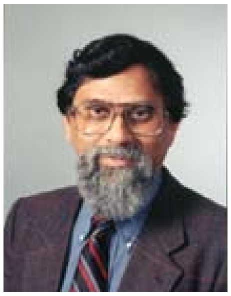
CORE AREAS: CAD of VLSI physical design, design and analysis of algorithms

STRATEGIC PLAN AREA: Small scale technologies

PUBLICATIONS

- Pan, M., N. Viswanathan, and C. Chu. 2005. An efficient and effective detailed placement algorithm. In *IEEE/ACM International Conference on Computer-Aided Design*.
- Chu, C. 2004. FLUTE: Fast lookup table based wirelength estimation technique. In *IEEE/ACM International Conference on Computer-Aided Design*, 696–701.
- Viswanathan, N., and C. Chu. 2004. FastPlace: An efficient analytical placement technique using cell spreading and iterative local refinement. In *ACM International Symposium on Physical Design*, 26–33.
- Chen, C.-P., C. C. N. Chu, and D. F. Wong. 1999. Fast and exact simultaneous gate and wire sizing by Lagrangian relaxation. *IEEE Transactions on Computer-Aided Design* 18 (7, July): 1014–25.
- Chu, C. C. N., and D. F. Wong. 1999. A quadratic programming approach to simultaneous buffer insertion/sizing and wire sizing. *IEEE Transactions on Computer-Aided Design* 18 (6, June): 787–98.

Vikram Dalal
WHITNEY CHAIR PROFESSOR



PhD, Electrical Engineering, Princeton University (1969)
MPA, Economics, Princeton University (1975)
BE, Electrical Engineering, University of Bombay, India (1964)

RESEARCH INTERESTS: Microelectronics and photonics, photovoltaic solar energy conversion devices, plasma processing, semiconducting materials and devices, sensor devices

CORE AREA: Advanced electronic materials

STRATEGIC PLAN AREAS: Bioengineering, energy, nanotechnology, photonics

PUBLICATIONS

- Stieler, D., V. Dalal, M. Noack, and E. Schares. Accepted. Electron mobility in nancorystalline Si. *J. Appl. Phys*.
- Wang, N., and V. Dalal. Accepted. Influence of chemical annealing on stability of amorphous Si solar cells. *J. Non-Cryst. Solids*.
- Dalal, V., K. Muthukrishnan, X. Niu, and D. Stiler. Accepted. Growth chemistry of nanocrystalline Si and Ge films. *J. Non-Cryst. Solids*.

- Shinar, R., D. Ghosh, B. Chouduary, M. Noack, V. L. Dalal, and J. Shinar. In press. Oxygen sensor structurally integrated with LED and a-Si photodetector. *J. Non-Cryst. Solids*.
- Niu, X., and V. L. Dalal. 2005. Growth and properties of nanocrystalline germanium films. *J. Appl. Physics* 98:096103.
- Dalal, V., and P. Sharma. 2005. Diffusion length and defect densities in nanocrystalline Si solar cells. *Appl. Phys. Lett.* 86:103510.
- Dalal, V. L., J. Graves, and J. Leib. 2004. Influence of pressure and ion bombardment on the growth and properties of nanocrystalline Si materials. *Appl. Phys. Lett.* 85:1413.

Tom Daniels
ASSISTANT PROFESSOR

PhD, Computer Science, Purdue University (2002)
MS, Computer Science, Purdue University (1999)
BS, Computer Science, Southwest Missouri State University (1995)

RESEARCH INTEREST: Information assurance and security

CORE AREA: Secure and reliable computing

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Anderson, B., T. E. Daniels. Submitted. Xen Worlds: Xen and the art of computer engineering education. In *ASEE Annual Conference and Exposition*. Chicago, Illinois.
- Gerdes, R., T. Daniels, M. Mina, and S. Russell. 2006. Device identification via analog signal fingerprinting: A matched filter approach. In *The 13th Annual Network and Distributed System Security Symposium*. 2–3 February, San Diego, California.
- Wang, W., and T. E. Daniels. 2005. Building evidence graphs for network forensics analysis. In *Proceedings of the 21st Annual Computer Security Applications Conference*. December, Tucson, Arizona.
- Mina, M., T. Daniels, S. Russell, and R. Gerdes. 2005. Intrusion detection, performance assurance, and system maintenance: A new paradigm in computer security. *Materials Evaluation* (ASNT) 64 (12, December).
- Daniels, T., M. Mina, and S. Russell. 2005. A signal fingerprinting paradigm for physical layer security in conventional and sensor networks. In *Proceedings of the First International Conference on Security and Privacy for Emerging Areas in Communication Networks (IEEE/CreateNet SecureComm)*. Athens, Greece.

James A. Davis
ASSOCIATE PROFESSOR

PhD, Computer Science, Iowa State University (1984)
MS, Electrical Engineering, Iowa State University (1982)
BS, Computer Science, Iowa State University (1975)

RESEARCH INTERESTS: Enterprise information security strategies, risk management, computer security education

CORE AREA: Computer security

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Yasinsac, A., and J. A. Davis. 2004. Modeling protocols for secure group communication in ad hoc networks. In *Lecture Notes in Computer Science*. Ed. B. Christianson, B. Crispo, J. Malcolm, M. Row, 243. Springer-Verlag.
- Jacobson, D., and J. A. Davis. 2004. Computer security faculty development workshop. In *Proceedings of the 2004 Frontiers in Education*. 20–23 October, Savannah, Georgia.
- Davis, J. A., and M. Dark. 2003. Teaching students to design secure systems. *IEEE Security & Privacy* 1 (2, March).
- Davis, J. A., and M. Dark. 2003. Defining a curriculum framework in information assurance and security. In *Proceedings of the 2003 ASEE Annual Conference*. 22–25 June, Nashville, Tennessee.
- Holeman, S., G. Manimaran, J. A. Davis, and A. Chakrabarti. 2002. Differentially secure multicasting and its implementation methods. *Computers & Security* 21 (8, November): 736–49.

Julie A. Dickerson
ASSOCIATE PROFESSOR

PhD, Electrical Engineering, University of Southern California (1993)
MS, Electrical Engineering, University of Southern California (1986)
BS, Electrical Engineering, University of California, San Diego (1983)

RESEARCH INTERESTS: Systems biology, bioinformatics, pattern recognition, data visualization, real-time sensor networks

CORE AREAS: Communications and signal processing

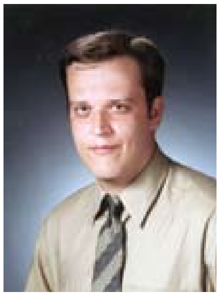
STRATEGIC PLAN AREA: Bio-engineering

PUBLICATIONS

- Rhee, S. Y., J. A. Dickerson, and D. Xu. 2006. Bioinformatics and its applications in plant biology. *Annual Review of Plant Biology* 57:335–59.
- Helgason, C. M., T. H. Jobe, and J. A. Dickerson. 2005. Introduction to the special section on fuzzy logic in biologic systems and medicine. Special issue of *IEEE Transactions on Systems, Man and Cybernetics, Part B* 35 (6): 1326–7.
- Du, P., J. Gong, E. S. Wurtele, and J. A. Dickerson. 2005. Modeling gene expression networks using fuzzy logic. Special issue of *IEEE Transactions on Systems, Man and Cybernetics, Part B* 35 (6): 1351–9.
- Yang, Y., L. Engin, E. S. Wurtele, C. Cruz-Neira, and J. A. Dickerson. 2005. Integration of metabolic networks and gene expression in virtual reality. *Bioinformatics* 21:3645–50.
- Ding, J., K. Viswanathan, D. Berleant, L. Hughes, E. S. Wurtele, D. Ashlock, J. A. Dickerson, A. Fulmer, and P. S. Schnable. 2005. Using the biological taxonomy to access biological literature with PathBinderH. *Bioinformatics* 21 (10): 2560–2.
- Shen, L., J. Gong, R. A. Caldo, D. Nettleton, D. Cook, R. P. Wise, and J. A. Dickerson. 2004. Barleybase—An expression profiling database for plant genomics. *Nucleic Acids Research* 33 (1): D614–8.
- Dickerson, J. A., D. Berleant, Z. Cox, A. W. Fulmer, and E. Wurtele. 2003. Creating and modeling metabolic and regulatory networks using text mining and fuzzy expert systems. In *Computational Biology and Genome Informatics*. Ed. C. H. Wu, P. Wang, and J. T. L. Wang. World Scientific.

Aleksandar Dogandzic

ASSISTANT PROFESSOR



PhD, Electrical Engineering and Computer Science, University of Illinois at Chicago (2001)
MS, Electrical Engineering and Computer Science, University of Illinois at Chicago (1997)
DiplIng, Electrical Engineering, University of Belgrade, Yugoslavia (1995)

RESEARCH INTEREST: Statistical signal processing theory and applications

CORE AREAS: Communications, control, signals

STRATEGIC PLAN AREA: Distributed sensing/decision making

PUBLICATIONS

- Dogandzic, A., and B. Zhang. 2005. Bayesian defect signal analysis. In *Proc. Review Progress Quantitative Nondestructive Evaluation*. August, Brunswick, Maine.
- Dogandzic, A., and B. Zhang. 2005. Parametric signal estimation using sensor networks in the presence of node localization errors. In *Proc. 39th Asilomar Conf. Signals, Syst. Comput*. November, Pacific Grove, California.
- Dogandzic, A., and B. Zhang. 2005. Distributed signal processing for sensor networks using hidden Markov random fields. In *Proc. 39th Annu. Conf. Inform. Sci. Syst*. March, Baltimore, Maryland.
- Dogandzic, A., and A. Nehorai. 2003. Generalized multivariate analysis of variance: A unified framework for signal processing in correlated noise. *IEEE Signal Processing Mag*. 20 (September): 39–54.
- Dogandzic, A. 2003. Chernoff bounds on pairwise error probabilities of space-time codes. *IEEE Trans. Inform. Theory* 49 (May): 1327–36.

Nicola Elia

ASSOCIATE PROFESSOR

PhD, Electrical Engineering, Massachusetts Institute of Technology (1996)
Laurea, Electrical Engineering, Politecnico di Torino, Italy (1987)

RESEARCH INTERESTS: Control theory, information theory

CORE AREA: Systems and controls

STRATEGIC PLAN AREA: Distributed sensing/decision making

PUBLICATIONS

- Tatikonda, S., and N. Elia. 2004. Communication requirements for networked control. In *Advances in Communication Control Networks; Lecture Notes in Control and Information Sciences* (LNCIS), 308/2004:303. Ed. S. Tarbouriech, C. T. Abdallah, and J. Chiasson.
- Kulkarni, V., J. De Mot, N. Elia, E. Feron, and J. Paduano. 2004. Communication constrained multi-agent path planning. Chapter 14 in *Recent Developments in Cooperative Control and Optimization*. Ed. S. Butenko, R. Murphey, and P. Pardalos. Boston, Massachusetts: Kluwer.
- Elia, N. 2003. Indelible control. In *Mohammed Dahleh's Symposium Lecture Series in Control and Information Sciences* 289/2003:33–46. Springer.
- Elia, N., and E. Frazzoli. 2002. Quantized stabilization of two-input linear systems: A lower bound on the minimal quantization density. In *Hybrid Systems Computation and Control Lecture Notes in Computer Science* 2289/2002:179–93. Springer.

Randall L. Geiger
RICHARDSON PROFESSOR

PhD, Electrical Engineering, Colorado State University (1977)
MS, Mathematics, University of Nebraska (1973)
BS, Electrical Engineering, University of Nebraska (1972)

RESEARCH INTERESTS: Analog VLSI design, VLSI testing, high-speed data converters

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA: Small scale technologies

PUBLICATIONS

- Oletta, B., H. Jiang, D. J. Chen, and R. L. Geiger. 2006. A deterministic dynamic element matching approach for testing high resolution ADCs with low accuracy excitations. *IEEE Trans. on Instr. and Measurement* 55 (June): 902–15.
- Lin, Y., D. Chen, and R. L. Geiger. 2006. Yield enhancement with optimal area allocation for ratio-critical analog circuits. *IEEE Trans. on Circuits and Systems* 53 (March): 534–53.
- Jin, Y. L., K. Parthasarathy, T. Kuyel, D. Chen, and R. L. Geiger. 2005. Accurate testing of analog-to-digital converters using low linearity signals with stimulus error identification and removal. *IEEE Trans on Instr. and Measurement* 54 (June): 1188–99.
- Cong, and R. L. Geiger. 2003. A 1.5-v 14-bit 100-MS/s self-calibrated DAC. *IEEE Journal of Solid State Circuits* 38 (12, December): 2051–60.

Manimaran Govindarasu
ASSOCIATE PROFESSOR

PhD, Computer Science and Engineering, Indian Institute of Technology, Madras (1998)
MTech, Computer Technology, Indian Institute of Technology, Delhi (1993)
BE, Computer Science and Engineering, Bharathidasan University Trichirapalli, India (1989)

RESEARCH INTERESTS: Real-time systems, intrusion detection, computer networking

CORE AREA: Computing and networking systems

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Al-Duwairi, B., and G. Manimaran. 2006. Novel hybrid schemes employing packet marking and logging for IP traceback. *IEEE Trans. on Parallel and Distributed Systems* 17 (5, May): 403–18.
- Chakrabarti, A., and G. Manimaran. 2005. Reliability constrained routing in QoS networks. *IEEE/ACM Trans. on Networking* 13 (3, June): 662–75.
- Omari, R. A., A. K. Somani, and G. Manimaran. 2005. An adaptive scheme for fault-tolerant scheduling of soft real-time tasks in multiprocessor systems. *Journal of Parallel and Distributed Computing* 65 (5, May): 595–608.
- Striegel, A., and G. Manimaran. 2004. DSMCast: A scalable approach for DiffServ multicasting. *Computer Networks* 44 (6, April): 713–35.
- Omari, R. A., A. K. Somani, and G. Manimaran. 2004. Efficient overloading techniques for primary-backup scheduling in real-time systems. *Journal of Parallel and Distributed Computing* 64 (5, May): 629–48.

Yong Guan
ASSISTANT PROFESSOR

PhD, Computer Science, Texas A&M (2002)
MS, Computer Science, Peking University, China (1996)
BS, Computer Science, Peking University, China (1990)

RESEARCH INTERESTS: Wireless and sensor network security, computer and network forensics, privacy-enhancing technologies for the Internet

CORE AREAS: Networking and distributed systems, software systems

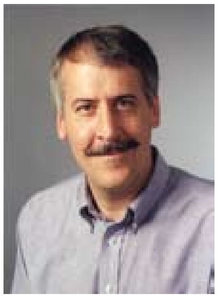
STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Wang, H., J. Cardo, and Y. Guan. 2005. Shepherd: A lightweight statistical authentication protocol for access control in wireless LANs. *Elsevier Computer Communications Journal, Special Issue on Applications and Services in Wireless Networks* 28 (14, September): 1618–30.
- Yu, Z., and Y. Guan. 2005. A key pre-distribution scheme using deployment knowledge for wireless sensor networks. In *Proceedings of the 4th ACM/IEEE International Conference on Information Processing in Sensor Networks* (IPSN 2005). 25–27 April, Los Angeles, California.
- Persaud, A., and Y. Guan. 2005. A framework for email investigation: Automated information extraction and linkage discovery. In *IFIP WG 11.9 First International Conference on Digital Forensics*. 13–16 February, Orlando, Florida.

- Guan, Y., X. Fu, R. Bettati, and W. Zhao. 2004. A quantitative analysis of anonymous communications. *IEEE Transactions on Reliability* 53 (1, March): 103–16.
- Guan, Y., X. Fu, D. Xuan, P. Shenoy, R. Bettati, and W. Zhao. 2001. NetCamo: Camouflaging network traffic for QoS-guaranteed mission critical applications. *IEEE Transactions on System, Man, and Cybernetics, Special Issue on Information Assurance* 31 (4, July): 253–65.

Doug Jacobson
ASSOCIATE PROFESSOR



PhD, Computer Engineering, Iowa State University (1985)
MS, Electrical Engineering, Iowa State University (1982)
BS, Computer Engineering, Iowa State University (1980)

RESEARCH INTERESTS:
Information assurance, large-scale cyber attack simulation

CORE AREA: Secure and reliable computing

STRATEGIC PLAN AREA: Cyber infrastructure

Ahmed Kamal
PROFESSOR

PhD, Electrical Engineering, University of Toronto, Canada (1986)
MASc, Electrical Engineering, University of Toronto, Canada (1982)
MSc, Electrical Engineering, Cairo University, Egypt (1980)
BSc, Electrical Engineering, Cairo University, Egypt (1978)

RESEARCH INTERESTS:
High-performance networks, optical networks, wireless and sensor networks, performance evaluation

CORE AREA: Computing and networking systems

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS
- Ul-Mustafa, R., and A. E. Kamal. To appear. Design and provisioning of WDM networks with multicast traffic grooming. *IEEE Journal on Selected Areas in Communications*.
- Hamad, A., and A. E. Kamal. 2005. Routing and wavelength assignment with power aware multicasting in WDM networks. In *Proceedings of Broadnets 2005*.
- Al-Karaki, J. N., and A. E. Kamal. 2004. Routing techniques in wireless sensor networks: A survey. *IEEE Wireless Communications* 11 (6, December): 6–28.
- Kamal, A. E. 2004. A discrete-time model of TCP Reno with RED-based routers in the presence of background traffic interference. *Performance Evaluation* 58 (2–3): 109–42.
- Kamal, A. E., H. El-Rewini, and R. Ul-Mustafa. 2004. Optimal and approximate approaches for selecting proxy agents in mobile network backbones. *Journal of Parallel and Distributed Computing* 64 (4, April): 554–68.

Jaeyoun Kim
ASSISTANT PROFESSOR

PhD, Electrical Engineering, University of Michigan at Ann Arbor (2003)
MS, Electrical Engineering, University of Arizona at Tucson (1994)
BS, Electrical Engineering, Kwangwoon University at Seoul, Korea (1992)

RESEARCH INTERESTS:
Photonics, plasmonics, application of optical nanostructures for bioengineering, optical BioMEMS, bio-mimetic optics

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREAS:
Small scale technologies and bioengineering

PUBLICATIONS
- Jeong, K.-H., J. Kim, and L. P. Lee. 2006. Biomimetic artificial compound eyes. *Science* 312:557–61.
- Liu, G. L., J. Kim, Y. Lu, and L. P. Lee. 2006. Optofluidic control via photothermal nanoparticles. *Nature Materials* 5:27–32 (highlighted in *Nature* 438:1058, 2005).
- Kim, J., G. L. Liu, Y. Lu, and L. P. Lee. 2005. Intra-particle plasmonic coupling of tip and cavity resonance modes in metallic apertured nanocavities. *Optics Express* 13:8332–8.
- Liu, G. L., Y. Lu, J. Kim, J. C. Doll, and L. P. Lee. 2005. A magnetic nanocrescent Raman probe for functional in vivo cellular nanospectroscopy. *Advanced Materials* 17:2683–8.
- Kim, J., G. L. Liu, and L. P. Lee. 2005. Lens-scanning Raman microspectroscopy system using compact disc optical pickup technology. *Optics Express* 13:4780–5 (highlighted in *Biophotonics International*, August 2005).
- Liu, G. L., Y. Lu, J. Kim, Y. Mejia, and L. P. Lee. 2005. Nanophotonic crescent moon structures with sharp edge for ultrasensitive biomolecular detections by local field enhancement effect. *Nano Letters* 5:119–24.

Sang W. Kim
ASSOCIATE PROFESSOR

PhD, Electrical Engineering, University of Michigan (1987)
MS, Electrical Engineering, Korea Advanced Institute of Science and Technology (1983)
BS, Electronic Engineering, Yonsei University (1981)

RESEARCH INTERESTS:
Wireless communications, cooperative communications, code division multiple access (CDMA), space-time coding, multi-user detection, cross-layer design

CORE AREA: Communications and networking

STRATEGIC PLAN AREA:
Distributed sensing and decision making

PUBLICATIONS
- Kim, S., and K. Kim. 2006. Log-likelihood ratio based detection ordering in V- BLAST. *IEEE Tr. on Communications*, 302–7.
- Kim, D., and S. Kim. 2006. Bit-level stopping of Turbo decoding. *IEEE Communications Letters*, 183–5.
- Kim, S. 2005. Cooperative spatial multiplexing in mobile ad-hoc networks. In *IEEE International Conference on Mobil Ad-hoc and Sensor Systems (IEEE MASS)*. November, Washington, D.C. (Best Paper Award).
- Kim, S., Y. G. Kim, and M. K. Simon. 2004. Generalized selection combining based on the log-likelihood ratio. *IEEE Transactions on Communications*, 521–4.
- Kim, S., and A. Goldmith. 2000. Truncated power control in code division multiple access communications. *IEEE Transactions on Vehicular Technology* 49 (3): 965–72.

Suraj C. Kothari
PROFESSOR

PhD, Mathematics, Purdue University (1977)
MS, University of Poona, India (1972)
BS, University of Poona, India (1970)

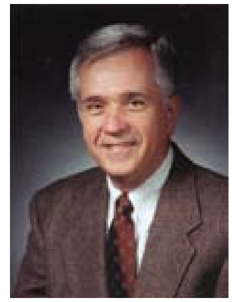
RESEARCH INTERESTS:
Parallel and distributed computing, computational biology

CORE AREA: Knowledge-centric software engineering

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS
- Kothari, S. C., G. Daugherty, L. Bishop, and J. Sauceda. 2004. A pattern based framework for detecting software anomalies. *Software Quality Journal* 12 (2, June): 99–120.
- Kalyanaraman, A., S. Kothari, V. Brendel, and S. Aluru. 2003. Efficient clustering of large EST data sets on parallel computers. *Nucleic Acids Research* 31 (11): 2963–74.
- Kalyanaraman, A., S. Aluru, V. Brendel, and S. Kothari. 2003. Space and time efficient parallel algorithms and software for EST clustering. *IEEE Transactions on Parallel and Distributed Systems* (December): 1209–21.
- Porubleva, L., K. Vander Velden, S. Kothari, D. J. Oliver, and P. R. Chitnis. 2001. The proteome of maize leaves: Use of gene sequences and expressed sequence tag data for identification of proteins with peptide mass fingerprints. *Electrophoresis* 22 (9): 1724–38.
- Kothari, S., J. Cho, Y. Deng, S. Mitra, X. Bian, R. Leung, J. Ghan, and A. Bourgeois. Software tools and parallel computing for numerical weather prediction models. *Journal of Parallel Algorithms and Applications*.

Kenneth C. Kruempel
ASSOCIATE PROFESSOR



PhD, Electrical Engineering, University of Wisconsin (1970)
MS, Electrical Engineering, Iowa State University (1963)
BS, Electrical Engineering, Iowa State University (1961)

RESEARCH INTERESTS:
Energy systems, circuit design

CORE AREA: Energy systems

STRATEGIC PLAN AREA:
Energy infrastructure

Ratnesh Kumar
PROFESSOR

PhD, Electrical and Computer Engineering, University of Texas at Austin (1991)
MS, Electrical and Computer Engineering, University of Texas at Austin (1989)
BTech, Electrical Engineering, Indian Institute of Technology, Kanpur, India (1987)

RESEARCH INTERESTS: Modeling, control, diagnosis, and verification of event-driven systems, real-time systems, and hybrid systems, and their applications in manufacturing, communication protocols, embedded controls, hardware and software systems, and power systems

CORE AREA: Systems and control

STRATEGIC PLAN AREA: Distributed sensing/decision making

PUBLICATIONS

- Zhou, C., R. Kumar, and S. Jiang. Accepted. Control of nondeterministic discrete event systems for bisimulation equivalence. *IEEE Transactions on Automatic Control*.
- Arapostathis, A., R. Kumar, and S.-P. Hsu. Accepted. Control of Markov chains with safety bounds. *IEEE Transactions on Automation Science and Engineering*.
- Qiu, W., and R. Kumar. Accepted. Decentralized failure diagnosis of discrete event systems. *IEEE Transactions on Systems, Man & Cybernetics—Part A*.
- Kumar, R., S. Jiang, C. Zhou, and W. Qiu. 2005. Polynomial synthesis of supervisor for partially observed discrete event systems by allowing nondeterminism in control. *IEEE Transactions on Automatic Control* 50 (4): 463–75.
- Jiang, S., and R. Kumar. 2004. Failure diagnosis of discrete event systems with linear-time temporal logic fault specifications. *IEEE Transactions on Automatic Control* 49 (6): 934–45.

Mark J. Kushner

DEAN OF THE COLLEGE OF ENGINEERING
JAMES MELSA PROFESSOR

PhD, Applied Physics, California Institute of Technology (1979)
MS, Applied Physics, California Institute of Technology (1977)
BS, Nuclear Engineering, University of California at Los Angeles (1976)
BA, Astronomy, University of California at Los Angeles (1976)

RESEARCH INTERESTS: Plasma and thermal materials processing; gas and solid-state lasers; pulse power plasmas; chemical lasers; laser spectroscopy; multiscale computer models to investigate fundamental plasma transport, chemistry, and plasma-surface interactions

CORE AREAS: Computational optics and discharge physics

STRATEGIC PLAN AREA: Small-scale technologies

PUBLICATIONS

- Sankaran, A., and M. J. Kushner. 2005. Etching of porous and solid SiO_2 in Ar/c-C_4F_8, O_2/c-C_4F_8 and Ar/O_2/c-C_4F_8 plasmas. *J. Appl. Phys.* 97:023307.
- Kushner, M. J. 2005. Modeling of microdischarge devices: Plasma and gas dynamics. *J. Phys. D* 38:1633.
- Subramonium, P., and M. J. Kushner. 2004. Pulsed inductively coupled plasmas as a method to recoup uniformity: A 3-dimensional modeling study. *Appl. Phys. Lett.* 85:721.
- Vasenkov, A. V., X. Li, G. S. Oehrlein, and M. J. Kushner. 2004. Properties of C_4F_8 inductively coupled plasmas, Part II: Plasma chemistry, reaction mechanism of modeling of Ar/c-C_4F_8/O_2 discharges. *J. Vac. Sci. Technol. A* 22:511.
- Dorai, R., and M. J. Kushner. 2003. A model for plasma modification of polypropylene using atmospheric pressure discharges. *J. Phys. D* 36:666.

John W. Lamont

PROFESSOR

PhD, Electrical Engineering, University of Missouri, Columbia (1970)
MS, Electrical Engineering, University of Missouri, Columbia (1966)
BS, Electrical Engineering, University of Missouri, Rolla (1964)

RESEARCH INTEREST: Energy systems

CORE AREA: Energy systems

PUBLICATION

- Lamont, J. W., and G. Sheble. 2000. Economics of bulk electric power supply. Chapter 12 in *Standard Handbook for Electrical Engineers*.

Chen-Ching Liu

PALMER CHAIR PROFESSOR

PhD, Electrical Engineering and Computer Sciences, University of California, Berkeley (1983)
MS, Electrical Engineering, National Taiwan University, Taiwan (1978)
BS, Electrical Engineering, National Taiwan University, Taiwan (1976)

RESEARCH INTERESTS: Alternate energy sources, electric power infrastructure

CORE AREA: Energy systems

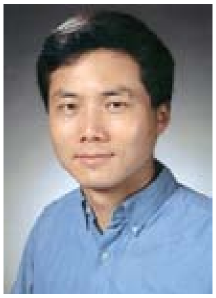
STRATEGIC PLANNING AREA: Energy infrastructure

PUBLICATIONS

- Gibescu, M., C. C. Liu, H. Hashimoto, and H. Taoka. Accepted. Energy-based stability margin computation incorporating effects of ULTCs. *IEEE Trans. Power Systems*.
- Schneider, K., C. C. Liu, and B. Howe. Accepted. State estimation and topological error identification for the NEPTUNE power system. *IEEE Trans. Power Systems*.

- Joo, S. K., C. C. Liu, Y. Shen, Z. Zabinsky, and J. Lawarree. 2004. *Optimization Techniques for Available Transfer Capability and Market Calculations*. Special Issue for IMA Series on Management Mathematics. Eds. R. Irving and Y. Song, 15:321–37. Oxford University Press.
- Li, H., G. Rosenwald, J. Jung, and C. C. Liu. 2004. Strategic power infrastructure defense. Invited for publication in *Proceedings of the IEEE* (Guest Ed., M. Amin).
- Chan, T., C. C. Liu, D. Lucarella, M. Gallanti, D. Sobajic, and M. Hofmann. 2003. Intelligent alarm analysis: Generalization and enhancement. *Int. J. Engineering Intelligent Systems*, selected by Int. Symp. Intelligent System Applications to Power Systems, Lemnos, Greece.

Yao Ma
ASSISTANT PROFESSOR



PhD, Electrical and Computer Engineering, National University of Singapore (2000)
MS, Electrical and Computer Engineering, University of Science and Technology of China, China (1996)
BE, Electrical Engineering and Information Science, Anhui University, China (1993)

RESEARCH INTERESTS:
Digital communication over fading channels, estimation and multiuser detection, adaptive filtering, MIMO systems, UWB communication

CORE AREAS: Communications, control, signals

STRATEGIC PLAN AREA:
Distributed sensing/decision making

PUBLICATIONS
- Ma, Y., Z. Wang, and S. Pasupathy. Accepted. Asymptotic performance of hybrid-selection/maximal-ratio combining over fading channels. *IEEE Transactions on Communications*.
- Ma, Y., R. Schober, and D. Zhang. Accepted. Exact BER of M-QAM with MRC and imperfect channel estimation in Rician fading channels. *IEEE Transactions on Wireless Communications*.
- Ma, Y., R. Schober, S. Pasupathy, and T. J. Lim. 2006. Efficient BER evaluation of linear multiuser detectors with imperfect channel estimation for CDMA fading channels. *IEEE Transactions on Communications* (February).
- Ma, Y., R. Schober, and S. Pasupathy. 2005. Effect of channel estimation errors on MRC diversity in Rician fading channels. *IEEE Trans. Vehicular Technology* (November): 2137–42.
- Schober, R., Y. Ma, L. Lampe, and T. Mathiopoulos. 2005. Diversity combining for coherent and differential M-PSK in fading and class-A impulsive noise. *IEEE Trans. Wireless Communications* (July).

James McCalley
PROFESSOR

PhD, Electrical Engineering, Georgia Institute of Technology (1992)
MS, Electrical Engineering, Georgia Institute of Technology (1986)
BS, Electrical Engineering, Georgia Institute of Technology (1982)

RESEARCH INTERESTS:
Operational decision making, security assessment, power system dynamics, asset management, integrated energy systems, multiagent system applications

CORE AREA: Electric power systems

STRATEGIC PLAN AREA:
Energy infrastructure

PUBLICATIONS
- Chen, Q., and J. McCalley. 2005. Identifying high-risk N-k contingencies for on-line security assessment. *IEEE Transactions on Power Systems* 20 (2, May): 823–34.
- Chen, Q., and J. McCalley. 2004. A cluster distribution as a model for estimating high-order event probabilities in power systems. In *8th International Conference on Probabilistic Methods Applied to Power Systems*. 12–16 September (first prize as best student-authored paper). Also in *Journal of Probability in the Engineering and Informational Sciences*.
- Ni, M., J. McCalley, V. Vittal, S. Greene, C. Ten, V. Gangula, and T. Tayyib. 2003. Software implementation of on-line risk-based security assessment. *IEEE Transactions on Power Systems* 18 (3, August): 1165–72.
- Ni, M., J. McCalley, V. Vittal, and T. Tayyib. 2003. On-line risk-based security assessment. *IEEE Transactions on Power Systems* 18 (1, February): 258–65.
- Quelhas, A., E. Gil, and J. McCalley. Nodal prices in an integrated energy system: A generalized network flow model. *International Journal of Critical Infrastructures* 2 (1).

Mani Mina
SENIOR LECTURER

PhD, Electrical Engineering, Iowa State University (1989)
MS, Electrical Engineering, Iowa State University (1987)

MS, Physics, Iowa State University (1985)
BS, Physics, Iowa State University (1982)

RESEARCH INTERESTS:
High speed measurement, electromagnetics, education

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA:
Small-scale technologies

PUBLICATIONS

- Gerdes, R., T. Daniels, M. Mina, and S. Russell. 2006. Device identification via analog signal fingerprinting: A matched filter approach. In *The 13th Annual Network and Distributed System Security Symposium*. 2–3 February, San Diego, California.
- Bahuguna, R., M. Mina, and W. Weber. 2005. Novel all fiber magneto-optic on-off switch. In *SPIE 50th Annual Meeting, Optical and Photonic 2005*. 31 July–4 August, San Diego, California.
- Mina, M., R. Weber, and R. Bahuguna. 2005. High speed systems engineering: Measurement and testing. In *2005 ASEE Annual Conference and Exposition*. July, Portland, Oregon.
- Mina, M., R. Weber, A. K. Somani, N. VanderHorn, and R. Bahuguna. 2005. High speed systems engineering: A new approach in electrical and computer engineering. In *2005 ASEE Annual Conference and Exposition*. July, Portland, Oregon.
- Legg, R., M. Tekippe, K. S. Athreya, and M. Mina. 2005. Solving multidimensional problems through a new perspective: The integration of design for sustainability and engineering education. In *2005 ASEE Annual Conference and Exposition*. July, Portland, Oregon.
- Jackson, E. A., and M. Mina. 2005. Designing a sustainable and dynamic problem-solving class for first-year engineering students. In *2005 ASEE Annual Conference and Exposition*. July, Portland, Oregon.

Tien Nguyen
ASSISTANT PROFESSOR

PhD, Computer Science, University of Wisconsin (2005)
Pre-doctorate, Computer Science, Swiss Federal Institute of Technology (1998)
BSc, Computer Science, Ho Chi Minh City University of Technology, Vietnam (1995)

RESEARCH INTERESTS:
Capturing the simulation-related semantics in the management system, providing a repository with multidimensional version control, defining capabilities to query the repository and search for files of interest, enabling automated manipulations of files, identifying relationships with similar problems (e.g., product families, XML document management, etc.)

CORE AREA: Secure software engineering

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Tien, N. 2005. Multi-level configuration management with fine-grained units. Paper presented at *31st IEEE/Euromicro International Conference on Software Engineering and Advanced Applications* (SEAA 2005).
- Tien, N. 2005. On product versioning for hypertexts. Paper presented at *12th ACM International Workshop on Software Configuration Management* (SCM-12), 1–6 September, Porto and Lisbon, Portugal.
- Tien, N. 2005. Managing the evolution of Web-based applications with WebSCM. Paper presented at *21st IEEE International Conference on Software Maintenance* (ICSM 2005), 29 September, Budapest, Hungary.

Santosh Pandey
ASSISTANT PROFESSOR

PhD, Electrical Engineering, Lehigh University (2006)
MS, Electrical Engineering, Lehigh University (2001)
BTech, Electrical Engineering, Indian Institute of Technology, Kharagpur (1999)

RESEARCH INTERESTS:
Bioelectronics, sensors, bioMEMS, devices, VLSI circuits

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA:
Bioengineering

PUBLICATIONS

- Pandey, S., and M. H. White. Accepted. A novel CMOS integrated amplifier for sensing single ion-channel current in biological cells. In *International Semiconductor Device Research Symposium*. 7–9 December (2005).
- Pandey, S., A. Bortei-Doku, and M. H. White. Accepted. Simulation of biological ion channels as solid-state nanodevices. *Computer Methods and Programs in Biomedicine*. May (2005).
- Pandey, S., and M. H. White. 2004. Detection of dielectrophoretic driven passage of single cells through micro-apertures in a silicon nitride membrane. In *26th International Conference of IEEE Engr. in Medicine and Biology Society*. September.
- Pandey, S., R. Mehrotra, S. Wykosky, and M .H. White. 2004. Characterization of a MEMS biochip for planar patch-clamp recording. *Solid State Electronics* 48:2061–6.
- Pandey, S., and M. H. White. 2002. Parameter-extraction of a two-compartment model for whole-cell data analysis. *Journal of Neuroscience Methods* 120:131–43.
- Pandey, S., and S. Kal. 1998. A simple approach to the capacitance technique for the determination of interface state density of MIS diodes. *Solid State Electronics* (June): 943–9.

Ralph E. Patterson
ASSISTANT PROFESSOR

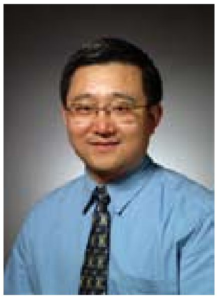
MS, Electrical Engineering, Iowa State University (1976)
BS, Electrical Engineering, Iowa State University (1963)

RESEARCH INTEREST: Energy systems

CORE AREAS: Communications, control, signals

STRATEGIC AREA: Distributed sensing and decision making

Daji Qiao
ASSISTANT PROFESSOR



PhD, Electrical Engineering, University of Michigan (2004)

RESEARCH INTERESTS:
Modeling, analysis, and protocols/algorithms design for wireless local area networks, for wireless sensor networks, and for wireless mesh networks

CORE AREA: Computing and networking systems

STRATEGIC PLAN AREA:
Distributed sensing/decision making

PUBLICATIONS
- Qiao, D., and S. Choi. 2005. Fast-responsive link adaptation for IEEE 802.11 wireless LANs. In *Proc. IEEE ICC'2005*. 16–25 May, Seoul, Korea.
- Qiao, D., and K. G. Shin. 2005. Smart power-saving mode for IEEE 802.11 wireless LANs. In *Proc. IEEE INFOCOM'2005*. 13–17 March, Miami, Florida.
- Mo, W., D. Qiao, and Z. Wang. 2005. Mostly sleeping wireless sensor networks: Connectivity, k-coverage and α-lifetime. In *Proc. the 43rd Annual Allerton Conference on Communication, Control, and Computing*. 28–30 September, Monticello, Illinois.
- Qiao, D., S. Choi, A. Jain, and K. G. Shin. 2003. MiSer: An optimal low-energy transmission strategy for IEEE 802.11 a/h. In *Proc. ACM MobiCom'2003*. 14–19 September, San Diego, California.
- Qiao, D., S. Choi, and K. G. Shin. 2002. Goodput analysis and link adaptation for IEEE 802.11a wireless LANs. *IEEE Transactions on Mobile Computing* (TMC) 1 (4, October-December).

Aditya Ramamoorthy
ASSISTANT PROFESSOR

PhD, Electrical Engineering, University of California, Los Angeles (2005)
MS, Electrical Engineering, University of California, Los Angeles (2002)
BTech, Electrical Engineering, Indian Institute of Technology, Delhi (1999)

RESEARCH INTERESTS:
Network information theory, sensor networks, error control coding with an emphasis on iterative coding techniques and applications in data storage and wireless communications

CORE AREA: Communications and signal processing

STRATEGIC PLAN AREAS:
Distributed sensing, decision making

PUBLICATIONS
- Ramamoorthy, A., K. Jain, P. A. Chou, and M. Effros. In press. Separating distributed source coding from network coding. In *IEEE Transactions on Information Theory*.
- Kim, J., A. Ramamoorthy, and S. W. McLaughlin. 2006. Design of efficiently-encodable rate-compatible irregular LDPC codes. In *IEEE Proceedings of the Intl. Conf. on Comm.*
- Ramamoorthy, A., J. Shi, and R. D. Wesel. 2005. On the capacity of network coding for random networks. In *IEEE Transactions on Information Theory* 51 (8): 2878–85.
- Ramamoorthy, A., and R. D. Wesel. 2004. Construction of short block length irregular LDPC codes. In *IEEE Proceedings of the Intl. Conf. on Comm.*
- Somasundara, A. A., A. Ramamoorthy, and M. B. Srivastava. 2004. Mobile element scheduling for efficient data collection in wireless sensor networks with dynamic deadlines. In *IEEE Proceedings of the Real-Time Systems Symposium*.

Diane Rover
ASSOCIATE DEAN, COLLEGE OF ENGINEERING
PROFESSOR

PhD, Computer Engineering, Iowa State University (1989)
MS, Computer Engineering, Iowa State University (1986)
BS, Computer Science, Iowa State University (1984)

RESEARCH INTERESTS:
Embedded systems, performance evaluation, education

CORE AREAS: Secure and reliable computing, software systems

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Santiago, N. G., D. T. Rover, and D. Rodriguez. 2006. A statistical approach for the analysis of the relation between low-level performance information, the code, and the environment. Special Issue of *Journal of Information* 9 (2). Ed. L. Yang.
- Mina, M., A. Somani, A. Tyagi, D. Rover, M. Feldmann, and M. Shelley. 2005. Learning streams: A case study in curriculum integration. In *Proc. 35th ASEE/IEEE Frontiers in Education Conference*. October.
- Lee, K., and D. Rover. 2005. A Web services and ontology-based performance visualization framework for grid environments. In *Proc. 2005 IEEE Intl. Conf. on Cluster Computing*. September.
- Schneider, J., M. Bezdek, Zi. Zhang, Zh. Zhang, and D. Rover. 2005. A platform FPGA-based hardware-software undergraduate laboratory. In *Proc. IEEE CS Int'l Conference on Microelectronic Systems Education*. June.
- Faidley, G., J. Hero, K. Lee, B. Lwakabamba, R. Walstrom, F. Chen, J. Dickerson, D. Rover, R. Weber, and C. Cruz-Neira. 2004. Developing an integrated wireless system for fully immersive virtual reality environments. In *Proc. Int. Symposium on Wearable Computers*, 178–9. October.

Steve F. Russell
ASSOCIATE PROFESSOR

PhD, Electrical Engineering, Iowa State University (1978)
MS, Electrical Engineering, Iowa State University (1973)
BS, Electrical Engineering, Montana State University (1966)

RESEARCH INTERESTS: Lewis and Clark Trail, wireless security

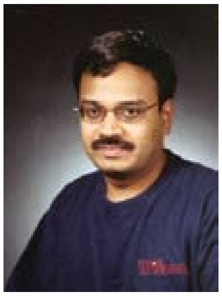
CORE AREA: Secure and reliable computing

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Russell, S. F. In press. *Lewis and Clark Across the Mountains*. Boise, Idaho: Idaho State Historical Society.
- Russell, S. F. 2005. *Lewis and Clark Lolo Trail Precision Survey*. Ames, Iowa: Historic Trails Press.
- Aegerter, M., and S. F. Russell. 2002. *Hike Lewis and Clark's Idaho*. Moscow, Idaho: University of Idaho Press.
- Fazio, J. R., M. Venso, and S. F. Russell. 2001. *Across the Snowy Ranges*. Moscow, Idaho: Woodland Press.
- Russell, S. F. 2000. The riddle of Hungery Creek, September 18–20, 1805, and June 16, 18, 25, 1806. *Idaho Yesterdays, Journal of the Idaho State Historical Society* 44 (1): 19–31.

Murti Salapaka
ASSOCIATE PROFESSOR



PhD, Mechanical Engineering, University of California, Santa Barbara (1997)
MS, Mechanical Engineering, University of California, Santa Barbara (1993)
BTech, Mechanical Engineering, Indian Institute of Technology (1991)

RESEARCH INTERESTS: Robust control, dynamical systems, nanotechnology, scanning probe microscopy, control of molecular systems

CORE AREAS: Controls and dynamical systems

STRATEGIC PLAN AREAS: Small-scale technologies, distributed sensing and decision making, bioengineering

PUBLICATIONS

- Gannepalli, A., A. Sebastian, J. Cleveland, and M. V. Salapaka. 2005. Thermally driven non-contact atomic force microscopy. *Applied Physics Letters* 87 (11): 111901.
- Sahoo(s), D., A. Sebastian, and M. V. Salapaka. 2003. Transient signal based sample-detection in atomic force microscopy. *Applied Physics Letters* 83 (26, December): 5521–3.
- Salapaka(s), S., A. Sebastian, J. P. Cleveland, and M. V. Salapaka. 2002. High bandwidth nano-positioner: A robust control approach. *Review of Scientific Instruments* 73 (9, September): 3232–41.
- Sebastian, A., M. V. Salapaka, D. J. Chen, and J. P. Cleveland. 2001. Harmonic and power balance tools for tapping—mode AFM. *Journal of Applied Physics* 89:6473–80.
- Salapaka, M. V., H. S. Bergh, J. Lai, A. Majumdar, and E. McFarland. 1997. Multimode noise analysis of cantilevers for scanning probe microscopy. *Journal of Applied Physics* 81 (6, March): 2480–7.

Arun K. Somani
CHAIR, DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
JERRY R. JUNKINS CHAIR PROFESSOR

PhD, Electrical Engineering, McGill University, Montreal, Canada (1985)
MS, Electrical Engineering, McGill University, Montreal, Canada (1983)
MTech, Computer Engineering, Indian Institute of Technology (1979)
BE, Electrical Engineering, BITS, Pilani (1973)

RESEARCH INTERESTS:
Optical fiber networking, computer system architecture, dependable computing

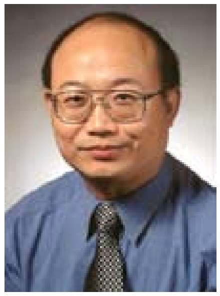
CORE AREA: Computing and networking systems

STRATEGIC AREA: Cyber infrastructure

PUBLICATIONS

- Wu, T., and A. K. Somani. 2005. Cross-talk attack monitoring and localization in all-optical networks. *IEEE/ACM Transactions on Networking* 13 (6, December): 1390–401.
- VanderHorn, N., S. Balasubramanian, M. Mina, and A. K. Somani. 2005. Light-trail test bed for IP-centric applications. *IEEE Communications Magazine*, special issue on *Optical Networking Testbeds: Experiences, Challenges and Future Directions* (August): 11–6.
- Sangireddy, R., H. Kim, and A. K. Somani. 2004. Low power high performance reconfigurable computing cache architectures. *IEEE Transactions on Computers* 53 (10, October): 1274–90.
- Ramasubramanian, S., and A. K. Somani. 2004. Analysis of optical networks with heterogeneous grooming architectures. *IEEE/ACM Transactions on Networking* 12 (5, October): 931–43.
- Somani, A. K., M. Mina, and L. Li. 2004. On trading wavelengths with fibers: A cost-performance based study. *IEEE/ACM Transactions on Networking* 12 (5, October): 944–51.

Jiming Song
ASSISTANT PROFESSOR



PhD, Electrical Engineering, Michigan State University (1993)
MS, Physics, Nanjing University, China (1988)
BS, Physics, Nanjing University, China (1983)

RESEARCH INTERESTS:
Fast and efficient algorithms in computational electromagnetics, modeling of VLSI interconnects on silicon and signal integrity, large-scale and parallel computation, inverse scattering and nondestructive evaluation, electromagnetic wave propagation and scattering, antenna analysis and design

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA:
Small-scale technologies

PUBLICATIONS

- Zhang, L., and J. M. Song. 2006. Comparison between different models for the thin metallic substrate in multilayer microstrip structures. *Micro. Opt. Tech. Lett*. 48 (6, June): 1113–7.
- Lloyd, T. W., J. M. Song, and M. Yang. 2005. Numerical study of surface integral formulations for low-contrast objects. *IEEE Antennas Wireless Propagation Lett*. 4:482–5.
- Velamparambil, S., W. C. Chew, and J. M. Song. 2003. 10 million unknowns, is it that big. *IEEE Antenna Propag. Mag*. 45 (2, April): 43–58.
- Song, J. M., and W. C. Chew. 2001. FMM and MLFMA in 3D and Fast Illinois Solver Code. Chapter 3 in *Fast and Efficient Algorithms in Computational Electromagnetics*. Ed. Chew, Jin, Michielssen, and Song. Artech House.
- Song, J. M., C.-C. Lu, and W. C. Chew. 1997. MLFMA for electromagnetic scattering by large complex objects. *IEEE Trans. Antenna Propag*. 45 (10, October): 1488–93.

Srikanta Tirthapura
ASSISTANT PROFESSOR

PhD, Computer Science, Brown University (2002)
ScM, Computer Science, Brown University (1998)
BTech, Computer Science and Engineering, Indian Institute of Technology, Madras (1996)

RESEARCH INTERESTS:
Distributed data processing, distributed coordination in wired and wireless networks

CORE AREAS: Algorithms, networking

STRATEGIC PLAN AREA:
Distributed sensing/decision making

PUBLICATIONS:

- Busch, C., and S. Tirthapura. In press. Analysis of link reversal routing algorithms. *SIAM Journal on Computing.*
- Herlihy, M., and S. Tirthapura. In press. Randomized smoothing networks. *Journal of Parallel and Distributed Computing*.
- Tirthapura, S. In press. Analysis of link reversal algorithms. *SIAM Journal on Computing*.
- Tirthapura, S. 2005. Adaptive counting networks. In *Proc. IEEE International Conference on Distributed Computing Systems* (ICDCS).
- Aduri, P., and S. Tirthapura. 2005. Range-efficient computation of F_0 over massive data streams. In *Proc. IEEE International Conference on Data Engineering* (ICDE), 32–43.
- Tirthapura, S. 2005. Range-efficient computation of F0 over a data stream. In *Proceedings of the International Conference on Data Engineering* (ICDE).

Gary L. Tuttle
ASSOCIATE PROFESSOR

PhD, Electrical Engineering, University of California, Santa Barbara (1991)
MS, Electrical Engineering, Iowa State University (1985)

BS, Electrical Engineering, Iowa State University (1983)

RESEARCH INTERESTS: Microelectronics, photonic bandgap devices

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA: Small scale technologies

PUBLICATIONS

- Moussa, R., S. Foteinopoulou, L. Zhang, G. Tuttle, K. Guven, E. Ozbay, and C. M. Soukoulis. 2005. Negative refraction and superlens behavior in a two-dimensional photonic crystal. *Physical Review B* 71:085106.
- Zhang, L., G. Tuttle, and C. M. Soukoulis. 2004. GHz magnetic response of split-ring resonators, *Photonics and Nanostructures—Fundamentals and Applications* 2 (2): 155–9.
- Sell, C., C. Christensen, J. Muehlmeier, G. Tuttle, Z.-Y. Li, and K.-M. Ho. 2004. Integrated horns for improved coupling into in-plane three-dimensional photonic crystals. *Applied Physics Letters* 85 (5): 707–9.
- Sell, C., C. Christensen, J. Muehlmeier, G. Tuttle, Z.-Y. Li, and K.-M. Ho. 2004. Waveguide networks in three-dimensional layer-by-layer photonic crystals. *Applied Physics Letters* 84 (23): 4605–7.
- Oliver, B., G. Tuttle, Q. He, X. F. Tang, and J. Nowak. 2004. Two breakdown mechanisms in ultrathin alumina barrier magnetic tunnel junctions. *Journal of Applied Physics* 95 (3): 1315–22.

Akhilesh Tyagi
ASSOCIATE PROFESSOR

PhD, Computer Science, University of Washington (1988)
MTech, Computer Engineering, Indian Institute of Technology (1983)
BTech, Electrical Engineering, Birla Institute of Technology and Science, Pilani (1981)

RESEARCH INTERESTS: Computer architecture, compiler backends, VLSI design and CAD with respect to secure and trusted computing platforms

CORE AREA: Computer and network systems architecture

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Mahadevan, G., and A. Tyagi. 2006. Architecture support for 3D obfuscation. *IEEE Transactions on Computers* 55 (5, May): 497–507.
- Tyagi, A. 2005. Energy privacy trade-offs in VLSI computations. In *Proceedings of INDOCRYPT 2005*, Lecture Notes in Computer Science #3797, 361–74. December. Springer-Verlag.
- Ge, J., S. Chaudhuri, and A. Tyagi. 2005. Control flow based obfuscation. In *Proceedings of ACM International Workshop on DRM*, 83–92. ACM Press.
- Blietz, B., and A. Tyagi. 2005. Software tamper resistance through dynamic program monitoring. In *Proceedings of First International Conference on DRM (DRMTICS*), LNCS #3919, 146–63. Springer Verlag.
- Ramarao, P., and A. Tyagi. 2005. An integrated partitioning and scheduling based branch decoupling. In *Proceedings of ACSAC 2005*, LNCS 3740, 252–68. Springer-Verlag.

Umesh Vaidya
ASSISTANT PROFESSOR

PhD, Mechanical Engineering, University of California, Santa Barbara (2004)
MTech, Systems and Control Engineering, Indian Institute of Technology, Bombay, India (1999)
BE, Electrical Engineering, Victoria Jubilee Technical Institute, Mumbai, India (1997)

RESEARCH INTERESTS: Transport in three-dimensional volume-preserving maps, KAM for three-dimensional measure preserving maps, mixing in microfluidic devices, uncertainty analysis using dynamical systems approach, controllability of Hamiltonian systems

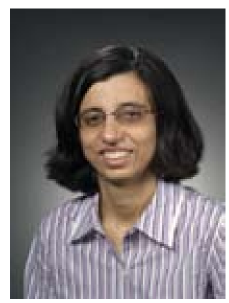
CORE AREA: Control and dynamical systems

STRATEGIC PLAN AREA: Distributed sensing/decision making

PUBLICATIONS

- Vaidya, U., and I. Mezic. 2004. Controllability for a class of area-preserving twist maps. *Physica D* 189:234–46.
- Ananthkrishnan, N., U. Vaidya, and V. Walimbe. 2003. Global stability and control analysis of axial compressor stall and surge phenomena using bifurcation methods. In *Proceedings of the IMECH E Part A, Journal of Power and Energy* 217 (June): 279–86.

Namrata Vaswani
ASSISTANT PROFESSOR



PhD, Electrical and Computer Engineering, University of Maryland (2004)
BTech, Electrical Engineering, Indian Institute of Technology, Delhi (1999)

RESEARCH INTERESTS: Statistical signal processing for computer vision, biomedical image analysis, and neural signal processing problems

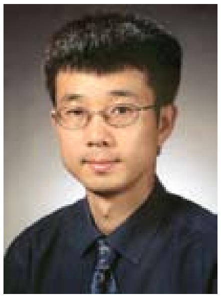
CORE AREAS: Developing particle filtering algorithms for tracking and change detection in state space models, with applications in visual tracking, abnormal activity detection, and medical image segmentation

STRATEGIC PLAN AREA: Bioengineering

PUBLICATIONS

- Vaswani, N., and R. Chellappa. In press. Principal component null space analysis for image and video classification. *IEEE Transactions on Image Processing*.
- Vaswani, N., and R. Chellappa. In press. Nonstationary shape activities. In *Proc. of IEEE Conf. on Decision and Control (CDC)*.
- Vaswani, N., A. RoyChowdhury, and R. Chellappa. 2005. Shape activity: A continuous state HMM for moving/deforming shapes with application to abnormal activity detection. *IEEE Trans. on Image Processing* (October): 1603–16.
- Rathi, Y., N. Vaswani , A. Tannenbaum, and A. Yezzi. 2005. Particle filtering for geometric active contours and application to tracking deforming objects. In *Proc. of IEEE Intl. Conference on Computer Vision and Pattern Recognition (CVPR)*.
- Vaswani, N. 2005. The modified CUSUM algorithm for slow and drastic change detection in general HMMs with unknown change parameters. In *Proc. of IEEE Intl. Conference on Acoustics, Speech and Signal Processing (ICASSP)*.

Zhengdao Wang
ASSISTANT PROFESSOR



PhD, Electrical Engineering, University of Minnesota (2002)
MSc, Electrical Engineering, University of Virginia (1999)
BE, Electrical Engineering and Information Science, University of Science and Technology of China (1996)

RESEARCH INTERESTS: Signal processing, communications, information theory

CORE AREAS: Communications, control, signals

STRATEGIC PLAN AREA: Distributed sensing/decision making

PUBLICATIONS

- Mo, W., Z. Wang, and A. Dogandzic. In press. An iterative receiver for coded MIMO system in unknown spatially colored noise. *Wiley's Wireless Communications and Mobile Computing*.
- Mo, W., D. Qiao, and Z. Wang. 2005. Mostly-sleeping wireless sensor networks: Connectivity, k-coverage, and alpha-lifetime. In *The 43rd Allerton Conference*.
- Wang, Z., and X. Yang. 2005. Blind channel estimation for ultra wide-band communications employing pulse position modulation. *IEEE Signal Processing Lett.* 12 (7, July): 520–3.
- Wang, Z., S. Zhou, and G. B. Giannakis. 2004. Joint coding-precoding with low-complexity turbo-decoding. *IEEE Trans. Wireless Commun.* 3 (3, May): 832–42.
- Wang, Z., and G. B. Giannakis. 2004. Outage mutual information rate of space-time MIMO channels. *IEEE Trans. Inform. Theory* 50 (4, April): 657–62.

Robert J. Weber
DAVID C. NICHOLAS PROFESSOR

PhD, Electrical Engineering, Iowa State University (1967)
MS, Electrical Engineering, Iowa State University (1966)
BS, Electrical Engineering, Iowa State University (1963)

RESEARCH INTERESTS: Electromagnetics, microwave circuits and systems, MEMS, electro optics

CORE AREA: Advanced electronics and materials

STRATEGIC PLAN AREA: Bioengineering

PUBLICATIONS

- Mina, M., R. Weber, and R. Bahuguna. 2005. High speed measurement and testing. In *2005 ASEE Annual Conference and Exposition*. July, Portland, Oregon.
- Wang, X., and R. Weber. 2005. Low voltage low power SiGe BiCMOS X-band LNA design and its comparison study with IEEE 802.11a LNA design. In *2005 IEEE International Radar Conference (RADAR 2005)*.
- CP760. 2005. *Review of Quantitative Nondestructive Evaluation.* Ed. D. O. Thompson and D. E. Chimenti, 24:1523–30. American Institute of Physics.
- Weber, R. J. 2005. Characterization of dielectric and magnetic properties of powdered materials such as powdered coal. In *Review of Progress in Quantitative NDE*, 431–8. American Institute of Physics. (Larger version of conference paper at Bowdoin College, Brunswick, Maine, 31 July–5 August.)
- Reid, M. S., B. Graubard, B. Reed, R. J. Weber, and J. A. Dickerson. 2005. Wireless eddy current probe for engine health monitoring (phase II). In *Review of Progress in Quantitative NDE*, 461–8. American Institute of Physics. (Also was a conference paper at Bowdoin College, Brunswick, Maine, 31 July–5 August.)
- Chan, K.-S., R. J. Weber, and R. C. Brown. 2004. Characterization of unburned carbon content in coal fly ash with dielectric constant measurement. In *Review of Progress in Quantitative NDE*. 25–30 July, Colorado School of Mines, Golden, Colorado.

Joseph Zambreno
ASSISTANT PROFESSOR

PhD, Computer Engineering, Northwestern University (2006)
MS, Computer Engineering, Northwestern University (2002)
BS, Computer Engineering, Northwestern University (2001)

RESEARCH INTERESTS: Reconfigurable computing, computer security, compilers, computer architecture

CORE AREA: Computing and networking systems

STRATEGIC PLAN AREAS: Cyber infrastructure, pervasive computing

PUBLICATIONS

- Zambreno, J., D. Honbo, A. Choudhary, R. Simha, and B. Narahari. 2006. High-performance software protection using reconfigurable architectures. In *Proceedings of the IEEE* 94 (2, February): 1–13.
- Zambreno, J., B. Ozisikyilmaz, J. Pisharath, G. Memik, and A. Choudhary. 2006. Performance characterization of data mining applications using MineBench. In *Proceedings of the 9th Workshop on Computer Architecture Evaluation Using Commercial Workloads (CAECW-9)* (February).
- Zambreno, J., A. Choudhary, R. Simha, B. Narahari, and N. Memon. 2005. SAFE-OPS: An approach to embedded software security. *ACM Transactions on Embedded Computing Systems (TECS)* 4 (1, February): 189–210.
- Zambreno, J., D. Nguyen, and A. Choudhary. 2004. Exploring area/delay tradeoffs in an AES FPGA implementation. In *Proceedings of the 14th International Conference on Field-Programmable Logic and its Applications (FPL '04)* (August).
- Zambreno, J., A. Choudhary, R. Simha, and B. Narahari. 2004. Flexible software protection using hardware/software codesign techniques. In *Proceedings of Design, Automation, and Test in Europe (DATE '04)* (February).

Zhao Zhang
ASSISTANT PROFESSOR

PhD, Computer Science, College of William and Mary (2002)
MS, Computer Science, Huazhong University of Science and Technology (1994)
BS, Computer Science, Huazhong University of Science and Technology (1991)

RESEARCH INTERESTS: Computer architecture, high-performance computing, computer security

CORE AREA: Computing and networking systems

STRATEGIC PLAN AREA: Cyber infrastructure

PUBLICATIONS

- Park, Y.-J., Z. Zhang, and G. Lee. 2006. Microarchitectural protection against stack-based buffer overflow attacks. *IEEE Micro* 26 (4, July/August): 62–71.
- Wu, M.-S., R. A. Kendall, Z. Zhang, and K. Wright. 2005. Performance modeling and tuning strategies of mixed mode collective communications. In *Proceedings of Supercomputing*. November, Seattle, Washington.
- Zhu, Z., and Z. Zhang. 2005. A performance comparison of DRAM memory system optimizations for SMT processors. In *Proceedings of the 11th International Symposium on High Performance Computer Architecture (HPCA-11)*. February, San Francisco, California.
- Zhang, Z., Z. Zhu, and X. Zhang. 2004. Design and optimization of large size and low overhead off-chip caches. *IEEE Transactions on Computers 53*(7, July): 843–55.
- Zhu, Z., Z. Zhang, and X. Zhang. 2002. Fine-grain priority scheduling on multi-channelmemory systems. In *Proceedings of the 8th International Symposium on High Performance Computer Architecture (HPCA-8)*. February, Cambridge, Massachusetts.

Faculty Honors and Awards

Ajjarapu, Ventakaramana
Chairperson, IEEE Voltage Stability Focus Group
IEEE Award for Edited Books on Voltage Stability (2005)
IEEE Award for Outstanding Performance as a Reviewer (2006)
Editor, *IEEE Power Engineering Letters*

Aluru, Srinivas
IEEE Computer Society Distinguished Visitor (2004–2006)
NSF CAREER Award (1997–2002)
IBM Faculty Award (2002)
Program Vice-Chair, IEEE HiPC (2006)
Tutorial Chair, IEEE HiPC (2002–2005)
Guest Co-Editor, *Journal of Parallel and Distributed Computing* (2003)

Bowler, John
International Research Collaborator Award from The Technical Cooperation Panel

Chang, Morris
Area Editor, *IEEE Wireless Networks and Middleware Magazine* (2004–)
Guest Editor, *Journal of Microprocessors and Microsystems* (2005)

Dalal, Vikram
Micron Faculty Fellowship for Excellence (2002–2006)
IEEE-EDS Distinguished Lecturer (2004)

Daniels, Tom
General Chair, Computer Network Forensics Workshop (2005)

Davis, James
Member Editorial Board, *International Journal of Information and Computer Security* (2004–)
Member Editorial Board, *IEEE Security & Privacy* (2003–2005)

Dogandzic, Aleksandar
NSF Career Award (2006)
IEEE Signal Processing Society: Young Author Best Paper Award (2003)
Best Paper Award (2004) *Signal Processing Magazine*

Elia, Nicola
NSF Career Award (2001–2006)

Geiger, Randy
Member, IEEE Fellow Committee (2005–)
IEEE Circuits and Systems Society Golden Jubilee Medal (2000)
IEEE Millennium Medal (2000)

Govindarasu, Manimaran
Workshops Chair, IEEE SecureComm Workshops (2005, 2006)
Workshops Chair, IEEE International Conference on High Performance Computing (2006)
Workshop Co-Chair, IEEE WPDRTS: Steering Committee (2006), General Chair (2004)
Member Editorial Board, *International Journal of Embedded Systems* (2005–)

Guan, Yong
Keynote Speaker, Symposium on Computer Forensics (2004)

Jacobson, Doug
R&D 100 Awards (2001, 2003)

Jiles, David
United Kingdom's Royal Society Ewing Lecturer (2005)

Kamal, Ahmed
Area Editor, *Elsevier Computer Networks* (2005–)

Kim, Sang
Associate Editor, *IEEE Communications Letters* (2005–)

Kumar, Ratnesh
Associate Editor, *Journal of Discrete Event Dynamical Systems* (2005–)
Associate Editor, *SIAM Journal on Control and Optimization* (1999–)
Associate Editor, *IEEE Transactions on Robotics and Automation*, (2000–2002)
Associate Editor, *IEEE Conference on Decision and Control* (1996–)
Associate Editor, *American Control Conference* (1996–)

Kushner, Mark
Editorial Board, *Journal of Physics D* (2003–)
Associate Editor, *Journal of Physics D* (2005–)
Editorial Board, *Plasma Chemistry and Plasma Processing* (2005–2008)
International Advisory Board, *Plasma Processes and Polymers* (2004–2009)
Associate Editor, *IEEE Transactions on Plasma Science* (1989–)
Editorial Board, *Plasma Sources, Science and Technology* (1993–)

Liu, Chen-Ching
IEEE Third Millennium Medal (2000)
IEEE Power Engineering Society Outstanding Power Engineering Educator (2004)
Member, Board of Directors, Washington Technology Center, State of Washington (2002–2006)
IEEE Power Engineering Society, Technical Committee Distinguished Service Award (2002)
Editor, *IEE Proceedings—Generation, Transmission and Distribution*, UK (2005–)
Editor, *IEE Japan International Journal Engineering Intelligent Systems* (2005–)

Ma, Yao
Associate Editor, *IEEE Transactions on Vehicular Technology* (2004–)
Editor, *IEEE Transactions on Wireless Communications* (2006–)

McCalley, Jim

Editor-in-Chief, *IEEE Power Engineering Society Letters* (2005–)
Chair, IEEE Power Engineering Society Risk, Reliability and Probability Applications (2004)

Oliver, Jim

Associate Editor, *ASME's Journal of Computing and Information Science in Engineering* (2005–2008)

Rover, Diane

IEEE Committee on Engineering Accreditation Activities (CEAA)
Member-At-Large, NAE Engineering Education Leadership Institute, resource person (2006)
Senior Associate Editor (Bookshelf), *ASEE Journal of Engineering Education* (2000–)

Salapaka, Murti

NSF Career Award (1998–2003)
Atomic force microscopy research highlighted in *Nature* (September 22, 2005)
Associate Editor, *IEEE Conference on Decision and Control* (2004–)
Associate Editor, *American Control Conference* (2004–)

Somani, Arun

Keynote Speaker, ONDM-2005, Milan, Italy (February 7, 2005)
Keynote Speaker, PDCS 2005, Dallas (November 14, 2005)
Distinguished Lecture, University of Texas, Dallas (January 27, 2006)
Coordinator, NSF-EU Workshop on Future of Optical Networking, Brussels (June 2005)
Editor, *Elsevier Microprocessor and Microsystems Journal* (1996–2006)
Area Editor, *Elsevier Computer Networks Journal* (2003–)
Associate Editor, *Elsevier Optical Switching/Networking* (2004–)
Program Chair, SPIE Optical Communication Conference (2003)
General Chair, IEEE/ACM/Creatnet BRODANETS (2005)
Associate Editor, *IEEE Transactions on Computers* (1997–2002)
Associate Editor, *IEEE/ACM Transactions on Networking* (2003–)

Song, Jiming

NSF Career Award (2006–)

Wang, Zhengdao

IEEE Marconi Paper Prize Award (2004)
IEEE *Signal Processing Magazine* Best Paper Award (2003)
Associate Editor, *IEEE Signal Processing Letters* (2005–)
Associate Editor, *IEEE Transactions on Vehicular Technology* (2004–)

ENDOWED CHAIRS AND PROFESSORSHIPS

David C. Nicholas Professorship
Robert Weber (2002–present)

Harpole Professorship
Open

Jerry R. Junkins Chair
Arun Somani (2002–present)

The Litton Industries Professorship
Manimaran Govindarasu (2004–05)
Aleksandar Dogandzic (2006–07)

Palmer Chair
Chen-Ching Liu (2006–present)

Richardson Professorship in Electrical and Computer Engineering
Randall Geiger (2002–present)

Sahai Professorship
Open

Thomas M. Whitney Professorship
Vikram Dalal (2002–present)

FELLOWS

American Association for the Advancement of Science
Edwin Jones, Emeritus Professor

American Physical Society
David Jiles, Collaborator
Mark Kushner
Joe Shinar, Adjunct Professor

American Society for Engineering Education
Robert Anderson, Emeritus Professor
Edwin Jones, Emeritus Professor

American Society for Nondestructive Testing
William Lord, Emeritus Professor

American Vacuum Society
Mark Kushner

British Institute of Non-Destructive Testing
William Lord, Emeritus Professor

Institute of Electrical and Electronics Engineers
Robert Anderson, Emeritus Professor
Robert Grover Brown, Emeritus Professor
Aziz Fouad, Emeritus Professor
Randall Geiger
David Jiles
Edwin Jones, Emeritus Professor
Mark Kushner
Chen-Ching Liu
William Lord, Emeritus Professor
James D. McCalley
James Melsa, Emeritus Professor
James Nilsson, Emeritus Professor
Arthur Pohm, Emeritus Professor
Gerald Sheblé, Emeritus Professor
Arun Somani
Satish Udpa, Collaborator
Subrahmanyam Venkata, Emeritus Professor
Vijay Vittal, Collaborator
Robert Weber

Institute of Electrical Engineers (UK)
David Jiles, Collaborator
William Lord, Emeritus Professor

International Union of Pure and Applied Chemistry
Mark Kushner

Japanese Society for Advancement of Science
Mark Kushner

Optical Society of America
Mark Kushner

EMERITUS FACULTY

Robert M. Anderson
John P. Basart
Paul R. Bond
Harrington C. Brearley, Jr.
William H. Brockman
R. Grover Brown
Wallace C. Caldwell
David L. Carlson
Larry B. Coady
Chester St. John Comstock
Glenn E. Fanslow
Aziz Fouad
Harry W. Hale
Richard E. Horton
Hsung-Cheng Hsieh
Edwin C. Jones, Jr.
J. O. Kopplin
William Lord
James Melsa
Morris H. Mericle
James W. Nilsson
John R. Pavlat
Arthur V. Pohm
Allan G. Potter
Alvin A. Read
Thomas M. Scott
Gerald B. Sheblé
Terry A. Smay
David T. Stephenson
Robert M. Stewart
Curran S. Swift
Charles L. Townsend
S. S. Venkata

COURTESY APPOINTMENTS

Virn Amin, Adjunct Assistant Professor (CNDE)
Rana Biswas, Adjunct Associate Professor (Ames Lab)
Brett Bode, Adjunct Assistant Professor (Ames Lab)
Carolina Cruz-Neira, Professor (IMSE)
Jennifer Davidson, Associate Professor (Math)
Brian Hornbuckle, Assistant Professor (Agronomy)
Glenn R. Luecke, Professor (Math)
James Oliver, Professor (Mechanical Engineering)
Dirk Reiners, Assistant Professor (Computer Science)
Joseph Shinar, Professor (Physics)

COLLABORATING FACULTY

Daniel Berleant, Associate Professor
David Jiles, Professor
Mustafa Khammash, Professor
Gyungho Lee, Professor
Gerald B. Sheblé, Professor
Lalita Udpa, Professor
Satish Udpa, Professor
Vijay Vittal, Professor

SUPPORT STAFF

ADMINISTRATIVE SUPPORT

Susana Alvarez, Administrative Specialist
Jean Bessman, Account Clerk
Karen Knight, Secretary
Charyl Winterink, Secretary
Tom Charles Baird, EPES Program Manager
Stephanie Drake-Zierke, EPES Account Clerk

COMPUTING SUPPORT GROUP

Steven Kovarik, System Support Manager
Imad Abbadi, System Support Specialist
Joseph Mesterhazy, System Support Specialist
Harold Mark Shamblin, System Support Specialist
Jason Boyd, Electronic Technician
Gary Bridges, Electronic Technician

STUDENT SERVICES

Vicky Thorland-Oster, Program Coordinator
Roger Bentley, Academic Advisor
Deb Martin, Academic Advisor
Tony Moore, Academic Advisor
Pamela J. Myers, Record Analyst
Virginia Anderson, Secretary

Student Honors and Awards

2005 National Merit Scholars

Eric Aderhold, Cpr E
Anthony Barsic, EE
Jesse Bartley, Cpr E
Kevin Cantu, EE
Michael Ciccotti, Cpr E
Mark Ciecior, EE
Daniel Degraaf, Cpr E
Michael Ekstrand, Cpr E
Ryan Ferneau, Cpr E
Nathaniel Gibbs, EE
Tyler Hardin, Cpr E
Lucas Hill, Cpr E
Laura Janvrin, EE
Alan Johnson, Cpr E
Kevin Korslund, Cpr E
Joshua Lichti, Cpr E
Matthew Lichti, EE
Jeremy Meeks, EE
Michael Morris, EE
Karl Peterson, Cpr E
Kristen Pudenz, Cpr E
Anthony Ross, Cpr E
Aaron Sartor, Cpr E
Russell Schmidt, Cpr E
Taylor Schreck, Cpr E
Steven Schulties, Cpr E
Cory Simon, Cpr E
Dwayne Stammer, Cpr E

2006 National Merit Scholars

Eric Aderhold, Cpr E
Anthony Barsic, EE
William Brubaker, Cpr E
Kyle Byerly, Cpr E
Mark Ciecior, EE
Daniel Congreve, EE
Daniel Degraaf, Cpr E
Michael Ekstrand, Cpr E
Scott Elliott, EE
Jacob Gionet, Cpr E
Daraius Guthridge, Cpr E
Tyler Hardin, Cpr E
Traylon Harrington, Cpr E
Lucas Hill, Cpr E
Niclo Hitchcock, EE
Laura Janvrin, EE
Paul Jennings, EE
Kevin Korslund, Cpr E
Joshua Lichti, Cpr E
Matthew Lichti, EE
Guillermo Molano, EE
Luis Munoz, EE
Karl Peterson, Cpr E
Ashley Polkinghorn, Cpr E
Kristen Pudenz, Cpr E
Thomas Reed, Cpr E
Matthew Rohlf, Cpr E
Jay Roltgen, Cpr E
Anthony Ross, Cpr E
Aaron Sartor, Cpr E
Russell Schmidt, Cpr E
Taylor Schreck, Cpr E
Steven Schulties, Cpr E
Clayton Schumacher, Cpr E
Peter Scott, EE
Cory Simon, Cpr E
Adrian Soltero, EE
Mathew Wymore, Cpr E

RESEARCH EXCELLENCE AWARDS

Qinming Chen (2005)
Pallab Datta (2005)
Basheer Al-Duwairi (2005)
Jing Fang (2005)
Rohit Gupta (2005)
Hanjun Jiang (2005)
Winbin Qiu (2005)
Jialing Liu (2006)
Shu Liu (2006)
Wei Shao (2006)

TEACHING EXCELLENCE AWARDS

Mikel Bezdek (2005)
Joshua Olson (2005)
Joe Paul Schneider (2005)
Ganesh Subramanian (2005)
Lu Zhang (2005)
Sudaha Anil Kumar Gathala (2006)
Arul Madhavan (2006)
Saqib Malik (2006)
Ramon Mercado (2006)

FELLOWSHIPS

The Jerry R. Junkins Chair Fellowship
Nathan VanderHorn (2006)

The Thomas M. Whitney Fellowship
Puneet Sharma (2005)

Harpole-Pentair Development Faculty Award Fellowship
Natrajan Viswanathan

Cisco Fellowship
Benjamin Anderson (2005)

Cowell Fellowship
Jeffrey Brown (2006)

Fulbright Scholar (Colciencias-Colombia)
Harold Salazar Isaza

GEM (National Consortium for Graduate Degrees for Minorities in Engineering and Science) Fellowship
Miguel Contreras (2005)
Anthony Persaud (2005, 2006)

IBM PhD Fellowship
Mahadevan Gomathisankaran (2005, 2006)
Anantharaman Kalyanaraman (2005, 2006)

Lockheed Martin Fellowship
Ramon Mercado (2005, 2006)

USDA MGET Fellowship
Benjamin Jackson (2005)

Departmental statistics

BS Degrees Awarded

YEAR	
2000–01	237
2001–02	222
2002–03	277
2003–04	257
2004–05	281
2005–06	248

MS Degrees Awarded

YEAR	
2000–01	66
2001–02	51
2002–03	60
2003–04	54
2004–05	38
2005–06	35

PhD Degrees Awarded

YEAR	
2000–01	20
2001–02	22
2002–03	16
2003–04	18
2004–05	14
2005–06	29

Number of Undergrad Students

YEAR	
2000–01	1,402
2001–02	1,519
2002–03	1,497
2003–04	1,327
2004–05	1,193
2005–06	995

Number of Grad Students

YEAR	
2000–01	251
2001–02	263
2002–03	242
2003–04	244
2004–05	251
2005–06	244

State Budget ($)

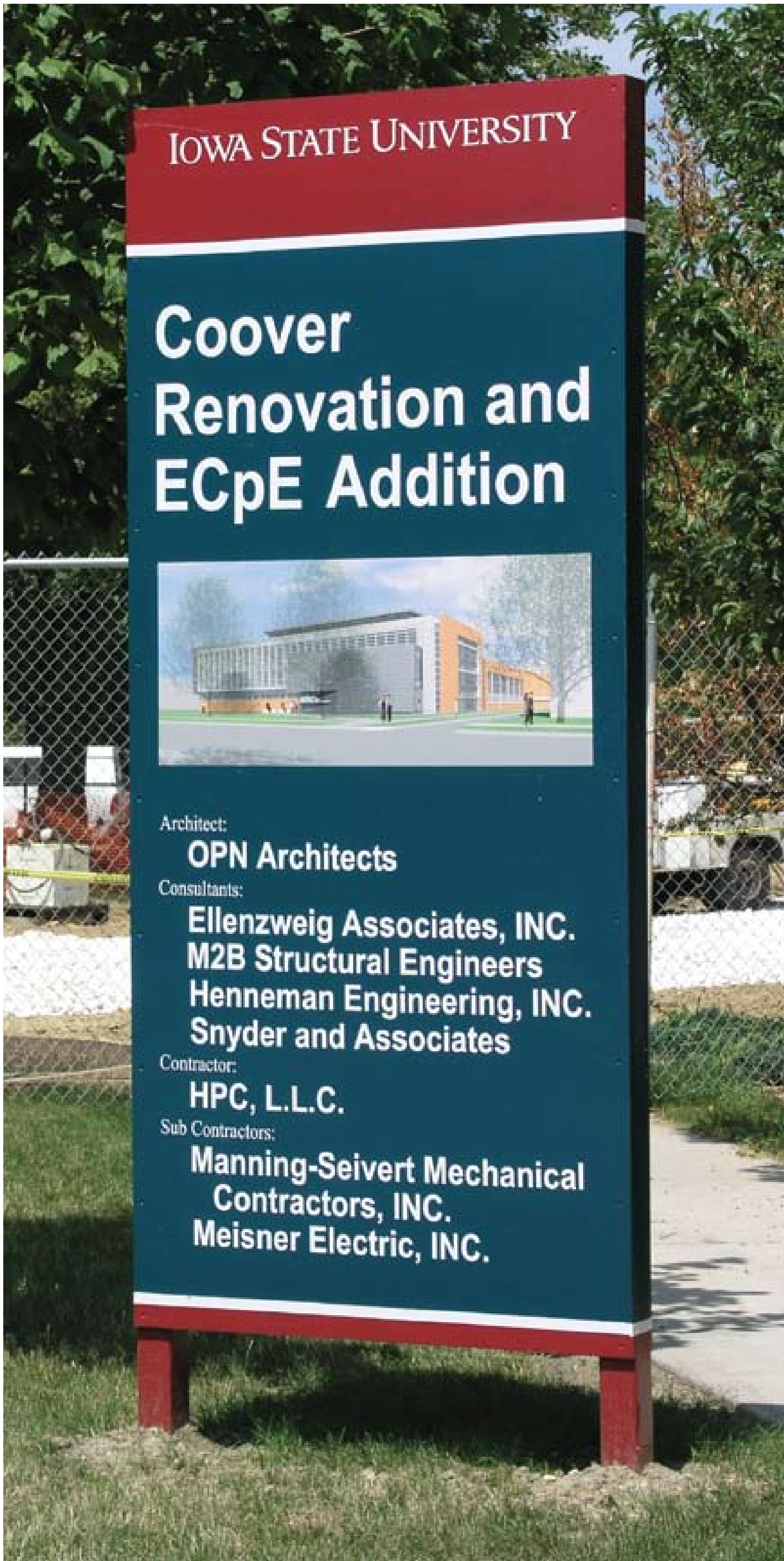
YEAR	
2000–01	$6,001,778
2001–02	$6,233,671
2002–03	$6,420,680
2003–04	$6,611,031
2004–05	$6,984,270
2005–06	$7,308,190

Research Expenditures

YEAR	
2000–01	$7,436,744
2001–02	$5,696,582
2002–03	$6,825,322
2003–04	$6,922,096
2004–05	$7,241,040
2005–06	not available

Renovation of Coover Hall

The first phase of the ECpE building project is underway. In the spring of 2006, work began on the demolition of Coover Hall's "Cyclone" addition, which was built in the 1950s on the southwest side of the original building. After the demolition, a new three-story building will be constructed.



Along with an interactive classroom on the first floor, the new structure will be home to additional teaching lab space on the second floor, as well as new research labs on the first and third floors. The first phase should be completed by early 2008.

Phase 2, expected to take about two years to complete, will begin after the first phase is completed. The work will consist of renovating the original Coover Hall, as well as additional new construction, which will eventually add about 20,000 square feet to the building. This portion of the project will have a much bigger impact on students and faculty because work will have to be completed floor by floor and will cover a much larger area than Phase 1.

In addition to the extra space, building improvements will bring about modern, flexible learning environments that can be adapted to meet the changing needs of the department. Labs will be clustered, creating a greatly enhanced environment for research that brings the department's faculty together under one roof.

ECPE VISION AND PRIORITIES

Vision

Students will become broadly educated in the fundamentals of electrical and computer engineering principles with an emphasis on skills that enable them to adapt to the regular paradigm shifts in the technological and engineering landscapes. We will aim to produce leaders who will shape the future technological arena.

The faculty will focus on research that is creative, innovative, and meaningful. The faculty will vigorously pursue and lead new emerging areas that have the potential to revolutionize the electrical and computer engineering and other related scientific and technological disciplines. The faculty will create, share, and apply the knowledge for the land-grant mission of the university.

Priorities

EDUCATION:

- Impart the ability to learn
- Encourage leadership
- Maintain high standards and an excellent international reputation
- Attract top students from reputed national and international schools
- Form strategic alliances with industry and research labs to enhance opportunities for research collaboration and student exposure

RESEARCH:

- Sustain faculty composition to have strength in core disciplines with adaptability
- Create centers of excellence
  - BioEngineering
  - Distributed Sensing and Decision Making
  - Small-Scale Technologies
  - Cyber Infrastructure
  - Energy Infrastructure
- Create strategic partnerships with reputed research labs, universities and industry
- Build strong support infrastructures
- Encourage the process of technology transfer

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College of Engineering
Iowa State University
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ecemail@iastate.edu