McCormick Northwestern Engineering

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Robert R. McCormick School of Engineering and Applied Science
Northwestern University

Growing Businesses

Farley Center for Entrepreneurship and Innovation spurs start-ups

Entrepreneurship — the spark of an idea, the excitement of innovation, the labor of love, the satisfaction of accomplishment — is central to any society, any future. At McCormick, where ideas and innovation abound but often need a little push, entrepreneurship recently got a big boost when Jim and Nancy Farley offered a significant donation to endow the Farley Center for Entrepreneurship and Innovation. The gift will help students, faculty, and alumni from across Northwestern take their ideas and turn them into reality.

Jim and Nancy Farley with Julio M. Ottino, dean of the McCormick School.
(Photo by Rose Lausten)

"I was an entrepreneur, and we built our company from a dry start," says Farley, a McCormick alumnus and the retired chair and chief executive officer of the multinational corporation SpeedFam-IPEC. "I've been an entrepreneur interested in entrepreneurship for a long time, so when I heard Northwestern was considering starting this center, I knew it was an area I wanted to support."

Farley graduated from McCormick in 1950 with a degree in electrical engineering and started out as a test engineer for General Electric. He then worked as a sales engineer for a Milwaukee motor control manufacturer. In 1960, when he sold a control to the inventor of a new lapping and polishing machine, he joined the inventor's company as a minority investor. The business grew rapidly when Farley expanded it across the world. When the company reorganized in 1974, Farley took ownership of the machine-tool side of the business, then named SpeedFam Corporation and later SpeedFam International. In 1999 SpeedFam International merged with IPEC (Integrated Process Equipment Corporation) to become SpeedFam-IPEC, which Farley led until he retired in 2002.

"Northwestern gave me my start," Farley says. "Every quarter they gave me a $75 check — half of my tuition. They helped finance my education, so I owe a lot to the school."

All engineers have to be entrepreneurial, he says, even if they aren't interested in starting their own business. While he always relied on his engineering background, Farley says the classes that helped him the most involved business. "You have to speak the language of accounting, whether you're in business for somebody else or for yourself," he says. "If you don't talk their language, you won't get very far. The business side is very, very important."

Julio M. Ottino, dean of the McCormick School, says the gift will lay the foundation to foster both student and faculty entrepreneurship. "This center fills a very clear need for undergraduates and graduate students in engineering and across Northwestern," he says. "It is no exaggeration to say that the Farley Center, together with our emphasis in design-thinking, will move innovation to a new plane. The gift from Jim and Nancy is an investment in the future of innovation."

"It's exciting to have such a great endorsement from such a successful alumnus," says Mike Marasco, director of the center. "The gift will allow us to expand entrepreneurship beyond the school level."

The gift comes as the center completes its first year of operation. Its first class, NUvention: Medical Innovation, brought together 82 students from four schools to teach them how to develop medical devices and create business plans for the ideas (see *McCormick*magazine, spring 2008). The center received more than $225,000 from more than 10 companies and venture capitalists to fund the program, and 11 provisional patents were filed.

The center also created Principles of Entrepreneurship, a course taught by Marasco and William White, professor of industrial engineering and management sciences and an entrepreneur himself. More than 100 undergraduate students enrolled in the course, and more than 50 were placed on a waiting list. Students presented elevator pitches as their final exams, and the best pitches received more than $3,000 in prize money.

In addition to creating and offering courses, the Farley Center advises several entrepreneurship-focused student groups and has begun offering a portfolio of services to faculty to help them evaluate the commercial potential of research and build their innovations into businesses.

The center has created an advisory board that will advise it how to continue with the new funding from the Farleys. Marasco says the center is in the process of creating more interdisciplinary courses like NUvention: Medical Innovation that will focus on energy or web-related companies. The center would like to offer grants to students and faculty to launch their own businesses, and ideally it would like to create a venture capital or "pre-seed" fund that gives potential entrepreneurs funding in the early stages of business creation.

Marasco says the center could also connect alumni with students and faculty members through events and an "angel network" of potential investors. "There are tons of great ideas in these buildings, and very few get out," he says. "We would like the center to be a one-stop shop for how to evolve an idea into a business."

While the gift will give entrepreneurship at Northwestern a boost, the entrepreneurial spirit is alive and well in students, faculty, and alumni who are willing to make the jump from academia to business, as the following stories show.

Finishing studies, starting a company

Dave Nahlik and Mike Marasco
(Photo by Andrew Campbell)

Dave Nahlik (MS biomedical engineering '08) spent most of the summer finishing up his master's thesis. This fall, while his peers search for jobs or go on to higher education, Nahlik has a different plan: He'll be running a company. "It's a daunting task," he says. "But I love this opportunity. I can't wait to get started."

The company, Onyx, grew out of an idea born in NUvention: Medical Innovation. Nahlik and a group of fellow students decided that surgical tools, which have changed very little over the past century, needed a better design. So they created two new surgical tools — the Shark, a scalpel, and the Raptor, a retractor — that "function as an extension of the surgeon," explains Nahlik. Both tools are more ergonomic than current models, with the Shark offering a nonslip grip and finger rests for added control, stability, and comfort, and the Raptor offering interchangeable retractor heads for quick and easy application adjustments.

After the course ended last spring, Nahlik took a lead role in making sure the ideas didn't die. He and other members of the team met with government agencies and nonprofit organizations to solicit help in forming a company. Now they're in the process of incorporating, after which they'll seek some outside funding.

While everyone on the team wanted to stay involved — either working on it part-time or making a financial commitment — Nahlik prepared throughout the summer for his full-time gig in the fall. He contacted insurance companies, set up meetings, and started to develop a web site so when his master's thesis is finished he can "go right in and work on the company full-time," he says. As the company's sole full-time employee, he'll act like a CEO but will also continue to design new surgical tools. "I've always had the dream of running my own company," he says. "It's stressful, but everyone in the group is very excited and passionate about making this work. And as an engineer, it's fun to see your work come to fruition."

Along the way, Nahlik says faculty and staff within the Farley Center for Entrepreneurship and Innovation have provided guidance and suggested business contacts. That kind of knowledge is needed for the group's ambitious first-year goals.

"At the end of next year we hope to have a full suite of five to eight production-ready surgical instruments that we can sell or license to another company," Nahlik says. "Eventually I'd like Onyx to be a household name in hospitals. But we'll see how the first year goes."

Teachers, scholars — and CEOs

Charles Kuehmann and Greg Olson

While McCormick faculty members primarily serve as educators and researchers, often they'll develop an idea that's just too good to pass up: It's new, it has a market, and they — or, in many cases, enterprising graduate students — think they might have what it takes to make it work.

When Greg Olson, now the Wilson-Cook Professor of Engineering Design, came to the University 20 years ago, he brought along a research group with the capability to create computationally designed materials — high-performance steels, in particular. Olson had helped develop software that took the performance requirement of a new material and integrated it into a modeling software system that accelerated the design and development of new materials.

Olson was content to use this software in research until PhD student Charles Kuehmann came along. "He had already started a company when he was an undergraduate," Olson says, "and he was very interested in exploring the ways that this design technology could be commercialized. The company wouldn't have happened if the right graduate student hadn't come along. I think that developing student entrepreneurship is key — that way the faculty member can stay at the University and teach while the student runs the company."

After Olson and Kuehmann reviewed several business concepts created as class projects by Northwestern undergraduate and graduate students, QuesTek was born a little more than a decade ago. Kuehmann, the enterprising student, started as president and CEO. "Our idea was, in the long term, to be a company that creates new materials, and in the short term, to supplement it with a services business," Olson says. "And that's what we have done."

QuesTek's first creation was a high-performance gear steel that was designed at Northwestern and licensed to the company. That steel has found an unusual market: Baja 1000 racing, where QuesTek's materials have led to better final drive gears for off-road racers, as demonstrated by the top five finishers of the 1600 class for the past several years. "That's helping to get the word out that our designed materials actually work," Olson says.

The company has also created the first stainless steel aircraft landing gear — a move funded by the federal government under a program designed to reduce pollution from military technology. Such landing gear can replace cadmium-plated landing gear, which poses an environmental hazard. Air force flight qualification testing has been fully completed, and the new steel is expected to take to the sky this year. QuesTek has also worked with the Navy to develop high-strength, high-toughness alloy steels for carrier-based aircraft components. Over the past four years, the company has become profitable. It now has 17 employees and does nearly $5 million a year in sales.

"My vision was to help bring about this computational materials design revolution and to get this new technology out in the world," Olson says. "I believe that if you really care about engineering, you have to start a company to do engineering. That experience helped me identify the sort of science we should be doing and teaching at the University."

Optimizing everything from tires to electricity delivery

Jorge Nocedal and Bob Fourer
(Photo by Andrew Campbell)

At the dawn of the new millennium, Jorge Nocedal, professor of electrical engineering and computer science, and his research group created software called KNITRO that performed complicated optimization calculations. "I realized what we were doing was new and powerful and had many applications," Nocedal says. "But it was going to be difficult to improve if we didn't have professional developers with us."

Nocedal, too, had a graduate student with the entrepreneurial spirit that spearheaded the jump from innovation to business. That student, Richard Waltz, was "very energetic and really wanted to do something to show how far this software could go," Nocedal says.

When the two partnered with Bob Fourer, professor of industrial engineering and management sciences, Ziena Optimization Inc. — which specializes in nonlinear optimization — was born. "We had no idea what we were doing," Nocedal admits of the early days. "But we didn't want any outside investment because we wanted complete control over the technology. What we didn't see is that we had to come up with so many solutions to unforeseen problems. We didn't know that we would need so much imagination to survive."

Fourer, who had experience with a start-up software company before, helped navigate the industry. "I knew what the products were and what their successes had been," he says. "This kind of business interested me because it really gets you involved with people who are trying to solve actual problems."

The team muddled through a mass of paperwork and found some funding through the National Science Foundation's Small Business Innovative Research grants. "That provided capital without strings attached," Nocedal says. "And the prestige we received from the NSF endorsement was crucial."

Slowly the business organized itself, and the team used its scientific contacts throughout the world to shape the company and create distribution agreements. Now the software is used in the energy, oil, auto, and financial industries to optimize everything from grooves on tires to the production and delivery of electricity. At Northwestern, Nocedal's PhD students use the software to develop new ideas, which they publish as part of their dissertations.

Along the way, the company has had its share of surprises. "Creating software is difficult because there are many areas to attend to," Fourer says. "You have to make sure it works for the customers."

The company has also faced competition from companies like IBM, which distributes similar software for free with the goal of selling customers a consulting service. "We have to be substantially better to compete," Nocedal says. "It's clear that if you're not highly innovative and energetic, you won't last. It's an incentive to make bigger ideas and implement them."

Sorting through the tiny world of nanotubes

While the companies of Olson and Nocedal and Fourer continue to grow, other McCormick faculty businesses are just getting off the ground. Mark Hersam, professor of materials science and engineering and chemistry, and his research group have developed a way to sort carbon nanotubes by diameter as well as by chiral angle, which describes the arrangement of carbon atoms along the length of the nanotube. Those parameters determine a carbon nanotube's properties, and since there is no technique for creating an identical population, sorting them could potentially be big business.


Mark Hersam
(Photo by Jasper Chen)

Hersam and his group use density gradient ultracentrifugation, a process in which researchers fill a centrifuge tube with a fluid that varies in density, load it with nanotubes, and spin it until the nanotubes reach their isopycnic point — the point where a nanotube's density matches the fluid's density. The relationship between a nanotube's density and its structure and properties can be engineered through the use of appropriate surfactant chemistry, so ultracentrifugation possesses great flexibility in sorting.

"While carbon nanotubes have great potential," Hersam says, "there is no large-scale technology based on them because of this sorting problem. We published a paper on the process, and the response was overwhelming. I stopped counting the number of requests for samples when it exceeded 100. The overwhelming demand suggested to me that there was an opportunity for commercialization."

After he filed a patent with the help of the University's Technology Transfer Program, Hersam found investors that shared his interest in scaling up the ultracentrifugation process. NanoIntegris was incorporated in January 2007, and since then researchers have achieved a 100-fold scale up. "Many people doubted we could do that," Hersam says. "Customer feedback has been positive thus far, so we anticipate further growth in the demand for our material."

Like other faculty members with start-up companies, Hersam considers himself a professor first and an entrepreneur second. But entrepreneurship has brought him challenges and experiences that he can teach his students. "It's exposing me to the real world," he says. "It helps me educate students and show how we can impact society more immediately than we can by simply publishing papers. When you publish a paper, it often just sits in the literature, and maybe somebody reads it, and maybe it will influence a business decision. But then the product won't come out for another five years, if not longer."

Hersam says McCormick is becoming a place where entrepreneurship is encouraged. "At Northwestern and in Chicago, there hasn't historically been a strong culture of high-tech start-ups," he says. "But I think things are changing for the better. You need to have that culture to cultivate these companies."

A new kind of diagnostics

"There are many ways for a researcher to have an impact," says Chad Mirkin. "One is to publish a really important paper. A second is to build an operation that takes your ideas and refines them, engineers them, and turns those ideas into a robust technology that can be distributed to the masses. A start-up is a natural outlet for innovations."

Mirkin knows entrepreneurship. A professor of materials science and engineering and of medicine and the George B. Rathmann Professor of Chemistry, he has cofounded two companies: Nano-sphere, a nanotechnology-based health care company that does diagnostic testing, and NanoInk, which commercialized dip-pen nanolithography, a groundbreaking nanoscale fabrication and analytical tool. Both have already had successes, and Nanosphere went public last year, raising $113 million.

Mirkin wasn't always the savvy entrepreneur. When he started Nanosphere eight years ago, he admits he was "clueless." But he started knocking on doors at the Kellogg School of Management and, through an entrepreneurship class taught by Barry Merkin, created a business plan for his idea. That led Mirkin to create the Small Business Evaluation and Entrepreneur's Program through his Interna-tional Institute for Nanotechnology, in which a team of Kellogg students researches and assists scientists in developing business plans to present to potential investors. Such plans help researchers commercialize their projects while giving Kellogg students experience with actual businesses. Fifteen companies have launched, thanks to the program.

"The biggest problems scientists and engineers have is that they don't always feel comfortable around business people. They're worried that they're going to get cheated or that it's not going to be a good deal for them," Mirkin says. "But if you don't get a deal done, it's not a good deal for anybody."

Scientists and engineers must not be so immersed in their research that they can't be bothered to see it to development, Mirkin says. But researchers can't let the business side consume them and take priority over their scientific development. "It's a balance," he says.

Building up after the dot-com bust


Rhonda Dibachi

When Rhonda Dibachi (BS nuclear engineering '83) and her husband, Farzad, started the software management company Niku in 1998, times were good. Within two years, it had grown to 1,200 employees, and the company went public in February 2000. The NASDAQ peaked a month later, and their stock prices were up to more than $100 a share.

Then the dot-com boom went bust.

"Watching our stock prices go from over $100 to less than $1 was really tough," Rhonda says. "It was a very, very long process of making the company viable again. And we did, and in the end we were very proud of our accomplishment."

When Dibachi graduated from McCormick, she didn't plan on becoming an entrepreneur. She got her MBA and worked for several different companies and, because nuclear engineering wasn't in demand at that time, she got into software engineering. After working for start-up Webvan — an online grocery business that became a notorious example of the dot-com bust — she got the start-up bug. "I was bored with industry," she says.

So Dibachi and her husband started Niku Corporation. When they first began, they took several wrong turns, and it took a year before their business model was solidified. Those kinds of twists and turns can make entrepreneurship lonely, she says, since many people will tell you you're making the wrong decisions. "If you enjoy being a part of clubs and surrounding yourself with like-minded people, you'll fail as an entrepreneur," she says. "If you enjoy being different, then that will make you succeed."

And working with her husband? "It was great," she says. "If you can find a family member that you can stand to look at 24 hours a day, it's by the far the best thing. At some point, though, you have to say at dinner, 'We're just not going to talk about the stock price tonight.'"

In 2002, tired of the long hours, the Dibachis left the company and took several years off. "Then we were bored, so we started another company," she says. That company is Noribachi, which is developing a new solar architecture for solar applications and products. "I didn't know anything about solar when we started a year ago — I just knew how to create and run a company," she says. "It's exciting to have your own little way of trying to solve a little bit of the world's problems, though. Software just didn't have that emotional ring."

Your virtual health coach is calling


Jesse Hercules

Jesse Hercules (BS industrial engineering and management sciences '01) was never one to just sit around at Northwestern. After learning how to write a business plan in a McCormick course, he and three other Northwestern students started a web site design business that catered to local businesses. "It was back in the mid-90s, when the Internet was new," he says. "But we really learned a few things about business, even as teenagers."

He first followed a traditional real-world path — after graduating in 2001 Hercules worked in industry at General Electric before enrolling in law school to become a patent attorney — but the entrepreneurial spirit never left him. While his peers did clerkships the summer after their first year of law school, Hercules spent his time thinking about how computers could be used to help people become healthier.

"People know they should be getting more exercise and eating better, and they're supposed to hold themselves accountable," he says. "In the business world, when you're on a team, there's external accountability, so tasks are accomplished. That kind of support is needed to be healthy as well."

So Hercules designed a software application for himself on his home computer that would call him on the phone and ask if he had exercised that day. It would then keep score of how often he exercised and whether he reached his goals. The idea could be scaled up to call many people, he thought, and instead of selling a gadget that would motivate people to exercise, he could just use the software to motivate them using gadgets they already had — their cell phones.

"That's when I knew I was going to make a business out of this," he says. After finishing law school and obtaining a patent on his invention, he moved the business to an incubator in Memphis and hired his first two employees. Earlier this year Extracon Science rolled out its first product: EcFit.

The software program allows users to sign up online with a weekly exercise schedule and a goal of completing, for example, 80 percent of their workouts. The system can then call the customer to remind them to exercise, ask whether they completed the exercise, and calculate whether the customer is reaching their goal. Boosting Hercules' idea was a recent study that showed a telephone system did just as well motivating people to exercise as another human. "So many people would say, I need another human being to motivate me," he says. "But the study shows the computer is as effective."

Hercules is marketing the product to employee wellness programs and to the fitness industry. "For me it's amazing that we haven't had any competitors pop up," Hercules says. "I feel like every day we're adding to our head start."

Hercules also hopes to expand the idea to automated coaching by phone for other health-related areas like diet and smoking. In the meantime, William White, professor of industrial engineering and management sciences and one of Hercules's former teachers, plans to use Extracon Science as a case study in his Organizational Behavior course.

"It comes full circle," Hercules says. "From IEMS classes to real-world application and back again."
As the Farley Center for Entrepreneurship and Innovation moves forward, Jim Farley expects his donation to help produce more entrepreneurs like these.

"I hope it will provide a long-term, successful way to promote entrepreneurship throughout the entire school," he says. "I certainly didn't have the feeling I would be an entrepreneur when I left school. I was going to be an engineer. But I've been much happier being in the business network."

—Emily Ayshford

Giving Report

Dear McCormick alumni and friends,

On behalf of the Walter P. Murphy Society, I would like to thank you for your support of the Robert R. McCormick School of Engineering and Applied Science during academic year 2007–08. We are grateful for the contributions and partnership of the more than 450 members of the Murphy Society and the hundreds of other donors whose names are listed on the following pages. To those who are not currently Murphy Society members or donors, please consider joining us and make a gift to the McCormick Annual Fund this year.

As you might know, the Murphy Society honors the legacy of Walter P. Murphy, the benefactor whose gifts supported the construction of Northwestern's Technological Institute. Murphy Society members make annual gifts of $1,000 or more and have a unique opportunity to assist the dean in making decisions to fund faculty and student projects through Murphy Society grants. Each year the Murphy Society supports a broad range of innovative faculty and student projects that are relevant and designed to impact undergraduate education. Two recently funded projects related to alternative energy were Professor Scott Barnett's student laboratory experience for undergraduates researching hydrogen fuel cells and a student-led initiative aimed to recycle and convert campus-wide waste vegetable oil into fuel for University shuttle buses.

Once again, Murphy Society members in 2008–09 will be recognized as members of the Northwestern University Leadership Circle, a pan-University giving society composed of Northwestern's most loyal friends and alumni.

Please know how much your gifts to McCormick are appreciated, and best wishes for the coming year.

Sincerely,
David A. Eckert '77
Chairman, Walter P. Murphy Society
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William S. Galliani '84, '88 and Carolyn McPadden Galliani '84, MS '88
Marvin E. Garrett '63, MBA '65 and Judith Wasilko Garrett '64
J. Jeffrey Geldermann, '72
Steven Gilbert, MS '86
Mark Gitomer and Susan Warner Gitomer
Marilyn Otto Goll '46
Michael J. Gordon '92 and Amy Gatewood Gordon '91
Marc Gosse, MS '88
Jeffrey T. Gotro, PhD '83 and Elaine M. Grossman-Gotro '79
Philip H. Graham '60 and Linda H. Graham '60
James E. Greenlee '66, MD '70, GMER '76 and Raylene J. Greenlee '69
Kevin John Gross '77 and Susan Luerssen Gross '79
Donald G. Gwinn, MSED '65, PhD '72 and Joanna Hall Gwinn '66, MSED '67, MMgt '83
Ronald H. Haas '61, MS '62 and Catherine E. Haas
Jeffrey A. Halpern and Elissa Cohen Halpern
Eva B. Hamilton
Steven J. Hampton and Margaret M. Bertelsen Hampton '80, MMgt '84
Edward T. Harley '49
Carolyn Larson Harman '48
Gilbert A. Harter '52, MS '54 and Miriam Knox Harter
John H. Heckmueller '70 and Virginia Hemelt
John Heintz and Maureen Heintz
Clyde E. Henderson '73 and Janis Henderson
Nancy J. Hermanson '83
Henry G. Herzing '59
Doris A. Hightower '79
David C. Hinton '95

Cynthia S. Hirtzel, MS '77, PhD '80
Carl J. Holdampf '51 and Margaret Miller Holdampf '51
James E. Hovis '67, MS '69 and Catherine Hovis
Robert Charles Howard '97, JD '04, MBA '04 and Sara J. Howard
Arthur P. Hurter '56, MS '58, PhD '62 and Florence E. Hurter
Karl M. Irwin, MME '93, MS '93 and Sania Choudhury Irwin, MS '93, PhD '95
Kiyoji Ishida, MS '68
D. Lynn Johnson
Gregory J. Johnson '69 and Brenda E. Johnson
Josetta I. Jones '92
Jeffrey P. Kao '97
Troy R. Karlsson '84
Dale A. Keister '62
Mark E. Kelly '50 and Doris Keane Kelly
Robert J. Kiep '88
W. Donald Kingsley '57 and Barbara Palicke Kingsley '58
Kenneth C. Kirsch '75, MS '78, PhD '80
Jack A. Koefoot '46
P. Jeffrey Kohler '80 and Barbara A. Kohler '78
Edward F. Kondis, PhD '69
Tom C. Krejcie '74
Gary Kremen '85
George F. Kroker '71
Edward A. Labahn '51
Robert T. Langan '71, MA/MS '74, MS '80 and Susan L. Griesbach '80, MS '84
George Z. Lannert '71, MMgt '73 and Martha N. Lannert
David B. Larimore '68
Stephen R. Larson '67 and Marcia Kempe Larson '73
John Lazar '48
Harvey Y. Lee '88
James A. Lee '88
Jeffrey Richard Lefebvre, MS '86, PhD '92 and Julie A. Lefebvre '87
Robert E. Leigh '54, MS '59 and Elaine Leigh
Steve Liao '92
John C. Lieske '82
Ding-Jen Lin and Chun-Ying Chen
Robert A. Long '81 and Sheryl Loyd Long '81
Carlos Cesar R. C. Lopes '03
Frank W. Luerssen and Joan Luerssen
Lydia Hoffman Lund '50
Herbert Malin, MS '51
Joseph S. Martinich '72, PhD '80 and Vicki Lynn Sauter '75, MS '77, PhD '80
Ralph C. McElvain '58, MMgt '73 and Peggy Pearce McElvain '57
Mark W. McGlothlin '77, MEM '81
Myron J. McKee Jr. '48
Gregory W. McKinney, MS '83 and Nancy Lubich McKinney
Charles S. McNeer '50
Joel D. Meyer and Enid Meyer

David Mintzer and Justine Mintzer
James J. Morreale '84 and Patricia A. Morreale '83
Mark J. Morton '66
Clyde Victor Moseberry, MS '97, PhD '05
George L. Nemhauser, MS '59, PhD '61 and Ellen Nemhauser '61
Kristin Guy Norton '91
Philip E. Novak '57
Iyabo A. Oladehin '97
Kim G. Ooi '80
Fred J. Osborne '83
J. M. Ottino and Alicia I. Loffler
Terry L. Overbey '72 and Lynette Pudvin Overbey '71
Garo A. Partoyan '59
Robert L. Peskin, MS '75, PhD '77
Gerald T. Petersen '57, CERT '74 and Carol Krametbauer Petersen '56
Galen K. Pflederer '49
Joe Phillip
Robert A. Phillips '63, MS '65, PhD '72
Nicholas G. Polydoris '54 and Gloria Polydoris
James W. Potthast '69
Thomas F. Powers '52
Robert L. Puette '64 and Mrs. J. P. Puette
Stuart M. Pulvirent '80
Vivek Ragavan '74 and Nilima Ragavan
Donald E. Rathbone, MS '57
Jerry L. Robertson, PhD '62 and Almeta Robertson
Donald E. Rome '77
William E. Rosner '75, MMgt '76 and Linda Rosner
Peter M. Rub '72, MMgt '75 and Monique Troglia Rub '76
Adam W. Saxler '94, MS '95, PhD '98
Timothy J. Scale, MS '75, PhD '80
Alan L. Scharff '46 and Sandra Scharff
Logan H. Schlipf '51
Walter G. Schmid, MBA '71 and Leslie Adickes Schmid, MBA '98
Joseph L. Schofer, MS '65, PhD '68 and Nancy L. Schofer
Arnold M. Schwartz '76
Lyle H. Schwartz '59, MS '64
Stephen B. Schwartz '57 and Nancy Astrof Schwartz
Stephen L. Schwartz '74, MMgt '76
Robert W. Semmler '50
Edward G. Sheppard Jr. '63
Raleigh A. Shoemaker Jr. and Katherine Dowding Shoemaker '95
Richard B. Silverman and Barbara K. Silverman
Verneta Simon, MS '93
Michael H. Sitko, MS '89
Alice Zajakala Sloma
Thomas M. Sprague and Laurie J. Anderson '80
David J. Spreutels '71 and Judith A. Spreutels '72

Jeffrey Staab '83 and Sara Hippe Staab '84
Michael J. Stark '78
Todd Eugene Steyer, PhD '93
Burton L. Streicher '72
Iren Suhami, MS '77, PhD '80
Chin-Teh Sun, MS '65, MS '67
Ronald J. Tabar '73 and Margaret Tabar
Antti P. Talvitie, MS '68, PhD '71
Gary F. Teletzke '78
Edward R. Teske '45, MS '48
Charles R. Thomas and Marilyn McCoy
Audrey Seelig Timkovich '85
Satya P. Tiwari '00
John M. Torkelson
William C. Trotter '58
Paul D. Ulland '66 and Judy Ulland
James M. Utterback '63, MS '65 and Margaret Nichols Utterback '65
Adam Varrenti and Diane Varrenti
Ira Wagner and Marcia Wagner
Robert W. Waldele '72
Samuel A. Walker III, MS '71 and Joanne Walker
Samuel Chih-Hung Wang, MS '75, PhD '79 and Sujane Chang Wang, MS '78, PhD '81
Nina Joag Waranica '85
Stephen M. Ward Jr. and Lori B. Ward
Jeffrey D. Warren '97
Sharon Sue Warsaski '84, MS '90
Alan J. Wasserstrom '62 and Daina Wasserstrom
Henry Arthur Weber '77, MMgt '78 and Leslie Weber
Jacob Morey Weinig '05
Howard J. Weiss, MS '73, PhD '75 and Lucia Beck Weiss
Bruce W. Wessels
James T. West '48
Richard V. Westerman '63 and Carla Westerman
Arthur R. Whale '45 and Roberta D. Whale
Kirk Richard Wheeler '75
James Wilde III and Lorraine Wilde
Charles S. Williams, MS '80
Roger G. Williams and Molly W. Williams '63
Donald R. Wilson '46
Adam E. Winter '97 and Jessica O. Winter '97
Alan Richard Wolff, PhD '08
Ronald J. Wong '77
Ying-Hon Wong '79
William A. Woodburn, MS '75
Dean A. Worrell '77
Marla L. Wright '93
James L. Zydiak, PhD '89 and Katrina L. Helmkamp '87, MMgt '92

From the Dean

Greetings from McCormick

We are happy to report that the McCormick School has received a significant donation from alumnus James Farley and his wife, Nancy, that endows the Farley Center for Entrepreneurship. This donation will help us become the epicenter of entrepreneurship for Northwestern. The center will offer more classes for undergraduate and graduate students and will provide the tools faculty and alumni need to become successful entrepreneurs.

The cover of this magazine features students from the center's inaugural NUvention: Medical Innovation course who are on their way to making their surgical tools into a viable business. Read about them and other successful faculty and alumni entrepreneurs inside.

We continue to be successful in faculty hiring, and I'm pleased to announce the recent addition of three computer theory professors: Jason Hartline, Nicole Immorlica, and Lance Fortnow. These additions have made the intersection between game theory and computer science a considerable strength at Northwestern. Leveraging the historic prominence of the J. L. Kellogg School of Management's work in game theory, the Department of Electrical Engineering and Computer Science looks to assume leadership in this quickly developing field.

We continue to build partnerships with key industries. We now have agreements with Honeywell, Ford, and Boeing. These partnerships give professors funding for research in their areas of expertise and allow companies to reap the benefits of that research.

Our professors are also doing important work on issues that have made the headlines recently: financial engineering. Vadim Linetsky and Jeremy Staum both research and create models that involve risk management, and in light of the recent financial crisis, their work is more important than ever.

In other exciting research news, Yonggang Huang and his colleagues at the University of Illinois at Urbana-Champaign created a camera based on the human eye. This is the first time that curved electronics have been used in such a device, and Huang's technique for creating the curved sensors will surely lead to many new innovations in electronics.

Of course, this progress would not be possible without the critical support of McCormick alumni and friends. I'm pleased to be able to take this opportunity to thank the many donors to the McCormick School in this issue.

I hope you enjoy this issue of *McCormick* magazine. I'm pleased to share our news with you.

Julio M. Ottino, Dean

EEconomiCS

Opportunities at the intersection of game theory and computer science

"A small band of economists and computer scientists, unified by an appreciation for mathematical beauty and a common vision, is amassing at Northwestern University. Your mission, should you choose to accept it, is to join this elite group in the time-honored search for truth, beauty, and science. The fate of the Internet and global electronic commerce rests in the balance."


Rakesh Vohra and Lance Fortnow

Rarely do recruitment posters for PhD programs parody movie trailers — but then again, rarely has a new group garnered the excitement that the newly formed Economics Group in the Department of Electrical Engineering and Computer Science has generated over the past year.

The group bridges the gap between two fields that have long shared many similarities — even a founder. In the 1940s and 1950s the work of noted mathematician John von Neumann gave rise to both computer science and game theory. Now, as the Internet provides new challenges to old theories and an entirely new way to observe human interaction, the two fields are increasingly intertwined.

At McCormick, three new hires have made this intersection between game theory and computer science a considerable strength. Leveraging the historic prominence of the Kellogg School of Management's work in game theory, the Department of Electrical Engineering and Computer Science (EECS) looks to assume leadership in this quickly developing field.

As Nicole Immorlica, assistant professor, settles into her new position at McCormick this fall, she joins Jason Hartline, assistant professor, and Lance Fortnow, professor of electrical engineering and computer science, to form the new Economics Group at McCormick. Also key to the development of the group is Rakesh Vohra, the John K. and Helen Kellogg Professor of Managerial Economics and Decision Sciences at Kellogg. Thanks to a joint appointment in EECS, Vohra links that department to Kellogg, which has been a leader in game theory for decades. The success of Kellogg's faculty in this area should help the interaction flourish.

"We have the largest group of people doing game theory at any one institution in the world," says Vohra. "This new area helps cement Northwestern's reputation in game theory. This is a growing field, and we now have a substantial strength that we didn't have before."

Predicting presidents and precipitation

Nicole Immorlica and Jason Hartline
(Photo by Andrew Campbell)

In the run-up to the 2008 presidential election, new polls surfaced several times a week, often switching favor between John McCain and Barack Obama. But the polls often lagged several days behind many major events — such as the oft-discussed postconvention "bounce." To avoid that delay, Fortnow considers a different method: prediction markets.

If you take any future event — like an election — create a stock that pays out only if the event comes to fruition, then trade it, the pricing of the security is an indicator of the likelihood of an event. These prediction markets have been shown to be quite accurate — better than polls and experts.

"The markets react immediately to news, but a proper poll can take three days," Fortnow says. "The markets move very quickly. They figured out that Joe Biden was going to be the Democrats' vice presidential pick before the announcement."

Several corporations also use prediction markets to forecast sales and pick release dates for products. Fortnow's research considers the theoretical models of these markets with the aim of understanding how they aggregate information so well. He also studies the effect of market manipulation on these markets and ways to design the markets and their presentation in order to maximize their usefulness.

Fortnow's other work in prediction is a collaboration with Rakesh Vohra. Together they've studied the accuracy of predictions, including one that affects each of us every day: weather. When the local TV weather forecaster predicts a 25 percent chance of rain, and then it rains, how do you judge the accuracy of the forecast? "If I say there's a 25 percent chance, and it rains, I'm not incorrect," Vohra explains. "The fact that it rained is not itself evidence of a bad forecast."

Since the 1950s economists have devised many ways to judge the accuracy of a forecast. One popular method, calibration, assigned a score to forecasts, with a score of 0 being perfect. But in the 1990s Vohra determined that it was possible to obtain a score of 0 even with no knowledge of the weather — raising doubts about the value of the score. "If I don't need to know anything to look good according to this measure, what does that say about the measure?" Vohra says.

Further research showed that all of the methods of determining the accuracy of a forecast fell victim to this problem. Recently Fortnow and Vohra have studied the computational complexity of devising ways to fool the system. "We looked at how complicated it was to construct the forecasts that would game the test," Vohra says. "Based on that information, we argued that someone gaming the test was somewhat impractical."

Advertising auctions

Internet search engines sell the advertisements that appear next to your search results. The advertising content displayed is the result of a complex auction that considers the popularity of your search terms, your location, the price advertisers are willing to pay to reach you, and the likelihood that you will click on a given result. But if you are a company such as Microsoft, Google, or Yahoo, how do you design these auctions in order to maximize your revenue? And how do you perform these massive computations in real time?

Online auctions are a relatively new phenomenon — and one that has put a new spin on economic auction theories. Understanding how to value online goods presents new challenges that require different solutions — which are exactly what Nicole Immorlica intends to find.

"In online algorithms you don't know the actions of the buyers but you need to design a solution," Immorlica says.

Every person assigns a real value to a given object — whether it's an ad on Google or a sweater on eBay. But when asked to state that value, a person is unlikely to provide that information. The only thing that you can count on is that buyers will act in their own self-interest. "You have to solicit information from users, and they can manipulate what they say," Immorlica explains. "We're trying to approximate a value in the absence of true information."

Immorlica also studies social networks, capitalizing on the vast amount of information that the Internet has made readily available. The Internet keeps a running log of collaborations — making it possible to see how groups form and dissolve around specific problems or projects. By understanding how these collaborations form and operate, it may be possible to encourage a specific behavior by applying those principles to the offline world.

"We're trying to understand how we can engineer social networks to introduce properties that we would like to see, such as diversity," Immorlica says. "In the housing market, for example, what effect do government policies have on increasing diversity in specific neighborhoods? Does it help to give subsidies to poor classes or to provide education about the values of diversity?"

What Immorlica likes most about this work is that it focuses on people. "I'm interested in understanding how and why things are the way they are and how we can affect them to make life better for everybody involved," she says. "It's compelling to think of people being in control of their own actions, but depending on how we design the systems in which people interact, we can affect the outcome. I want to try to make these systems work well and optimally."

Mechanism design

When a city planner lays out the traffic scheme for a city — which streets are one-way or two-way — he's essentially designing a game. And when you're stuck in traffic on the way home, both you and the city planner have lost.

That's how Jason Hartline explains the complex topic of mechanism design, his primary area of research. Mechanism design is the process of setting the rules and incentives of a system so that a certain objective is obtained. In the traffic example, it's setting the rules of the road so that when all drivers behave in their own interest, everyone gets to their destination quickly. And if the system isn't designed optimally, gridlock results. "Mechanism design is setting up a game so that when people behave selfishly, good things happen." Hartline explains.

Northwestern has been a pioneer in the field of mechanism design. Many major advances in the field came from Kellogg in the 1970s: For example, 2007 Nobel laureate Roger Myerson was awarded the prize for work he did at Northwestern during that time. "One of the reasons why I moved to Northwestern is that it has traditionally been a center for this area," Hartline says.

As a computer scientist, Hartline approaches mechanism design differently than his economist colleagues. "I tend to view design questions the way computer scientists tend to view design questions," he says. "If you want a computer system to solve some problem, you want to solve it every time, and you want it to be good no matter what. In economics, the typical approach is to design a mechanism for a particular stylized setting. My work tries to design a single mechanism that works in all settings, not just a particular one."

One of the ways that Hartline does this is to focus on approximating an optimal solution instead of focusing on the optimal solution itself. "When an optimal solution is complicated, maybe a simple one is approximately optimal — and maybe this simple solution is much more reasonable and realistic in the real world," Hartline says. "In the real world complicated things don't tend to happen; instead, very simple things tend to work."

By approximating an optimal solution, it's also possible to limit the computational power needed to arrive at an answer — a key concern for computer scientists who are interested in solving problems quickly and under the constraints of a given computer system.

Looking to the future

Fortnow, Hartline, and Immorlica all say that the opportunity to build a program from scratch was one of the things that brought them to Northwestern — though it also presents a significant challenge. "Students tend to be wary about coming to a group that doesn't have a history," Fortnow says. "Some of it will come with time."

Hartline thinks the group is up to the challenge. "To be at an institution with the best economists and game theorists is what brought me here," he says. "I wanted to go somewhere with an excellent economics group where I can have a high-level interaction and then make the computer science part happen. It's a challenging undertaking to go to a computer science department where there is no presence in the area that you work in. Having the three of us here is a great beginning. We are here to put together a really strong group."

—Kyle Delaney

McCormick News

Ajit Tamhane and Rich Lueptow
Photo by Andrew Campbell

New dean's office appointments
The McCormick School recently restructured the Office of the Dean, making new appointments and altering duties. Ajit Tamhane, professor and chair of industrial engineering and management sciences, joined the office as senior associate dean for planning and graduate studies. Tamhane is responsible for faculty hiring, building planning and renovation projects, and graduate studies. Rich Lueptow, professor of mechanical engineering, was appointed senior associate dean last year. Lueptow now serves as senior associate dean for operations and research. He oversees research, administrative, and financial operations.

Copenhagen comes to Tech
One night in September 1941 the Nobel Prize–winning German physicist Werner Heisenberg visited his friend and mentor Niels Bohr in Nazi-occupied Denmark. The two went for a walk, and their conversation ended in an argument stemming from Heisenberg's revelation that he was leading a research effort that might provide Nazi Germany with atomic weapons. In September three actors — including Matthew Grayson, assistant professor of electrical engineering and computer science — revisited that fateful conversation when the Tony Award–winning play *Copenhagen* by Michael Frayn was performed in the Technological Institute during Wildcat Welcome, Northwestern's new student week.

McCormick in the media
Yonggang Huang, Joseph Cummings Professor in civil and environmental engineering and mechanical engineering, collaborated with researchers from the University of Illinois at Urbana-Champaign to create a camera based on the human eye. The device uses a new way of stretching electronics to allow them to conform to curved surfaces. Their research was featured on the cover of *Nature* in August, and dozens of media outlets — including the *Chicago Tribune*, *Wired* magazine, *U.S. News & World Report*, Reuters, and *PC World* — ran stories on the research.

The Northwestern Solar Car Team, which recently placed 13th in the North American Solar Challenge, was featured on CNN with commentary by team adviser Walter Herbst, clinical professor of mechanical engineering and director of McCormick's Master of Product Development Program. That story was broadcast throughout the world, and McCormick friends reported seeing it in places as far away as Malaysia and Denmark.

Kristian Hammond, professor of electrical engineering and computer science, was featured in both *Crain's Chicago Business* and *TimeOut Chicago* magazine this fall. *Crain's* listed Hammond's favorite television shows, web sites, and books as part of their "Info Junkie" feature. One of his projects, News at Seven, was featured in TimeOut Chicago in early October. That system automatically identifies who's being talked about in the news, then finds images and videos that go along with that story. News at Seven was featured at *Wired* magazine's Nextfest in Chicago's Millennium Park, which showcased innovations that are transforming the world.

New programs for undergraduates
In September McCormick began offering a Certificate in Managerial Analytics in conjunction with the Kellogg School of Management. The program will teach undergraduates to apply their analytical skills to guide strategic as well as tactical business decisions in the context of finance, marketing, operations, and strategy. Kellogg also offers a financial economics certificate in partnership with the Judd A. and Marjorie Weinberg College of Arts and Sciences. That program, which began in September 2007, focuses on corporate finance, capital markets, and securities pricing and has been developed for undergraduates with a strong foundation in analytics, mathematics, and economics.

The Murphy Institute is a new program that enables a group of McCormick's best undergraduates to engage in self-directed activities with support from faculty advisers. The invitation-only program allows students, known as Murphy Institute Scholars, to create their own curriculum, pursue a funded research or design project, and work with an interdisciplinary team of faculty fellows. Scholars also participate in a seminar series called Engineering Dialog, which covers topics like fighting disease in Africa with engineering solutions, emotional design, saving art through conservation science, and molecular electronic devices.

Tech plaza renovation
The plaza in front of the Technological Institute has undergone a complete renovation this year. Throughout the summer and into the fall, workers installed new brick and stone paving, stone seat walls, accessible ramps, decorative lighting, and new planting beds and trees.

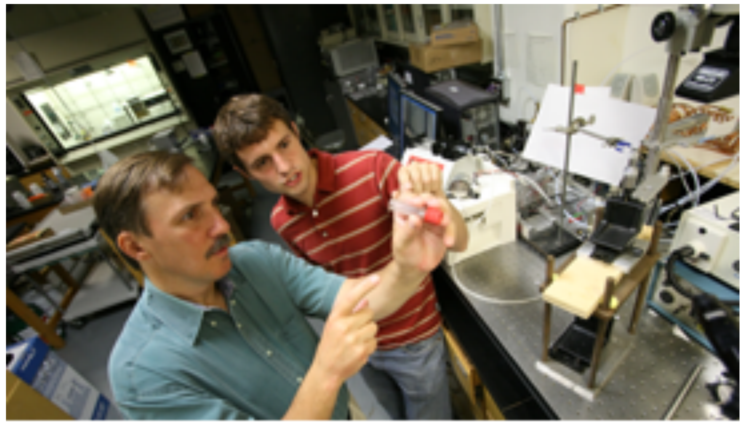
The landscape design includes 14 new Accolade elms (a disease-resistant hybrid) that will frame the courtyard with their classic urn shape. In addition, the plantings will include serviceberries, yews, hydrangea, spirea, and lilacs.

New engineering life sciences facility
A five-story addition to the Technological Institute will be built to house engineering life sciences programs. The facility will be a multidisciplinary center of research excellence designed to retain and attract the best faculty in the field of engineering life sciences. The addition, totaling 54,000 square feet, will occupy space on the north side of the Technological Institute between the B and C wings, currently a small parking lot. The two-year construction project is expected to begin in June 2009. The ground floor of the new building along with some adjoining space in the Technological Institute will be used for the Integrated Molecular Structure Education and Research Center, an improved and expanded version of the existing Analytical Services Laboratory, a facility that provides essential shared instrumentation for the analysis of molecules and materials. The building's upper floors will provide core laboratory and office space for McCormick researchers whose work emphasizes the life sciences and their relation to engineering. The addition will not include any classroom space.

Grand alliances

Ford-Boeing partnership fuels research

When a new automobile or commercial aircraft rolls off the line, its paint — the slick sheen that ranges from bright blues to burnt oranges — is actually a multitude of layers applied through a multistep process. How well those layers stick to each other — and how to measure how well they stick — is an area where research so far has been imprecise. But now, under a new kind of agreement with Ford Motor Company and the Boeing Company, McCormick researchers hope to find the best way to measure paint adhesion.



Ken Shull and Garrey DeNolf
(Photo by Andrew Campbell)

In October 2005 Ford and Boeing signed a three-year agreement to establish funding for Northwestern researchers to study nanocomposites, specialty metals, thermal materials, coatings, and sensors. With stagnant federal research funding and the changing nature of research and development, the McCormick School has thrived by creating research agreements like these with some of the top companies in the nation. These partnerships give faculty members the means to pursue research in their areas of expertise and allow companies to reap the benefits of that research. McCormick's Office of Corporate Relations has overseen such agreements with Ford and Boeing and with Honeywell International.

"A fluid partnership with corporate partners is critical due to major changes at multiple levels: the changing nature of federal funding and R and D funding within major corporations and a much higher level of entrepreneurship among faculty and students," says Dean Julio M. Ottino.

When Ken Shull, professor of materials science and engineering, learned of the agreement, he was immediately interested since his primary research lies in adhesion. "Paint adhesion was one of the things Boeing and Ford cared about, and we had some ideas based on other adhesion experiments we were doing," he says.

Under the agreement, Shull and graduate student Garret DeNolf have proposed developing new ways to determine how well a paint sticks to a surface. The pair has developed a new membrane-contact method that quantifies the adhesion of paint layers to different surfaces. In this method, Shull and DeNolf apply a layer of paint to a thin, flexible membrane, then push the membrane into contact with a particular surface. After the paint cures, researchers can measure the adhesion of the paint by peeling off the paint layer.

Shull and DeNolf are also using a nondestructive test of adhesion using acoustic waves. This sort of testing is often used in structural analysis, and Shull thought it might also work to see whether a coating had stuck well to either metal or a previous coat of paint. "It's like an ultrasound that can see if there is an internal crack in the paint," Shull says.

The process uses the vibrations of a quartz crystal to determine how paint layers — which are usually 20 to 100 microns thick — have stuck to a surface. Sometimes engineers have trouble making the first coat of paint stick to a metal, and sometimes the second coat won't stick to the first. "If you have paint flaking off your car, that's a huge problem for a company that's selling that car by the thousands," Shull says.

While engineers at Ford and Boeing certainly understand the dynamics of paint adhesion, there can be a lot of variables. Paint applied in humid Alabama, for example, might act differently than paint applied in dry Arizona. "They don't know exactly why paint acts differently in different circumstances, and that's what we're best at answering," Shull says. "We're driven by intellectual curiosity, so figuring out these problems is a good fit for us. We can make a connection between how these paint coatings are behaving and how they fail based on what we measured during the curing process. There aren't any good tests yet to really quantify adhesion with the precision that we need."

Shull and DeNolf, who will continue working on the project through 2009, say the project brings new goals and new chances to work with engineers in the field. "I like working with industrial collaborators because they have a good sense of what is of practical value," Shull says.

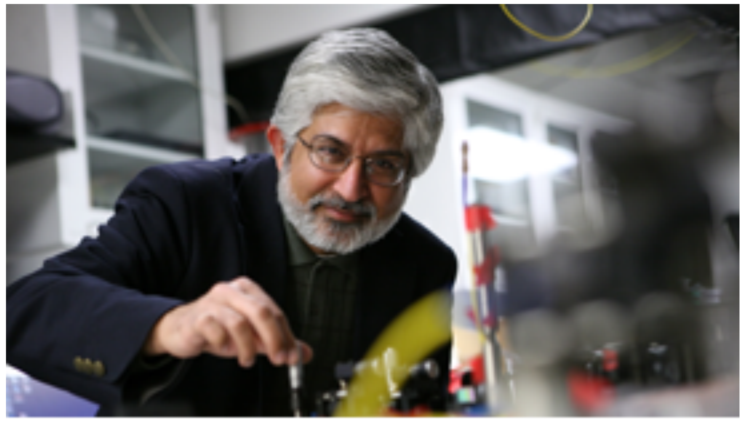
DeNolf, who has been giving Ford and Boeing monthly updates on the project, says such timelines have given him a good look at how the research is progressing. "It keeps you moving, and it really shows the application of the research," he says.

—Emily Ayshford

A step toward quantum computing

For now, full-fledged quantum computers are the stuff of science fiction

For now, full-fledged quantum computers are the stuff of science fiction — as in the 2007 blockbuster movie *Transformers*, in which the bad guys use quantum computing to break into the U.S. Army's secure files in just 10 seconds flat. But Prem Kumar and his research group are one step closer to realizing that technology, though for far better purposes. The group recently demonstrated one of the basic building blocks for distributed quantum computing using entangled photons generated in optical fibers.



Prem Kumar
(Photo by Andrew Campbell)

"Because it is done with fiber and the technology is already globally deployed, we think that it is a significant step in harnessing the power of quantum computers," says Kumar, the AT&T Professor of Information Technology in the Department of Electrical Engineering and Computer Science and director of the Center for Photonic Communication and Computing.

Quantum computing differs from classical computing in that a classical computer works by processing "bits" that exist in two states, either one or zero. Quantum computing uses quantum bits, or qubits, which in addition to being one or zero can also be in a "superposition" — or both one and zero simultaneously. This is possible because qubits are quantum units (like atoms, ions, or photons) that operate under the rules of quantum mechanics instead of classical mechanics. The "superposition" state allows a quantum computer to process significantly more information than a classical computer and in a much shorter time.

The field of quantum computing took off about 15 years ago, after mathematician and physicist Peter Shor created a quantum algorithm that could factor large integers much more efficiently than a classical computer. Though researchers are still many years away from creating a quantum computer capable of running the Shor algorithm, progress has been made. Kumar's group, which uses photons as qubits, found that they can entangle two indistinguishable photons in an optical fiber very efficiently by using the fiber's inherent nonlinear response to intense pulses of light. They also found that no matter how far you separate the two photons in standard transmission fibers, they remain entangled and are "mysteriously" connected to each other's quantum state.

Kumar's team used the fiber-generated indistinguishable photons to implement the most basic quantum computer task: a controlled-NOT gate, which allows two photonic qubits to interact. "This device that we demonstrated in the lab is a two-qubit device — nowhere near what's needed for a quantum computer," Kumar says. "So what can you do with it? It's nice to demonstrate something useful to give a boost to the field, and there are some problems at hand that can be solved right now using what we have."

Kumar has received funding for his group's next effort — a study of how to implement a quantum network for physically demonstrating efficient public goods strategies. He says such a network could help out with high-stakes auctions: For example, if the Department of Defense wanted to build an expensive airplane, it would send out a request for bids. No one company could build the entire airplane, and there could be 15 companies that can build some part of the plane, whether it's a navigation system or an engine. Instead of just giving the project to the lowest overall bidder, the government could save public dollars by allowing companies to make conditional bids. Maybe the engine company worked with the fuselage company before, and they could be more efficient and less expensive working together than other companies. The engine and fuselage companies could then send in conditional bids based on that possibility, along with bids covering other scenarios.

"Figuring out the best possible outcome is possible with quantum computers," says Kumar. "Based on these fiber-type gates that utilize entanglement, the auctioneer has an efficient way of determining optimal outcomes when bidders make conditional bids. When the computation is done, it reveals only the winning strategy, and all other bids disappear — even the auctioneer does not know who bid what. Secrecy of conditional bids can be paramount in high-stakes scenarios, since unauthorized revelations could jeopardize future relationships among cooperating parties."

Kumar says they hope to perform this experiment sometime in the next year. "The goal is to demonstrate the power of the computer," he says. "With this experiment we can demonstrate a few things that show the promise of quantum computing."

—Emily Ayshford

Stretching electronics

Yonggang Huang explores ways to make circuits more flexible

Yanggang Huang
(Photo by Andrew Campbell)

Circuits that can wrap around your arm. A camera based on the human eye. Electronic newspapers. These tantalizing technologies are not yet available to the public, but a partnership between Yonggang Huang, the Joseph Cummings Professor in civil and environmental engineering and in mechanical engineering, and John Rogers of the University of Illinois at Urbana-Champaign has brought them closer to reality.

Electronic components have historically been flat and unbendable because silicon, the principal component of all electronics, itself is inflexible: Any significant bending or compression renders an electronic device useless.

Huang and Rogers have new ideas on how to overcome this hurdle. The pair has created stretchable circuits that could be used for everything from wearable electronics to circuits that can wrap around an airplane's wings. And they've created a camera with a curved sensor array that's based on the design of the human eye, which gives a photograph a wide field of view with a greater range of focus. That technology — which uses "pop-up" wires to connect electrical components so they don't degrade when bent — could lead to further advances in the area.

"Stretchable and bendable electronics have many applications that could be available to the public within a few years," Huang says.

Bend, don't break

Their research had its first breakthrough in December 2005, when Huang and Rogers developed a one-dimensional, stretchable form of single-crystal silicon that could be stretched in one direction without altering its electrical properties. This year they extended that concept to two dimensions. To create their fully stretchable integrated circuits, the researchers began by applying a layer of polymer to a substrate. They then deposited on top of this layer another very thin plastic coating, which supported the integrated circuit. The circuit components were then crafted on the surface using both conventional techniques and nanoscale printing methods, which create tiny nanoribbons of silicon that are used as the semiconductor. Researchers wash away the initial polymer layer, leaving the complete circuit system with the plastic coating as a flexible substrate. It has a total thickness of about 1/50th the diameter of a human hair.

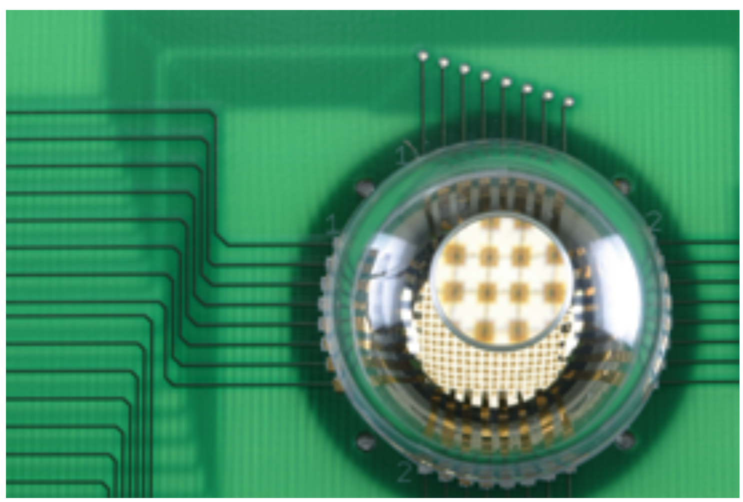
Next, this flexible, ultrathin circuit is bonded to a piece of silicone rubber that is prestretched, like a drumhead. When released, the rubber springs back to its initial shape, compressing the circuit. That compression spontaneously leads to a complex pattern of buckling, creating a two dimensional "wavy" configuration that allows the circuit to be folded or stretched in different directions to conform to a variety of complex shapes or to accommodate mechanical deformations during use.

Using this method, researchers constructed integrated circuits consisting of transistors, oscillators, logic gates, and amplifiers. These circuits can wrap around complex shapes such as spheres, body parts, and aircraft wings and can operate during stretching, compressing, folding, and other types of extreme mechanical deformations, all while maintaining electronic properties comparable to those of similar circuits built on conventional silicon wafers. Huang's research group is responsible for the mechanical analysis that guides the design of these circuits so they avoid mechanical failure and degradation of electrical behavior when stretched and bent.

That type of mechanical analysis also allowed Huang and Rogers to create a kind of camera based on the human eye — work featured on the cover of the journal *Nature* in August. This time around, the team created an array of silicon detectors and electronics that conformed to a curved surface. Like the human eye, the curved surface then acts as the focal plane array of the camera, which captures an image. On a normal digital camera, such electronics must lie on a flat surface, and the camera's complex system of lenses must reflect an image several times before it hits the right spot on the focal plane.

"The advantages of curved detector surface imaging have been understood by optics designers for a long time and by biologists for an even longer time," Huang says. "That's how the human eye works — using the curved surface at the back of the eye to capture an image."

Electronic eye



Exactly how to place those electronics on a curved surface to yield working cameras has stumped scientists, despite many attempts over the last 20 years. Huang and Rogers have established theoretical foundations and experimental methods, respectively, for an effective way to transfer the electronics from a flat surface to a curved one.

Huang and Rogers created a hemispherical transfer element made of a thin elastomeric membrane that can be stretched into the shape of a flat drumhead. In this form, planar (flat) electronics can be transferred onto the elastomer. Popping the elastomer back into its original hemispheric form enables the transfer of the electronics onto a hemispherical device substrate. Since silicon wafers can only be compressed 1 percent before they break and fail, a major challenge was finding a way to apply this process without catastrophic mechanical fracture in the brittle semiconductor materials.

Huang and Rogers got around this by creating an array of photodetectors and circuit elements that are so small — approximately 100 micrometers square — they aren't affected when the elastomer pops back into its hemispheric shape. Think of them like buildings on the Earth: Though flat buildings are built on the curved Earth, the area they take up is so small that the curve isn't felt. The tiny circuits on the array are connected by thin metal wires on plastic that form arc-shaped structures that Huang and Rogers call "pop-up bridges." These bridges interconnect the circuits and allow for the strain associated with return of the elastomer to its curved shape.

The researchers designed the array so that the silicon component of each device is sandwiched between two other layers, the so-called natural mechanical planes. That way, when the top layer is stretched and the bottom layer is compressed as in bending, the middle layer experiences very little stress. When tested, more than 99.9 percent of the devices worked after the elastomer returned to its hemispherical shape. Researchers found that the silicon in the devices was only compressed .002 percent — far below the 1 percent point where silicon fails.

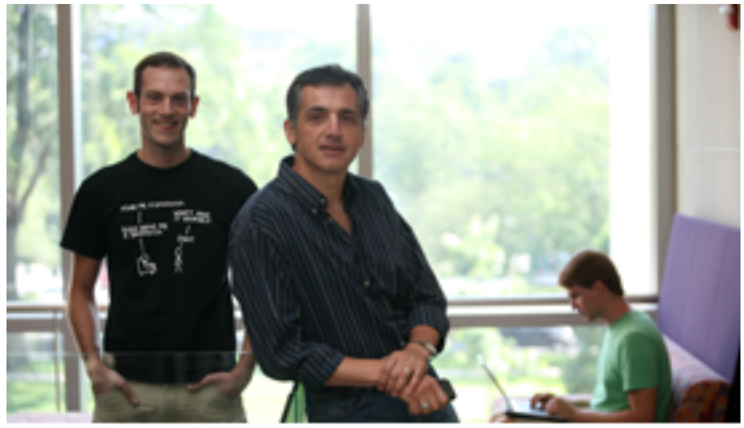
Early images obtained using this curved array in an electronic eye–type camera produce large-scale pictures that are much clearer than those obtained with similar planar cameras when simple imaging optics are used. “In a conventional planar camera, parts of the image that falls at the edges of the field of view are typically not imaged well using simple optics,” Huang says. “The hemispheric layout of the electronic eye eliminates this and other limitations, thereby providing improved imaging characteristics.”

Huang and Rogers will continue to optimize the camera by adding more pixels. “There is a lot of room for improvement, but early tests show how well this works,” Huang says. “We believe that this is scalable, in a straightforward way, to more sophisticated imaging electronics. It has been a very good collaboration between the two groups.”

—Emily Ayshford

Clearing the path

Identifying nearby computers to speed P2P traffic



David Choffnes and Fabian Bustamante
(Photo by Andrew Campbell)

In the early days of the Internet, traffic was low, and users could spend a lazy day driving through scant message boards and minimalist web sites. But with the explosion of music, video, and other file sharing, the Internet is becoming clogged with the virtual semitrailer traffic of downloading and uploading from across the globe.

Peer-to-peer (P2P) file-sharing services, which connect individual users for simultaneous uploads and downloads directly rather than through a central server, are reported to account for as much as 70 percent of Internet traffic worldwide. That level of use has led to a growing tension between Internet service providers (ISPs) and the P2P file-sharing services their customers use. And it has driven ISPs to forcefully reduce P2P traffic at the expense of unhappy subscribers and the risk of government investigations.

Now researchers at McCormick have discovered a way to ease that tension: Ono, a unique software solution that allows users to efficiently identify nearby P2P clients. The software, which is freely available and has been downloaded by more than 250,000 users, benefits ISPs by reducing costly cross-network traffic without sacrificing performance for the user. In fact, when ISPs configure their networks properly, Ono significantly improves transfer speeds — by as much as 207 percent on average.

Ono was developed by Fabián E. Bustamante, associate professor of electrical engineering and computer science, and PhD student David Choffnes, and it has been deployed for the Azureus BitTorrent P2P file-sharing client. “Finding nearby computers for transferring data may seem like a simple thing to do,” says Choffnes, “but the problem is that the Internet doesn’t have a Google Map. Every computer may have an address, but it doesn’t tell you whether the machine is close to you.”

Worse yet, the simplest solution to finding computers that are close to you requires measuring the distance to most of them — an operation that is too costly and time consuming to be practical.

Instead, Ono — Hawaiian for “delicious” — relies on a clever trick based on observations of Internet companies like Akamai (Hawaiian for “clever,” incidentally). Akamai is a content-distribution network (CDN) that off-loads data traffic from web sites onto their proprietary network of more than 10,000 servers worldwide. CDNs such as Akamai and Limelight power some of the world’s most popular web sites and enable higher performance for web clients by sending them to one of those servers in close proximity. Using the key assumption that two computers sent to the same CDN server are likely close to each other, Ono allows P2P users to quickly identify nearby users.

Ono is different from other software applications that address the conflict between ISPs and P2P traffic (see, for example, the recently announced partnership between Verizon and P4P) because it requires no cooperation or trust between ISPs and P2P users. Ono is also open source and does not demand the deployment of additional infrastructure. Bustamante's Aqualab research group made Ono publicly available in March 2007 and recently published code that makes it easy to incorporate Ono services into other applications. "The more users we have, the better the system works, so we're just trying make it easy to spread," says Bustamante.

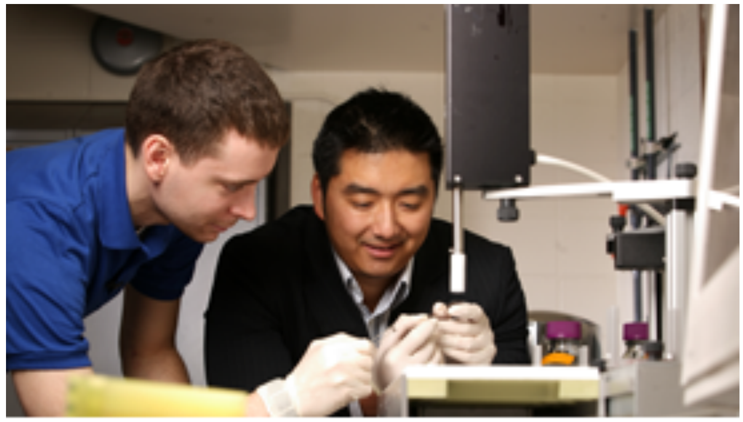
Since news of Ono first hit the media (including being featured on the popular technology blog Slashdot.org) in May 2008, the number of users has grown from 130,000 to over 250,000. Most recently, the team has created and made available NEWS, a new plug-in for Vuze/Azureus BitTorrent clients that allows peers to cooperatively detect network problems and unfriendly ISPs. In just a couple of months and without any publicity, the new service has already been downloaded by more than 7,000 users.

To learn more about Ono (and other related source code), visit the Aqualab web site at http://aqualab.cs.northwestern.edu.

—Kyle Delaney

Tiny diamonds, big impact

Dean Ho's gem of a drug-delivery system hides as it heal



Dean Ho
(Photo by Andrew Campbell)

Diamonds and cloaks are the treasures and tools of jewel thieves, not professors. But when researchers use them on a much smaller scale, diamonds can help deliver drugs inside the human body, and cloaks in the form of polymer films can help shield the medicine from the body's immune system and healthy cells.

Dean Ho, assistant professor of biomedical engineering and mechanical engineering at McCormick, has used these tools on a nanometer scale — or one billionth of a meter — to deliver chemotherapy to patients and to localize and disguise drugs from the immune system.

Nanodiamonds have a carbon structure similar to that of the diamonds we see in jewelry — but with a diameter of two to eight nanometers, hundreds of thousands of these nanodiamonds could fit onto the head of a pin. Ho and his research team aggregated clusters of 50 to 100 nanodiamonds and then loaded the chemotherapy drug on the surface. The drug remains inactive until the cluster reaches its target, when the cluster breaks apart and slowly releases the drug.

Researchers say that the clusters are ideal for carrying chemotherapy because they shield the drug from normal cells and prevent problems that plague current drug-delivery systems — such as inflammation, which can block the drug's effectiveness and even promote tumor growth.

After the research was published it received nationwide media attention, including mentions in more than 100 outlets, such as CNN and United Press International.

In another study, Ho, along with researchers from Northwestern and UCLA, coated tiny chips with layers of the nanoscale polymer films, about four nanometers per layer, to build a sort of matrix or platform to hold and slowly release the anti-inflammatory drug Dexamethasone. The films act like an invisibility cloak, hiding the chips from the body's defenses.

The coated chips were implanted in one group of mice and compared with a second group without implants and a third with uncoated implants to assess immune response. Researchers found that the coated implants suppressed the expression of cytokines, proteins released by the cells of the immune system to initiate a response to a foreign invader. By contrast, the uncoated implants generated an inflammatory response from the surrounding tissue, which ultimately would have led to the body's rejection of the implant and the breakdown of its functionality. Tissue from the mice without implants and the mice with the coated implants was virtually identical, proving that the nano-cloaked implants were effectively shielded from the mice's defense system.

“For chemotherapy, this system could enhance treatment efficacy while preventing uncontrolled delivery and the resultant patient side effects,” Ho says.

“Furthermore, as implantable devices continue to find widespread application in cardiovascular medicine, neural disorders, and diabetes, the nano-cloaking capabilities can serve as a widely applicable approach to extend the lifetime of these devices. This would eliminate unnecessary surgeries and enhance the efficiency of patient care.”

Ho recently received the Wallace H. Coulter Foundation Early Career Award for Translational Research. The award allows Ho to explore the application of devices that combine nanodiamond clusters and nanoscale polymer films to treat complications (e.g., inflammation and scarring) associated with open heart surgery.

“Nanotechnology is changing the face of drug treatment strategies,” Ho says. “We’re hoping our research will inspire new applications for nanomedicine that stand at the forefront of biology and engineering.”

—Emily Ayshford

A leader who listens

Neil J. Pedersen's rules of the road

Neil Pedersen

From energy issues and environmental concerns to major financial strain, the nation's transportation experts are increasingly faced with daunting challenges. As administrator of the Maryland State Highway Administration and a leader in the national transportation research and policy arenas, Neil J. Pedersen (MS civil and environmental engineering '76) is at the forefront of these challenges.

"He's the go-to guy," says Joseph L. Schofer, professor of civil and environmental engineering and associate dean at the McCormick School, who served as master's thesis adviser for Pedersen while he was a McCormick graduate student in 1975. Like Pedersen, Schofer is very involved with the Transportation Research Board, where over the years the two men have served on a variety of committees together.

"Everywhere I turned, I ran into Neil, and he is always the consummate professional," Schofer says. "He is always the guy they ask to be chairman. He is very even-handed, a good listener, and extraordinarily fair. He is the kind of guy I like to point to when talking to my current graduate students as an example of where you can go in your career with the right skills and the right attitude."

Pedersen is quick to credit Schofer and his McCormick education for his achievements — particularly as they relate to his ability to "critically think through the issues, analyze, and ultimately understand what's important in making a decision." As the head of a state highway administration of a populous and highly political area, Pedersen has had more than his share of difficult and high-profile decisions.

"Engineers love to solve problems, and I get to solve really big problems now," Pedersen says. "I enjoy being given a huge challenge, sometimes an almost intractable challenge, and I especially like the process of going through consensus building and trying to find the win-win solution."

Pedersen has found win-win solutions when others said it couldn't be done. From the award-winning Woodrow Wilson Bridge project, which was recognized for revitalizing a crossing that had stalled travel in the Washington, D.C., region for decades, to the Intercounty Connector, which his team made a reality after it languished for 50 years in a purgatory of planning and pronouncements of impossibility, Pedersen's stewardship has led to a number of major accomplishments. The list of his awards — including the Thomas H. McDonald Memorial Award, George S. Bartlett Award, and the American Planning Association's Planner of the Year Award — as well as his numerous professional activities and publications — are a powerful measure of Pedersen's success.

"I'm just overwhelmingly impressed with what he's been able to achieve," Schofer says. "It's really a thrill to be in a professional setting and hear people talk about him in a revered way. I take great pride in having a connection with him."

Key to the highway

Public service was always a draw for Pedersen, who says that upon graduation from McCormick he thought his ideal job might be a planning director for a state department of transportation. After working as a private consultant for seven years, he made the switch to the public sector when he was tapped to serve as the deputy director for planning and preliminary engineering for the Maryland State Highway Administration. Two years later, at the age of 32, he was named planning director, essentially meeting what he thought was his ultimate career goal. He served in that role for 16 years, before being named administrator in 2003.

Then and now, Pedersen finds great satisfaction in his job: "What fulfills me is making a difference in improving the quality of life for people, and better mobility makes so many other opportunities possible."

Pedersen credits his listening skills as an essential element of his success. An active mentor and cosponsor of an advanced leadership program, Pedersen says his number 1 message in helping others understand the challenges of successful leadership is to learn the real value of listening. "It's not just listening to the words. It's really understanding the message people are trying to deliver. I spend time trying to validate everyone's message and making sure I understand their goals. That's how we build common ground and work together in a room full of disparate points of view."

The fact that Pedersen has served as the state's top highway official not only through leadership changes, but also through party changes in the governor's office is a testament to his communication skills and diplomacy. "I attribute my being fortunate enough to survive a party change to a decision I made a long time ago. I decided as long as I was in a responsible position in a government agency, I would be most effective by maintaining a sense of professional, nonpartisan objectivity," explains Pedersen.

That ability to approach complex decisions with a sense of objectivity goes back to his studies at Northwestern, and particularly his work with Schofer, Pedersen says. Schofer was the author of a national transportation research study considering evaluation methods for effective decision making, which Pedersen remembers as a great learning tool in both the classroom and his thesis work.

Facing the future

One of Pedersen's areas of interest in transportation research relates to developing more effective processes for project development and approval. "We've gotten to the point in the system where the whole approval process takes years and years," he laments. Environmental stewardship is another area of importance, Pedersen says, noting that issues such as climate change will and should drive key research in the immediate future and for years to come.

An additional challenge that worries Pedersen is ensuring that enough young people are attracted to careers in transportation. "I am concerned that we are not seeing as many high-caliber people interested in the field — particularly in public sector careers," he says. Pedersen's volunteer work and leadership is focused on trying to get more high school students interested in engineering related to transportation.

"He's an exceptional role model," Schofer says, citing Pedersen's strong technical base in engineering and his powerful ability to reason out logical decisions. "He has such a global grasp of problems. I think he brings great power to his position."

Pedersen traces his success back to McCormick. "My time at Northwestern probably prepared me for executive decision-making work in the public sector better than any other part of my background," Pedersen says. He remembers clearly deciding to pursue graduate studies at McCormick when he also had the opportunity to attend prestigious programs at Berkeley and MIT.

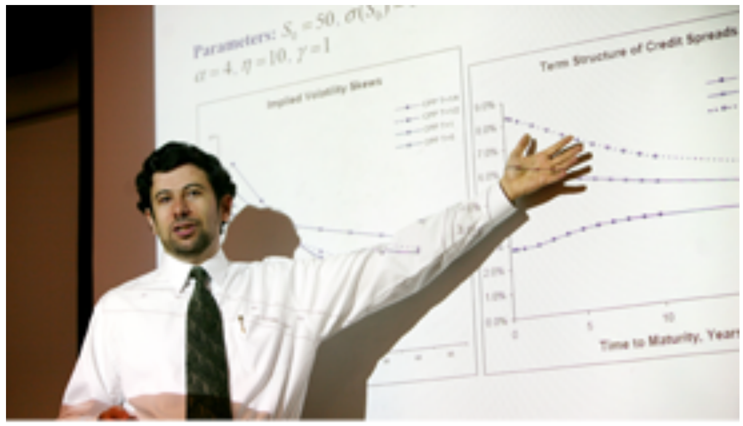
"I often reflect back on the difficult decision of where to attend grad school," he says, "and I'm absolutely convinced I made the right one. Beyond the technical expertise, I think Northwestern did a good job of teaching me to look at the big picture and stay grounded in the reality of what's actually happening and the situation at hand."

—Susan White

Risk averse

Financial engineers model the financial world

It has been called the worst financial crisis since the Great Depression: consumers and banks suffering from the subprime mortgage crisis, airlines reeling from high oil prices, financial institutions like IndyMac, Bear Stearns, and Lehman Brothers collapsing, investment banks restructuring.



Vadim Linetsky
(Photo by Sally Ryan)

What were the chances of this happening? Could better risk models have prevented these crises? These are questions for which financial engineers Vadim Linetsky and Jeremy Staum seek answers.

Financial engineering is an interdisciplinary field that integrates methods and knowledge from mathematics, statistics, economics, operations research, and computer science. Financial engineers develop quantitative tools that help banks, manufacturing and service firms, and public institutions make disciplined financial decisions in the face of risk and uncertainty. Financial engineers also devise computational algorithms to implement these tools and calibrate them to financial market data.

Gauging financial risk

Staum's research group focuses on big-picture risk, creating computer simulations that can model an entire financial institution's risk. Global financial institutions have large portfolios that include investments in different parts of the world and in different markets. To consider the risk of that entire portfolio, an institution must take into account factors such as stock prices, interest rates, exchange rates, and credit risk. Above all, the financial institution must consider the chance that it will become insolvent. "That's when people start worrying about major banks or hedge funds going bankrupt, and the talking heads on TV are saying the entire financial system might seize up," says Staum, who is an associate professor of industrial engineering and management sciences. "What we're seeing now are the extremely severe consequences of using inadequate risk models. This is the extreme scenario that shows financial institutions that they should invest in risk management technology in order to hold adequate capital reserves to absorb possible losses from their portfolios."

Most financial institutions focus on protecting against losses 99 percent of the time. But there is no good model that shows what could happen under extreme scenarios, so banks are often unprepared when extreme events happen. "It's very difficult to model everything because of all the interdependencies and correlations," Staum says.

Part of the problem lies in computing. Much of the financial world relies on simpler models because they take less computing time and are cheaper to implement. Those models say that extreme events are highly unlikely, so institutions often can get comfortable with those models and then fail to prepare for the worst.

That was the mistake made by Long Term Capital Management, a hedge fund that collapsed in the 1990s. “That was one instance where the model was an utter failure,” Staum says. “Over the past 11 years we have faced crisis after global financial crisis in which people’s risk models broke down, including the dot-com bubble and the current mortgage crisis. That led people to say we need to develop better models. With the current events, it’s like when a bridge collapses — nobody says we’d better stop building bridges. They say, We really better figure out how to build safer bridges. So we really need to figure out how to create better risk management models.”

The computation required to create better models is challenging and expensive, so Staum and his team are looking for more efficient algorithms to make the computing faster and cheaper. They are also working to combine several models and, looking at the degree of plausibility from each model, using that information to get a better picture of the risks that an institution faces.

Understanding credit risk

Vadim Linetsky, professor of industrial engineering and management sciences, focuses on modeling credit risk. Credit risk is the risk of default by a corporation or an individual on a financial obligation, such as a bond, loan, mortgage, or pension. Linetsky’s work is distinctive because it creates a model that combines both market and credit risk. His current focus is on risk in financing an asset acquisition, such as a real estate mortgage or an aircraft mortgage. He is working with the global aviation industry on creating better models to assess risk in aircraft mortgages — loans to airlines to purchase aircraft.

Jeremy Staum
(Photo by Sally Ryan)

Lenders financing such a purchase face the risk that the airline will default on its loans — a risk that heightens when oil prices go up. If the airline defaults on the loan, the lender will have to repossess the aircraft and try to sell it to another airline — which, since airline bankruptcies tend to cluster during the times of economic downturns, is exactly the time when the market for used aircraft is depressed. Therefore the risk of airline’s default and the risk of aircraft market price decline are closely linked.

Linetsky is creating probabilistic models that consider this relationship between market and credit risk. Based on his risk models, he is modeling how much interest a financial institution should charge to finance the purchase of an airplane, and he is creating models that manage the risk of that liability over the life of the loan. “Banks need to make sure they have adequate capital reserves to cover losses,” he says. “It can get complex.”

It gets even more complicated when a government provides export credit guarantees to foreign purchasers of domestically manufactured aircraft. In that case, if an airline goes into bankruptcy and defaults on its aircraft mortgages, the government can seize the aircraft and sell it. Linetsky currently works with the industry to create better models to evaluate commercial aircraft loans and come up with fair premiums for these export credit guarantees.

Linetsky believes that his work on modeling aircraft mortgages can be extended to model the risk in residential home mortgages as well as in financing other types of assets, from real estate to mobile equipment to energy generation assets.

In addition to credit-risk models, Linetsky has also developed an interest-rate model called the Black-Gorovoi-Linetsky (BGL) model that was eventually adopted by the Bank of Japan, that nation's version of the Federal Reserve. Linetsky is also creating a model for highly volatile commodity prices, such as oil, and he and his PhD students use so-called mean-reverting jump processes to model violent price spikes observed in commodity and energy prices.

—Emily Ayshford

Ethnographic engineering

Paul Leonardi learns by watching others work

Paul Leonardi
(Photo by Andrew Campbell)

As an undergraduate, Paul Leonardi studied in Spain, learning the language, seeing the sites — and eventually asking himself a question that would shape his career.

"I noticed that many people in Spain were using cell phones, while in the United States at the time, I didn't know anyone with a cell phone. People there would ask for my cell phone number, which I didn't have, and I would ask for their e-mail address, which they didn't have," Leonardi says. "I wondered why it was that everyone I knew in the United States used e-mail while everyone in Spain seemed to use cell phones."

What started as a simple question sparked an interest in the intersection of culture and technology: why we adopt some technologies and not others, and how we might be able to implement even better technologies. It was a question that led him to graduate school — first a master's program and then a doctoral program in management science and engineering at Stanford — before it brought him to Northwestern, where he is the Breed Junior Professor of Design in McCormick's Department of Industrial Engineering and Management Sciences and the Department of Communication Studies at the School of Communication.

In his quest to understand how technologies, cultures, and organizations interact and affect each other, Leonardi quickly focused on engineers. "I wanted to determine how engineers could develop technology better and how organizations could be designed to use technology better," he says.

Much of his recent work has been in the auto industry. He studies how automotive engineers use finite element analysis and simulations to improve their efficiency and how organizational changes can help make new technologies more effective.

To begin his research, Leonardi watches engineers in action, following them to meetings, watching over their shoulders as they work, and conducting interviews and surveys, all the while taking copious notes. "As an ethnographer, I spend a lot of time observing people doing their everyday work to better understand their constraints and opportunities," he says. "I go into a company and spend six months to a year observing engineers."

Leonardi's subjects are quite willing to share information and often provide meaningful insights. "If you think about it, people spend the majority of their lives at their workplace. How often is it that you go home and someone asks you with genuine interest, 'What did you do today?' and actually wants to know every little detail?" he says. "People relish the opportunity to talk about their work, to show you what's good and what frustrates them on a daily basis."

Leonardi uses this data to understand how organizations can better use new technologies. "Some of the most rewarding experiences for me are giving presentations to senior management at the companies I study," he says. "I tell them, 'Here's what your engineers do every day, and here is why they perform these activities.' They often look at me and say, 'Are you kidding?' I can show them the evidence, then make suggestions to develop new tools or to refocus the engineers' work. Managers may think that the engineers are just afraid of new technology or stuck in old ways, but ethnography allows us to step back and look at the principled reasons why they might reject a technology."

Leonardi is working to revitalize behavioral sciences research in industrial engineering and management sciences. Along with Noshir Contractor, the Jane S. and William J. White Professor of Behavioral Sciences, he is building strong connections with the School of Communication and with the Kellogg School of Management. He says behavioral science is an area that allows industrial engineers to make more meaningful contributions.

"My colleagues in IEMS need to make assumptions about how people behave — in order to create models," Leonardi says. "We're interested in gathering empirical data to provide a concrete understanding of what people are likely to do and why they might do those things, which makes those assumptions more accurate and, ultimately, will lead to more useful models."

—Kyle Delaney

Powering student projects

Each year, members of the Walter P. Murphy Society fund student and faculty project proposals ranging from student-group projects to new laboratory gear to the development of new course work. These stories follow the trials and successes of two Murphy-funded student projects.

Down to the wire in a solar car

On a rural highway somewhere between Texas and Canada, Patrick Markan (mechanical engineering '09) watched as people gawked. They waved. They slowed down to stare. They pulled ahead onto the shoulder and got out their cell phone cameras, clicking away as the car rolled past.

(Photo by Steve Anzaldi)

Then they drove off — burning gas, spewing exhaust — to the next gas station to fill up, while Markan and the rest of the Northwestern University Solar Car Team continued on, using only sunlight and battery power to make their way across the continent.

The team was participating in the North American Solar Car Challenge, in which 15 college teams raced solar-powered cars from Plano, Texas, to Calgary, Alberta, over 10 days last July. The Northwestern team placed 13th in the race, overcoming a fried motor controller and a blown-out tire to coast to its best finish ever. The race was two years in the making for the Northwestern team. Building a solar car requires not only a year of design work but also endless hours of fundraising, getting donated equipment, and reaching out to teach about the possibilities of solar power.

Before the team could get on the road, however, they had to finish another race: completing the car. Critical suspension components for the vehicle — called sc5 — arrived just a month before the race, and team members were still waiting on donated equipment needed to actually drive the car. It all arrived within the next two weeks. "Luckily, the first time we put it all together, it worked fine," Markan says.

The car runs by capturing solar power using solar cells. When sunlight isn't abundant, it runs on a lithium ion battery — which means team members had to consider sunlight and battery power to determine how fast and long they could go each day.

Each morning during the Solar Challenge, team members charged the car's batteries from 6:30 to 8 a.m. Then they drove until 6 p.m. before spending the evening charging the battery and working out bugs. Each driver drove up to six hours, while the other team members drove in vans in front of and behind the car; an additional truck pulled a trailer to haul the solar car, if it came to that.

“It was pretty exciting,” Markan says. “You’re always monitoring what’s going on with the car, deciding how fast to go, looking at the weather. Inside the car, the motor was really loud, and in Texas it got pretty hot.”

The race took the cars along secondary highways, where team members sometimes had to pull over to let traffic pass. That’s where the gawkers came in. “Some would just ride alongside us at 30 miles per hour and look out the window and wave,” Markan says.

In the end, the team finished the race in 113 hours and 58 minutes to take 13th place — Northwestern’s best finish in its 10-year history with the race. This sc5 car will spend the rest of its days at outreach events, and team members hope to tend to details that they never got to before the race — like installing a speedometer.

“We learned a lot,” Markan says — and now they’re passing that knowledge on to the new team members who ogled the car at a new member kickoff meeting in September. The learning began immediately — the team will waste no time before beginning work on a sixth-generation solar-powered vehicle, which will race during the summer of 2010.

Shuttle buses go green — with a little help from the deep fryer

(Photo by Sally Ryan)

Every week the dining halls on Northwestern’s Evanston campus produce nearly 170 gallons of waste vegetable oil. In the same amount of time, intercampus shuttles use anywhere from 200 to 300 gallons of diesel fuel to transport students and faculty between the Evanston and Chicago campuses.

Math and logic point to a possible solution: adapt the shuttle buses to run on vegetable oil instead of diesel fuel. Implementing such a change has been years in the making, and recently a group of Northwestern students found that even great plans take a lot of work.

The idea to have the buses run on the oil was proposed two years ago by Engineers for a Sustainable World, a Northwestern student group that works to reduce poverty and improve global sustainability. Aaron Greco, a PhD student in mechanical engineering working on the project, can quickly list the benefits of such a system: The emissions are cleaner, with no sulfur and fewer particulates, and the net carbon contribution to the environment is significantly less than that of diesel-fueled buses.

Since the idea first blossomed, students in both Engineering Design and Communication and Segal Design Institute courses — taught by both McCormick and Writing Program faculty — have worked on various aspects of the project, from oil-quality testing to cost analysis. Though student teams got off to a good start on the project, many of their ideas, as often happens, just didn’t work out. Last winter a team made up of Charles Weschler (political science ’08), Rebecca Hoo (biomedical engineering ’09), and Ji Hun Lee (industrial engineering ’10) took on the project and came up with a whole new operation, from collection to filtration to distribution.

Their plan works like this: Each week three students take a University-owned truck and drive around to gather the 55-gallon drums of waste vegetable oil from dining halls. They then pour the oil into a large vat that acts as the first step of the filtration system. They let the oil settle for a week — allowing the large particles of food and sludge to sink to the bottom — before pumping out the top oil through a small filtration system. The result is vegetable oil with no water or particles larger than five microns in size — clean enough to run a modified diesel engine.

In fact, the team created a prototype diesel engine that runs on vegetable oil and gives off not the odor of diesel fumes but rather the scent of campus-staple French fries. But what's a little fried-food smell compared to a cleaner, more sustainable system? "It saves hundreds of dollars a week in diesel fuel," Hoo says.

While developing the operation, students say that, in addition to learning about the fine points of filtration, they learned about dealing with systems and people. "We learned how to create a system from scratch," Weschler says. "It was the first time I helped create something that was working in real time and had a real-life application."

The team also learned about compliance with regulations — like the rule that only certain colored barrels can be used — and learned that the most important part of executing a plan is often not the plan itself. "We ran into problems in terms of communication, so I think we learned how to better coordinate that," Lee says. Managing the needs of the food service company, the bus company, and the University can be a job in itself, he says.

The last hurdle is converting the engine of the bus to run on the vegetable oil. The vegetable oil is much thicker than diesel, so the bus will need a conversion kit that uses the heat of the engine to thin the oil. "It's actually not a major overhaul of the engine," Greco says.

In the long run, the group hopes that the project will become part of the University, with students donating a few hours each week to make the system work.

"This project demonstrates an alternative that improves the sustainability of the traditional system," Greco says. "By taking a waste product (used cooking oil) that is expelled from the campus and then reintroducing it into the campus system to be used as fuel for the buses, we are not only eliminating a campus waste stream but also reducing our demand for a nonrenewable resource. We hope this project will ultimately bring awareness to sustainability and to how these solutions can benefit the environment and the University."

—Emily Ayshford