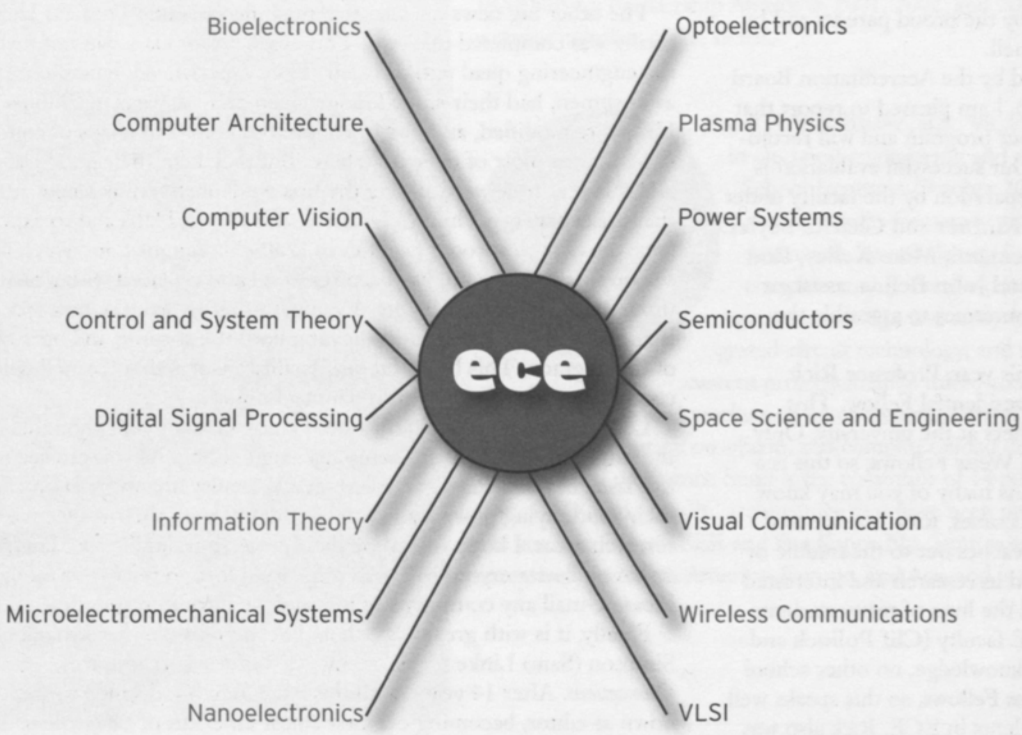
CONNECTIONS

A Report from the School of Electrical and Computer Engineering • Cornell University

Prospects for Future Research
in the School of Electrical and Computer Engineering



This sketch lists the major areas of current teaching and research in the Cornell School of Electrical and Computer Engineering. Comparison of these topics with similar listings of past years clearly indicates the difficulty of predicting the future of the discipline. Still, six members of the ECE faculty, based on their knowledge of their individual areas, have attempted projections of developments in the fields indicated in red in the sketch. Their efforts are presented in the articles in this issue.

Sketch courtesy of Sam Linke.

Cornell University
College of Engineering

This 14th edition of *Connections* features the results of the "SEERS Project," a challenge to the ECE faculty to examine their respective areas and attempt a forecast of possible new developments and prospects for future research. The thoughts of six faculty members who responded are recorded in the following pages. Future editions may contain predictions by other members of the faculty. The "Positive Feedback" section contains news of recent alumni activities. Other items of interest to alumni are listed below in the table of contents. Please fill out the information coupon on page 22 of this report, clip it, and mail it to us. We want to hear what you are up to.

***Simpson (Sam) Linke**, editor*

Fall 2005
In This Issue

Report from the Director

I started writing this near the end of May as we were preparing for graduation. After a long winter, not unusual for Ithaca, when all the trees and bushes finally leaf out, the Cornell campus is at its most beautiful. The explosion of green and the flowering of the dogwoods is metaphorical with our graduation: a long period of hard study and then suddenly it's finished and our students' thoughts turn to new directions and possible careers. I always enjoy this time of year, both for the natural beauty that comes with winter's retreat and for the natural celebration experienced by the proud parents and by our students as they graduate from Cornell.

In November 2004, we were evaluated by the Accreditation Board of Engineering and Technology (ABET). I am pleased to report that our inspector was very impressed with our program and will recommend accreditation for six more years. Our successful evaluation is the result of many months of careful preparation by the faculty under the overall guidance of Professors **Paul Kintner** and **Charles Seyler**. Professors **Adam Bojanczyk**, **Sheila Hemami**, **Mike Kelley**, **Ron Kline**, **Rajit Manohar**, **Farhan Rana**, and **John Belina**, assistant director, worked tirelessly on special committees to assemble the required documentation for the visit.

Our faculty received several honors this year. Professor **Rick Johnson** was named a Stephen Weiss Presidential Fellow. This honor is given to truly outstanding teachers at the university. Only three faculty members a year are named Weiss Fellows, so this is a particularly selective and special award. As many of you may know from firsthand experience in one of his courses, Rick is a rigorous and demanding teacher. But he always reaches out to the middle of the class and gets those students involved in research and interested in a deeper education. Rick has changed the lives of many students. He joins two other members of the ECE faculty (**Clif Pollock** and **Mike Kelley**) as Weiss Fellows. To my knowledge, no other school or department at Cornell has three Weiss Fellows, so this speaks well for the undergraduate experience of students in ECE. Rick also was named a Fulbright scholar and will spend a sabbatical leave in France next year working on telecommunication problems at Conservatoire national des arts et métiers in Paris. Professor **Kevin Kornegay** was honored twice this year. He was selected as one of the 50 most influential Black researchers by *Science Spectrum* magazine. The citation is based on sustained impact of his work on society. Kevin is a leading expert on radio frequency integrated circuits, and he heads a group of 10 students and researchers on designs for broadband wired and wireless circuits. He later was honored by the National Society of Black Engineers with the Janice Lumpkin Award as Outstanding Educator of the Year. You may have noticed a nice article on Kevin in the June issue of the *IEEE Institute*. Professor **Bob Thomas** has received the 2005 IEEE/PES Outstanding Power Engineering Educator Award. This award is made annually to a member of the Power Engineering Society for excellence in teaching. Professor **Alyssa Apsel** was named on the *MIT Technology Review* TR-100 list as one of the world's young innovators whose work has transformed society. Alyssa works on high-speed optical interconnects for communication between and on chips. She also has organized a popular seminar series on VLSI that meets several times each semester.

Among our retirees, two former ECE directors are now emeritus professors. Jim Thorp retired last summer after being at Cornell for 50 years. He started as a freshman in 1954 and retired as a chaired professor and former director in 2004. Similarly, Joe Ballantyne retired after 40 years on the faculty. He also served as director of EE, director of the Cornell Nanofabrication Facility, and vice president for research and advanced studies at Cornell.

The other big news for our current students is that Duffield Hall finally was completed this year. This year's senior class had not seen the engineering quad until this fall. They experienced dynamite blasts as freshmen, had their study lounge taken away as parts of Phillips Hall were modified, and had to endure the noise and chaos of construction for most of their time here. But they kept their good humor, and this year they were among the first students to enjoy a new atrium that exists between Phillips, Duffield, and Upson Halls and to experience the new cleanroom facilities in Duffield. Knight Lab, which held the original cleanroom, has been removed and replaced with a facility three times larger than before. Even with this growth the new space is already crowded, thereby indicating both the wisdom and necessity of the upgrade. This beautiful new facility ensures that Cornell will continue to be an innovator in nanotechnology.

Let me ask a favor of you. I would enjoy hearing your thoughts on the future of electrical and computer engineering. As you can see in this issue of *Connections*, we asked several faculty members to practice their soothsaying powers and predict the future of their respective research areas. I hope you enjoy their projections and if you disagree, or have a better crystal ball than ours, we'd love to read your opinions. Please e-mail any comments to me, and we'll try to respond.

Finally, it is with great warmth and deep gratitude that I thank Simpson (Sam) Linke for his many years of work as editor of *Connections*. After 14 years, with this issue Sam has decided to step down as editor, becoming our first editor emeritus of *Connections*. Sam was the founding editor of this publication and has nurtured each issue from cradle to mailbox. He is an exemplar of how to put the past of our great institution in context with the emerging developments of our exciting future. John Belina bravely has agreed to pick up the editorial pen for *Connections*, and we all know John will do a great job, but he has enormous shoes to fill. Thank you, Sam, for your hard work and devotion to your school and to your field. Our best wishes to you and Esther as you enter your well-deserved second retirement!

Clifford R. Pollock
Ilda and Charles Lee Professor of Engineering
Director, School of Electrical and Computer Engineering

Editor's Note

I wish to announce that next year the new editor of *Connections* will be **John Belina** '74 B.S.E.E., '75 M.E.E. Back in 1992, Director **Noel MacDonald** asked me to undertake production of an annual newsletter for distribution to alumni of the EE/ECE School. *Connections* evolved from that first issue. Someone has said that after a publication has endured for 10 years it becomes an institution, and indeed after 14 years it has certainly attained that status. It has been a distinct pleasure to have served as your editor for all these years. I am sure that John will do an excellent job in the task of keeping ECE alumni informed about school activities.

***Simpson (Sam) Linke**, editor*

Newcomers

David H. Albonesi, B.S.E.E. '82 (U. of Massachusetts, Amherst), M.S.E.E. '86 (Syracuse U.), Ph.D. '96 (U. of Massachusetts Amherst, electrical and computer engineering), is an associate professor of electrical and computer engineering. He joined the Computer Systems Laboratory at Cornell after spending eight years (1996–2004) as a faculty member at the University of Rochester where he led the Complexity-Adaptive Processing project. From 1982 to 1992, he held technical and management positions at IBM Corporation and Prime Computer, Incorporated, working on memory hierarchies and shared memory multiprocessors. His current research interests include adaptive microarchitectures, multithreaded processors, and power-efficient robust computing. David received the National Science Foundation CAREER Award in 1997 and IBM Faculty Partnership Awards in 2001, 2002, and 2003. He holds seven U.S. patents and is a senior member of the IEEE.

Sunil Ashok Bhave, B.S. '98, Ph.D. '04 (U. of California at Berkeley in electrical engineering and computer sciences), joined the ECE School faculty in October 2004 as an assistant professor. His expertise is in radio-frequency microelectromechanical (RF MEMS) resonators for cellular applications, development of integrated complementary metal-oxide semiconductor (CMOS) MEMS processes, design and analysis of microsensors using silicon integrated-circuit technology, and post-PC microarchitecture design. His current projects include micro-mechanical signal processors for wireless communications and mechanical computation, merged nanoscale-resonator/CMOS oscillators for clock distribution on silicon, and computer-aided design (CAD) for synthesizing filters and mode-locked oscillators. Sunil is the co-author of 14 publications in RF MEMS, inertial sensors, CAD, and post-PC architecture that have been presented at conferences and workshops. He is a member of IEEE and Eta Kappa Nu. Sunil is an avid photographer who has traveled extensively in North America, Europe, and Asia and is a 3.5-division squash player.

Enrollment and Graduation Statistics

Undergraduate Program

Year	Sophomores	Juniors	Seniors	Degrees
02-03	115	172	188	179
03-04	110	159	164	153
04-05	122	142	145	145

M. Eng. (Electrical) Program

Year	August	January	May	Degrees
02-03	28	11	68	107
03-04	18	17	68	107
04-05	21	6	35	62

M.S./Ph.D. Program

Year	Applicants	Admissions	Total Enrollment	Degrees
02-03	810	26	194	17 Ph.D., 13 M.S.
03-04	625	26	186	27 Ph.D., 7 M.S.
04-05	808	40	182	33 Ph.D., 4 M.S.

Note: Undergraduate students now affiliate with the ECE School when the first semester of sophomore math and physics is completed.

These figures indicate that over the past three years the undergraduate program has decreased moderately, the M.Eng. (Elec.) program has decreased significantly, and M.S./Ph.D. enrollment has remained unchanged on average.

The Promise of Biomedical Electronics

John Belina

Imagine a future world in which the general public has ready access to innovative biomedical devices based on foreseeable advancements in electrical engineering, computer engineering, materials science, chemistry, and mechanics. A prediction of the possibilities may be challenging but is aided by the current state of many related technologies being closer to reality than to science fiction. Research labs today contain prototypes that may be commercialized into revolutionary equipment for health care in the next generation.

Additions to the biomedical armamentarium over the next 20 years will involve two major categories of device innovation: diagnostic and treatment. As always, diagnostic devices will exit the research laboratory environment relatively quickly and may become truly disruptive technologies—the way computed axial tomography (CAT) scan and scanning and magnetic resonance imaging (MRI) have replaced the need for many exploratory surgeries. Newly emerging diagnostic instruments may completely negate the need for more invasive diagnostic procedures in common use today. As imaging equipment attains new levels of resolution, the ability to perform "electronic biopsies" will be possible for many abnormal growths within the human body. Many such growths are benign and harmless; others are invasive and demand prompt treatment to effect a total cure. A day may come when part of a yearly physical examination is a full body scan that can locate millimeter-sized abnormal growths and mark them as benign, malignant, or "to be investigated further or watched carefully." Since cure rates depend heavily on early detection, these new total body scans will save countless thousands of lives per year when introduced into customary practice.

An important area of the treatment-device category involves the repair and replacement of occluded coronary arteries—the blood vessels that keep our hearts beating constantly over our lifetime. Cardiac disease is the largest cause of mortality in the United States and many other countries. Simpler, yet effective repairs of the damage occurring over a lifetime will have a major impact on quality of life. Robotic surgery, combined with advances in motion imaging detection, will allow replacement of damaged coronary arteries with a procedure scarcely more invasive or complex than laparoscopic knee surgery today. Robotically assisted surgical tools such as scalpels, forceps, and clamps will be guided by a cardiothoracic surgeon seated in front of a liquid-crystal display (LCD). The display will be operated by an imaging system that removes the motion of the beating heart, allows complete visualization of the heart anatomy, and facilitates remote control of surgical instruments inserted within small openings in a patient's chest to effect arterial repairs or replacement.

Perhaps some of the greatest benefits will be realized from nanotechnologies now being explored in places like the Duffield Hall laboratories on our campus. Carbon nanotubes hold promise for use within the human body to repair structural weaknesses such as those caused by osteoporosis or osteoarthritis. Organic transistors hold promise for an array of new devices that might improve biocompatibility and allow long-term monitoring of electrochemical activity. Suitable electrodes attached to the brain will feed biosignals to these organic amplifiers coupled to microcontrollers and robotics to operate artificial limbs by the normal thought process.

If we look back to the biomedical advancements of the past generation, we can confidently anticipate improved electrical and computer engineering technologies that will give medical practitioners the power to observe and therefore learn more about living systems with an eye toward improving the human condition. Researchers and development engineers from ECE areas will play a critical role in these exciting developments.

The SEERS Project

Twenty years ago, the Centennial of Electrical Engineering issue of the *Cornell Engineering Quarterly* (vol. 19, no. 4) featured "A Look into the Future: Predictions of Things to Come by Electrical Engineering Seers." For this issue of *Connections*, members of the ECE faculty were invited to participate in a 2005 version of the "SEERS Project." Keenly aware of the old adage "Making predictions is dangerous, especially when looking into the future," six intrepid faculty members nevertheless accepted the challenge. Their prognostications are presented herein. Comparison of the centennial seers' forecasts with today's reality indicates a reasonably good track record. Perhaps our latter-day SEERS have done equally well.

Whither Information Theory?

Toby Berger

The subject of information theory has matured considerably since 1948 when its development was announced by C. E. Shannon in his landmark, two-part paper "A Mathematical Theory of Communication" (*Bell System Technical Journal*, pp. 379–423 and 623–56). The recent development of turbo codes and the reconsideration of LDPC (Low Density Parity Check) codes that it prompted have led to implementable coding strategies that transmit information reliably at rates quite close to the capacity of many real-world communication channels. By coupling these channel-coding advances with universal source-coding techniques such as those of Ziv and Lempel (*IEEE Transactions on Information Theory*, 337–43, 1977, and 530–36, 1978) and related lossy coding schemes of various authors, it becomes fair to say that the basic problem of point-to-point information transmission that Shannon solved in the theoretical sense now has been "solved" in the practical sense as well. What, then, are the research directions that information theorists are exploring or may explore in the future?

Since the early 1970s considerable effort has been aimed at developing a multiterminal version of information theory in which there are two or more transmitters and/or two or more receivers. It is easiest to explain what this means by giving examples.

Broadcast Channel. A classic memoryless channel is described by its instantaneous transition probabilities $\{p(y|x)\}$, where x indexes the possible channel inputs and y indexes the possible channel outputs at any given moment. A memoryless broadcast channel with N receivers is described by $p(y_1, \ldots, y_N|x)$, where y_i is the output seen by the i^{th} receiver. If all the receivers were in the same place, then this would be the same as a classic memoryless channel whose output alphabet consists of N-tuples of the form $(y_1, \ldots, y_N)$, but the broadcast channel's receivers are at N separate locations. The problem is to determine all vectors of data rates at which the receivers can simultaneously obtain information of interest to them from the single transmitter via the broadcast channel, and implementable encoding and decoding schemes that effectively realize these achievable rate vectors.

Relay Channel. A communicates to C through both a channel directly linking A to C and via a path that consists of a channel from A to relay point B, a possible recoding at B, and another channel from B to C.

Multiple Access Channel. Separated senders 1 through N, who are not interconnected by a communication network, seek to send possibly correlated messages to a common destination over a channel whose instantaneous behavior is described by a conditional probability measure of the form $p(y|x_1, \cdots, x_N)$, which is known by all. Again, all vectors of simultaneously achievable data rates and means of achieving them are sought.

Distributed Source Coding. Several sources of information, usually correlated with one another, are observed at separate locations. Each of a collection of receivers wishes to obtain approximate replicas of some subset of these sources. For some values of (i, j) a communication link of capacity $C_{i,j}$ is built from source location i to receiver j. Source i must be recovered at receiver j with average distortion $D(i, j)$ or less, as measured in accordance with an appropriately selected fidelity criterion. What C, D vectors are attainable, i.e., which sets $\{C_{i,j}\}$ suffice to permit achievement of a specified set $\{D_{i,j}\}$ of tolerable values of distortion?

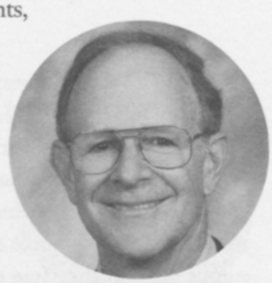
One special case of Distributed Source Coding, called the Multiple Descriptions Problem, has only one source but many receivers. This task can be seen to be equivalent to the sending to a single receiver over various separate channels information streams each of which provides partial information about the source and then imposing "graceful degradation" conditions on robustness of performance in the face of failures of given subsets of the channels. The important Internet problem of successive refinement, also known as progressive transmission, is a special case of Multiple Descriptions. Another special case, called the CEO Problem, has many sources but only one receiver. The sources are noisy observations by field agents of a hidden source of interest to a corporation's CEO, and the only fidelity criterion imposed is on the accuracy to which this hidden source can be ascertained when the sum of the data rates from all the agents to the CEO is constrained.

A few multiterminal information theory problems have been solved exactly, and in many instances upper and lower bounds have been determined for more challenging problems that are quite closely separated. For further information, see issues of the *IEEE Transactions on Information Theory* from 1971 forward and the texts by Csiszar and Korner (Academic Press, 1981) and by Cover and Thomas (Wiley, 1991). For a different type of network information theory, see Yeung (Kluwer Academic, 2002, Chapters 11 and 15).

Whither else information theory? Many problems in the life sciences cry out for the application of information theory. Key among these are investigations in genomics, functional genomics, and proteomics, sometimes referred to collectively as bioinformatics. In this writer's opinion, however, the principal biological vein in which insights from information theory will prove to be highly enlightening and eventually of significant practical value is in the discipline I have termed neuroinformation theory. Some neuroscientists and information theorists by now have been earnestly engaged for the better part of a decade on studies of information processing in the brain, arguably the greatest information problem of all. They are joined in this endeavor, of course, by neurobiologists, neurophysicists, physicians, physicists, computer scientists, mathematicians, statisticians, control theorists, signal processing experts, etc. Only when great minds attack great problems do great things happen. Still greater things should happen when great minds work on the problems of mind and brain.

Plasmas in Our Future

David A. Hammer



Faculty, students, and practitioners in laboratory plasma science have a very bright 20-year period in store for them based on developments in the field over the past 10 years. What is so interesting at this moment? Plasmas as hot as the center of the sun and nearly as dense now are being studied routinely in the laboratory, as in university-scale plasma-producing facilities such as the pulsed power machines at Cornell. Along this line of "high-energy-density plasma research," the Grand Challenge problem of achieving controlled fusion ignition in the laboratory by inertial confinement will be addressed starting in 2010 by the National Ignition Facility (NIF), a large laser system now under construction at the Lawrence Livermore National Laboratory (LLNL) in California. The other line of controlled fusion research involves magnetically confined plasmas. Great progress has been made in the past 10 years because of major improvements in diagnostic instruments for experiments and even more major advances in our ability to carry out large-scale computer simulations of realistic magnetically confined plasma configurations. The resulting better understanding of why plasmas leak out of magnetic bottles and how to prevent this has led to an international agreement to begin building a large-scale experiment in France. Its purpose is to study the physics and engineering issues associated with magnetically confined plasmas that burn fusion fuel. This device, the International Thermonuclear Experimental Reactor (ITER), will be in operation in about 10 years.

The applied plasma-science research and development being carried out in preparation for the NIF and the ITER, as well as in support of existing related facilities, has led to a rebirth of interest in fundamental plasma science. Excitement is particularly high, and progress is already rapid in high-energy-density plasma research. A U.S. National Academy of Sciences and National Research Council (NAS/NRC) publication* has identified this effort as a growth area. This is because very capable moderate and large-scale facilities now are available at universities and national laboratories that enable the study of matter, including plasmas, with densities and temperatures that previously were not achievable in the laboratory. Likewise, sources of plasma turbulence and its effects on plasma confinement are being studied in moderate-density hot plasmas confined by magnetic fields in several different configurations.

What can we expect 10 and 20 years from now from a research field energized by these new facilities? In 10 years, we probably will have achieved ignition in inertial confinement fusion on the NIF. Ignition is operationally defined as obtaining as much energy output from fusing hydrogen nuclei as was delivered by the laser to cause the fusion reactions to initiate, expected to be about 1.5 million joules. Scientists at LLNL believe the facility will be able to achieve a factor of 10 or 20 gain for a maximum output of about 30 million joules (8 kilowatt-hours). However, continued maintenance of the safety and reliability of our nuclear weapon stockpile by means of pulsed-power or laser-based laboratory experiments only, that is without the need for nuclear testing, is expected to require 10 times more energy release than is predicted from laboratory inertial-confinement fusion. Twenty years from now, this major goal might be achieved by a pulsed-power machine similar to the present 20-million-ampere Z-machine, a pulsed-power generator at the Sandia National Laboratories in Albuquerque, N.M. At Cornell we can expect to be contributing high-energy-density plasma-science results toward that goal for the next 10 to 20 years using our own 1-million-ampere pulsed-power machine, COBRA (Cornell Beam Research Accelerator) (see Figure 1), that was completed in 2004. Also in 20 years, I foresee that electrical and mechanical engineers and computer scientists will be using the results from ITER and other plasma-research programs, both fundamental and applied, to design a prototype fusion reactor that will be capable of putting power on the grid.

The final area of plasma science worthy of mention in the context of the Cornell ECE School is the use of low-temperature plasmas as a versatile fabrication tool for the manufacture of electronics. As the features on chips have become smaller and smaller, it has been found necessary to transfer many fabrication processes to the use of reactive plasmas instead of gases in order to carry out necessary etching, surface preparation, and deposition steps. Over the next 10 years, this trend will increase, and nanofabrication with plasmas is likely to be key to pushing electronics to ever-smaller feature sizes. I will not even attempt to suggest I know what the level of such capability will be 10 years from now, much less 20. I think I can safely predict that plasma processing science is likely to be an important piece of fabrication research and development in electrical and computer engineering in both of those time frames.

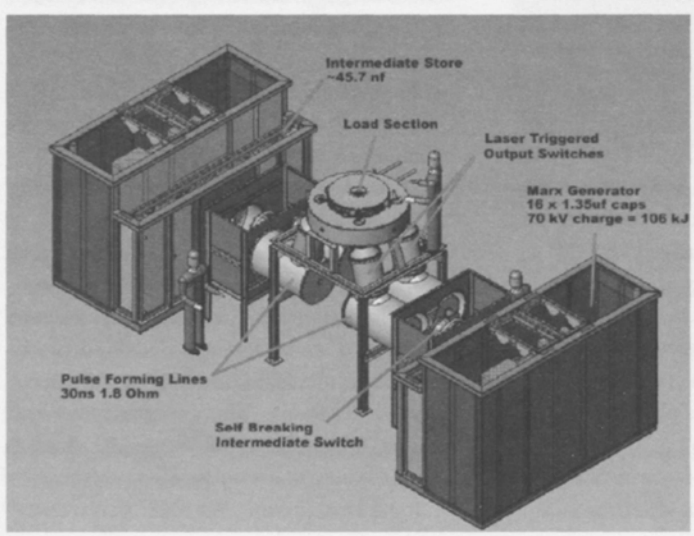
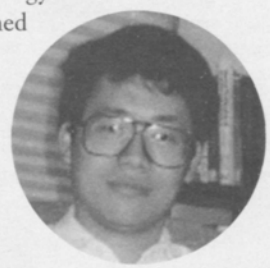


Figure 1. The COBRA machine, built to Laboratory of Plasma Studies specifications by **Stephen Glidden,** B.S. E.E. '75, produces a variable (zero to peak) pulse with a rise time of 90 to about 175 ns through four separately triggered switches. The machine is used for plasma physics experiments with an emphasis on x-ray diagnostics. Figure courtesy of David Hammer.

**Frontiers in High Energy Density Physics—The X-Games of Contemporary Science* (National Academies Press, Washington, D.C., 2003).

Nanotechnology Research in the Next 50 Years

Edwin C. Kan



Nanotechnology is concerned with the large-scale functional and manufacturing integration of individually addressable and controllable nanoscale entities such as electronic devices, molecules, or crystalline structures. Nanotechnology is different from nanoscience, where the main focus is on the phenomena and physical principles of individual nanoscale entities. Several major road blocks are preventing nanotechnology from having a major impact on the market and society. We do not yet have individual control of nanoscale entities or the designer interconnect that links these entities into a useful functional module. We do not yet have a design platform that can tackle that level of complexity, nor the appropriate apparatus for an economically feasible large-scale manufacturing. process. Nanoelectronics, as in the form of 22–90 nm complementary metal-oxide semiconductor (CMOS) technology, probably is the closest example of that platform that we have today if we consider both functional and manufacturing integration. Although the gate oxide is around 1–3 nm, the functional density still is in the 50–200 nm range, not truly addressable at the nano scale. However, the principles of patterning and self-assembly, the hierarchical design platform, and large-scale manufacturing of CMOS technology provide a realistic look at future systems based on nanotechnology. If we are able to overcome these major road blocks of nanotechnology, the possible applications surely could be rewarding and would enhance greatly our understanding of system operation and production with nanoscale controllability. Imagine a computer system that could deliver peta-scale (10^{15}) memory and operations. Not only is this close to the capacity of our present understanding of human intelligence, but the system also would allow us to perform a true human-like interface with real-time image and language processing. Bulky electronic gear would not have to be carried since the form factor and power consumption would be determined mostly by the interface instead of by the processing and memory units.

Imagine we could have real-time programmable chemical functional ends or receptors with nanoscale resolution. A drug could be programmed to adapt dynamically to new diseases, and it also would be possible to provide the very necessary 100X resolution in metrology for biological research. Panaceas no longer would be a fiction but a job for a computer program. For sure, analysis of detailed information, either in the form of DNA coding or protein reactions (see Figure 2), also would need the assistance of the peta-scale computer. Imagine we could manufacture small autonomous systems based on individual nanoscale components that could do basic sensing, actuation, processing, control, and communication and could provide an integrated power source. Environmental monitoring and biomedical diagnostics could then take great advantage of a large-number sensor network to provide highly accurate assessment capabilities. For example, in the movie *Twister*, the autonomous sensors are hand-made entities attached to a Pepsi can. If those sensors could be the size of a flea and be mass produced, we are not talking about just another sci-fi movie.

Imagine we will be able to design and control the nanoscale features to finally resolve the problem in paintable/sprayable electronics and optoelectronics to support either multimedia or renewable energy-source purposes. Imagine a large-area multimedia wallpaper that can change theme as on today's computer screen. You could walk into a room and with a voice command mimic the dynamics of Yellowstone National Park or a rock concert. Imagine large-area solar cells that could be painted inexpensively on every house to supply a large percentage of necessary energy.

These projections are just a few examples of the scientific, economic, and social impacts that could accompany the potential applications of nanotechnology. When this list is combined with an even larger set of possible developments, we can enjoy a future society that will be very different from the one in which we live today.

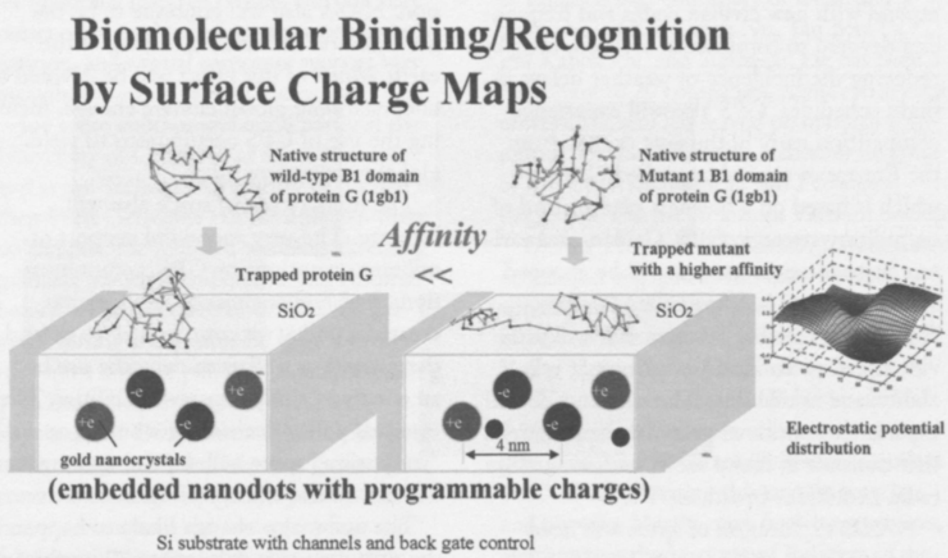


Figure 2. Individually addressable quantum dots interfaced to surface-charge maps of proteins. Sketch courtesy of Edwin Kan.

Space Science and Engineering: The Future

Paul Kintner

Some wag once said, "If I could predict the future, I would not be working for a living." Well, most of us are not independently wealthy and many of us enjoy working for a living, so here are a few thoughts on how space science and engineering will change in the future based on what has happened in the past.

The most profound obstacle to utilizing space fully is the cost of launch. The recent X-prize competition, won by SpaceShipOne, demonstrated that some applications can be accomplished less expensively by entrepreneurs, but for the foreseeable future there is nothing that dramatically will decrease the cost-to-space access. Incremental reductions in launch costs may come from Russian, Indian, and Chinese competition with the United States, Europe, and Japan.

Continued expensive access to space will result in space use to be dominated by military and civilian applications that are uniquely performed in space and by the new NASA Exploration Initiative. For example, the Global Positioning System (GPS) will expand with new civilian codes and frequencies devoted to commercial aviation, thereby reducing the incidence of weather delays in flight schedules. GPS also will experience competition early in the next decade from the European equivalent, called Galileo, which is based on a business plan instead of on military strategy. GPS, Galileo, and various augmentation systems will be grouped under a general heading called Global Navigation Satellite Systems that will provide signals with increased accuracy, reliability, and availability. The civilian side will experience continued growth in applications that transmit to many users, such as satellite radio and direct-broadcast TV.

NASA's exploration of space will need to adjust to the "Exploration Initiative." This enterprise has set visionary goals with an inadequate budget, unresolved differentiation between the roles of manned and robotic investigation, and principal motivation based on the potential for finding evidence of extraterrestrial life. If such evidence is found, especially on Mars, NASA's major goal likely will be the manned exploration of Mars, an endeavor that will require the effective use of nuclear power for propulsion. NASA also will continue to be the prime source for remote sensing of the earth. Much of this effort will be devoted to understanding global climate change, including the use of GPS occultations to yield global temperature maps.

Figure 3. The CASCADES payload being prepared for a launch that carried five Cornell GPS receivers for formation flying. Photo courtesy of Paul Kintner.

The military use of space also will increase. The very successful support of military operations by GPS, communications, and reconnaissance satellites has created a policy vacuum on how to defend these assets as well as to deny the use by an enemy of similar space capabilities. The eventual policy decision of whether or not to "weaponize" space will depend upon current debates on the efficacy of these resources.

The one major change likely to happen in the next decade is that space will become a tourist destination. SpaceShipOne demonstrated that it is possible to transport tourists briefly to the edge of space. There is an adequate market for a few tourist space ships to begin operation. So for those of you who are independently wealthy, here is your opportunity.

Research in space science and engineering in the ECE School at Cornell will be based on data obtained from launch vehicles (see Figure 3) to focus on the electrical properties of the upper atmosphere (ionosphere) that affect space systems. The largest source of error and disruption for GPS signals is the ionosphere. The recently discovered global ionospheric storms that sweep from the tropics across North America to the Arctic have profound consequences on the safe use of GPS in life-critical situations such as aviation. At high latitudes the northern lights can also disrupt trans-ionospheric signals. Operational integrity will require characterization of these storms, their effects on GPS signals, the proper response of GPS receivers, and the design of GPS receivers that are resistant to disruption. The future ECE research goal is to continue being world leaders in ionospheric research and GPS receiver design.

Retirements

Joseph M. Ballantyne, a member of the EE/ECE School faculty for 40 years, became professor emeritus on July 1, 2004. Joe obtained his B.S. in mathematics and his B.S.E.E. in electrical engineering in 1959, both at the University of Utah, and the S.M. and Ph.D. at the Massachusetts Institute of Technology, both in electrical engineering, in 1960 and 1964, respectively. After completing his doctoral work, Joe was a staff member at M.I.T.'s Laboratory for Insulation Research for nine months. He joined the EE faculty as an assistant professor in 1964, became an associate professor in 1968, and was appointed to full professor in 1975. From 1977 to 1978 he was acting director of the National Research and Resource Facility for Submicron Structures (NRRFSS), director of the School of Electrical Engineering from 1980 to 1984, university vice president for research and advanced studies from 1984 to 1989, director of the Semiconductor Research Corporation (SRC) Center of Excellence in Microscience and Technology from 1992 to 1995, and Lester B. Knight Director of the Cornell Nanofabrication Facility from 1998 to 1999.

Joe has devoted his career to innovative research and energetic teaching at both graduate and undergraduate levels together with dedicated service to the EE/ECE School, the College of Engineering, and the university. During his first years on the faculty Joe found exciting opportunities with the Cornell Materials Science Center (MSC) to continue his previous M.I.T. research on ferroelectric materials. He became involved in research on photoelectronic devices when he took over Professor Glenn Wade's group after Wade moved to the University of California at Santa Barbara. Joe also participated in advanced semiconductor research. During his first sabbatical leave in 1970–71, as a National Science Foundation (NSF) senior fellow at Stanford University, he studied the physics of photoemission and tunneling in nanoscale thin-film structures that could be used in semiconductor lasers. Later, when NSF sought proposals to establish a national facility for the study of submicron structures and electronic devices, Joe led a group from MSC and the EE School in preparing the proposal that in 1977 won a $5 million, five-year grant for the establishment of NRRFSS, with Joe as its first director. NRRFSS, now the Cornell NanoScale Science and Technology Facility (CNF) is housed today in Duffield Hall, the new multidisciplinary nanoscale research and teaching complex.

Following a second sabbatical in 1978–79 at the IBM Watson Research Center as a visiting scientist, Joe began a four-year term in 1980 as director of the EE School. In this period he substantially reconstituted the faculty by hiring 17 out of 44 members, including the first two women and first black instructor in the school's history, led the school to be ranked sixth in the nation among EE departments, and secured funding for major renovations. He maintained his interest in NRRFSS activities, directed the research of several doctoral candidates, and was instrumental in establishing the Semiconductor Research Corporation (SRC) Center of Excellence in Microscience and Technology in Phillips Hall. Joe, keenly aware of the coming centennial of the EE School in 1985, proposed "Future Directions in Electrical Engineering" as its theme and established faculty committees to plan six national symposia based on this concept.

From 1984 to 1989, Joe served as university vice president for research and advanced studies. Under his direction, Cornell research funding and expenditures grew to new levels, four national research centers and one state center were established against intense competition, and annual corporate support was brought to second rank in the nation.

Joe spent another sabbatical partly at the University of California at Santa Barbara and at the Technical University of Aachen in then West Germany. For his next two years on campus, Joe resumed teaching, directing graduate students, and conducting research before becoming director of SRC for five years, during which time he led the center through a difficult period of contract funding.

When a new director of SRC was appointed in 1995, Joe maintained his interest in the center's activities but guided the research of his group on the production of major advances in the understanding and fabrication of monolithic semiconductor ring lasers. From 1996 to 1997 he spent part of his sabbatical year on campus with duties to strengthen the SCR Center and also was a visiting professor at the University of California at San Diego for six months.

Joe assumed leadership of CNF in January 1998, obtained a five-year renewal grant from NSF, recruited a new director, hired two new staff members, and reorganized safety activities. His leadership resulted in an award of one of five Defense Advanced Research Projects Agency (DARPA) Optoelectronic Centers for the study of on-chip detection preprocessing of biological and chemical-warfare agents with integrated optoelectronic microsystems. This $4.5 million, four-year grant allowed the establishment of the Center for Biochemical Optoelectronic Microsystems (CBOM) that involves Cornell, the University of Rochester, and Harvard. Joe also directed his research group in developing materials for direct-bandgap laser structures for monolithic use on silicon for future "systems on a chip" and for bringing optical communication to the silicon-chip level.

In 1999, Joe designed a well-received set of new laboratory experiments for EE 315, Electronic Circuit Design. He developed new and original procedures for one experiment and major portions of two others, and taught both lectures and laboratories when the revised course was first offered in spring 2000.

Joe has presented or published more than 200 research papers and holds several patents. He is a fellow of the Institute of Electrical and Electronics Engineers (IEEE), was awarded the Clyde Distinguished Chair of the College of Engineering, University of Utah, and is a member of Eta Kappa Nu, Tau Beta Pi, Phi Kappa Phi, and Sigma Xi. He has been a consultant to 20 companies, adviser to several universities, and has served on national committees for the IEEE, the American Institute of Mining, Metallurgical, and Petroleum Engineers, and the American Vacuum Society.

During a leave in 2002–2003, Joe remained on campus engaged in full-time research and winding down his laboratory. In 2003–2004, he was on a service assignment for Brigham Young University in Jerusalem at its Center for Near Eastern Studies. He has spent his first year of retirement working on unpublished work based on recent graduate student Ph.D. theses. Starting this past August, Joe and his wife, Martha, on a year-long mission, are directing the Institute of Religion of the Church of Jesus Christ of Latter-day Saints at Cornell.

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Retirements

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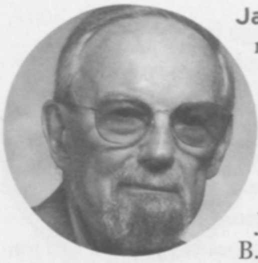

James S. Thorp, a member of the EE/ECE School faculty for 42 years, became professor emeritus on July 1, 2004.

Jim obtained his B.E.E. in 1959, M.S. in 1961, and Ph.D. in 1962, all in electrical engineering, from Cornell University. Upon completion of his doctoral studies he joined the EE faculty as an assistant professor, became an associate professor in 1966, and was appointed full professor in 1975. He served as associate director of the EE School from 1991 to 1994, was named the Charles N. Mellowes Professor in Engineering in 1994, and was the director of the school from 1994 to 2001. Upon his retirement from Cornell, Jim became department head and the Hugh P. and Ethel C. Kelly Professor in the Department of Electrical Engineering at Virginia Tech in Blacksburg, Va.

Jim's career at Cornell has been characterized by excellent teaching and innovative research in the EE/ECE School, dedicated service to the school, the College of Engineering, and the university, and outstanding contributions to the electric utility industry. Jim spent the first decade or so of his career developing courses and conducting research in control systems. In the early 1970s, he applied his control-system expertise to the complexities inherent in large power-system networks, and recognized the potential for digital computers in power-system operation and control. Following a faculty internship with the American Electric Power Service Corporation in 1976, he joined with colleagues at Cornell to establish the Cornell Program in Power Systems and directed the design and construction of the Eugene Kettering Energy System Laboratory. The Power Group submitted research proposals to suitable energy agencies, graduate students were encouraged to undertake thesis research in the discipline, and Jim developed new courses in advanced power-system analysis. In October 1976, he presented his first power-related article, an IEEE transactions paper that described a controller for stabilization of large transient swings in power systems.

Jim has made important contributions to the understanding of the new field of computer relaying and to development of several new protection and control techniques that take advantage of this new technology. He was the first power-system analyst to demonstrate quantitative bounds on the performance of certain impedance relays that determine the distance to a fault. He initiated the use of estimation theory in relay algorithm analysis. He also has been involved in the introduction of the concept of adaptive protection and control in which measurements can be used to alter the characteristics of the protection system in response to changing system conditions. Power transfer within a power system network at any given time is related directly to the magnitudes of the relative power angles of the generators in the system as load conditions are met. Simultaneous sampling of the power angles over a wide geographical area was impossible until several ago when Jim, together with Professor Arun Phadke of Virginia Tech, invented a device called a phasor measurement unit (PMU) that achieved these requirements. The availability of PMUs for synchronized power-angle measurements has prompted research by Jim and his graduate students leading to development of algorithms for microprocessor-based protection systems.

Jim has made outstanding contributions to development of estimation and control theory applied to protection and control of large-scale power systems. He has made equally important contributions to studies of the complicated dynamical and chaotic behavior of power systems under conditions of system instability, the mechanisms of cascading disturbances, and the generation of "fractals" by such systems. When fully applied, these techniques will mark the end of the troublesome blackouts and brownouts that have plagued the industry in the past.

Jim was elected to the National Academy of Engineering in recognition of his distinguished academic and professional career and his outstanding service and contributions to the Institute of Electrical and Electronic Engineers (IEEE). He has chaired five IEEE committees, served as editor of *IEEE Transactions on Power Delivery* and as associate editor of *IEEE Transactions on Circuits and Systems for Large-Scale Systems and Power*. Jim was elected to the grade of IEEE Fellow "for contributions to development of digital techniques for power-system protection." He received the Best Paper Award in the 37th Annual Hawaii International Conference on System Sciences Complex Systems Track; the IEEE Power Engineering Society's Power Service Award; and the Prize Paper Award from the IEEE Power System Relaying Committee. In addition, he received technical paper awards from the U.S. National Committee of the Conférence Internationale des Grands Réseaux Electriques à Haute Tension (CIGRE). Jim has authored or co-authored more than 90 refereed journal articles and over 90 conference articles, all in the power field, and authored or co-authored over 20 articles in the control field. He is co-author, with Professor A. G. Phadke, of two textbooks and has contributed chapters to five volumes in his discipline. Jim has been awarded two U.S. patents in related fields.

As director of the school, Jim was conversant with the activities of each department, and his even-handed leadership in setting school policies and priorities was generally appreciated by the faculty. He was notably successful in rebuilding the EE faculty after the retirement of many long-term members; his first eight assistant professor appointees received National Science Foundation Career awards. In the classroom Jim was known for his carefully prepared, clear-cut presentations, which led to four Excellence in Teaching Awards. He supervised the graduate studies of 36 Ph.D. candidates. He was particularly active in service to the academic community with membership on 12 separate university committees and chairmanship of three others. He also chaired three engineering college committees, co-chaired one, and was a member of four others, including the recent Dean's Special Committee to Examine the Core Curriculum.

Jim also has been active in off-campus educational activities. In 1988 he was an Overseas Fellow at Churchill College in Cambridge University. He has offered short courses in his discipline at several U.S. universities and has conducted seminars on his work in eight countries. Jim is a member of the honorary societies Tau Beta Pi, Eta Kappa Nu, and Sigma Xi and recently was named by a Cornell University Presidential Scholar as the faculty member who had the most positive influence on her education at Cornell.

Jim's hobbies include painting; in recent years he has presented colorful results of his fractal research as interesting pieces of art. As an avid golfer he is particularly proud of achieving a hole-in-one, witnessed by Professor **John Nation,** at the Soaring Eagles Golf Course in Elmira, N.Y.

In Memoriam

Professor Emeritus **Paul Denzil Ankrum** died at age 90 on August 27, 2005, in Ithaca, N.Y. Paul received the B.S.E.E. degree in 1935 from Indiana Technical College in Fort Wayne (now the Indiana Institute of Technology) and was an instructor in mathematics at Ashland College in Ashland, Ohio, for a year. In 1936 he became an instructor in electrical engineering at Indiana Tech and in 1938 was appointed chairman of the university radio engineering department, a position he held until 1942. He received the A.B. degree in mathematics from Ashland College in 1939. Paul came to Cornell in 1942 as an instructor and graduate student in the School of Electrical Engineering where he taught naval officers for the duration of the war under the National Engineering Science and Management War Training (ESMWT) program. Paul received the M.S. degree in engineering from Cornell University in 1944 and in the same year joined the EE School faculty as an assistant professor. He was promoted to associate professor in 1949, became a full professor in 1963, and retired as professor emeritus in 1982.

Paul's 38-year career at Cornell was characterized by conscientious attention to undergraduate education, advising, and service to the EE School, the College of Engineering, and the university. During the war years in ESMWT he taught laboratory courses in electric circuits and electric machinery in Rand Hall until 1946 when he transferred to electronics circuits, his major area of interest. In 1948 he was given complete charge of instruction in basic electronics in the EE School. In the following year and again in the 1956-57 academic year he served as acting area supervisor of communications. During this period when the EE School began to require courses in electronics, Paul found no suitable textbooks available for his courses. To fill this need he developed his own text, *Principles and Applications of Electron Devices*, which also was used by 16 other colleges and universities.

Paul's career took a dramatic turn when he returned from a sabbatical leave as a member of the Technical Staff of Hughes Aircraft Company in Culver City, Calif. He effectively introduced the field of semiconductor electronics in the school by assuming responsibility for course EE 4529, Transistors, which he subsequently expanded into a popular elective two-course sequence. In 1971 Paul published *Semiconductor Electronics*, a textbook that became a standard in the new field.

Paul's dedication to teaching was evident from his willingness to teach in areas that were not likely to enhance his professional status in his major field. For a number of years he taught in the school program for New York Telephone employees, and in the Engineering Problems and Methods course for freshmen. He was responsible for the development of many laboratory experiments in the electronics area and in basic measurements. Throughout his career Paul was an active participant in faculty discussions on educational programs and made many valuable contributions to curriculum development. During the period when a senior project was a required component in the EE curriculum, Paul's services as a senior project adviser were in constant demand. He was a popular student adviser who was known for his knowledge of and his concern for his advisees and their problems, both curricular and personal. He served as chairman of the Ithaca Section of the Institute of Electrical and Electronic Engineers (IEEE) and, for the five years before his retirement, was faculty adviser of the student section of IEEE. Paul was a senior member of IEEE and a member of the American Society for Engineering Education.

Over the years, Paul had a remarkable record of service to the school, the college, and the university. For a time he was an elected member of the Faculty Committee of the school, a formidable group that established policies on curricular and educational matters, and in other periods he served on the EE School Committee for Design, the EE School Student-Faculty Committee, and as class adviser to the Division of Basic Studies. He was secretary of the Engineering College Faculty for a number of years and an engineering college member of the University Faculty Committee of Representatives (FCR). In the latter capacity he served as chairman of the University Faculty Committee on Prizes and as chairman of the FCR Committee on Physical Education. He also was a member of the radio station WHCU Advisory Board.

There is one aspect of Paul's contributions to the EE School that may not have been known by most of the hundreds of students who inadvertently benefited during the years that Paul taught in the school. Paul's master's thesis is titled "Electronic Voltage Regulator for a Direct-Current Generator."When Paul arrived at Cornell and became an instructor in electric machinery in Rand Hall, dc power for the laboratory experiments was supplied by two 50 kW motor-generator sets. Since machinery experiments in the laboratory are highly dependent upon a reliable power supply with constant voltage, it was necessary for the two machines to have some kind of voltage regulator, either mechanical or manual. Paul's thesis involved an early application of power-electronics control that set him upon his eventual career and, as a side benefit, provided an advanced solution to the voltage regulation problem of the Rand Hall laboratory power supply. Based on his thesis research, Paul constructed two power electronic systems that used early mercury-vapor gas-discharge tubes called ignitrons to monitor and control the field currents of the two dc generators. When the school moved into Phillips Hall in 1955, the two generators and Paul's regulators were installed in the basement and continued to perform admirably until the machines were retired in 1986.

Paul was highly regarded by faculty and students alike as an effective teacher and adviser and was admired for his careful preparation of lecture and laboratory presentations and for his meticulous attention to detail. He was generous with friendly advice to young faculty members and helped several to choose their ultimate careers. Paul was an effective presence in the school who was well-known for his care and attention to undergraduate education and for his particular concern that the laboratories should offer useful exercises. It is not surprising that returning alumni were always glad to see him.

Paul Ankrum long will be remembered as a conscientious and dedicated teacher and adviser, a respected colleague, and a devoted friend.

A Quest for the Future of Wireless Communications or It's

Zygmunt J. Haas

I admit I never suspected that writing this article would turn into such an adventure. When I accepted the invitation, I thought that I would be done in three to four hours, especially since my research was always leaning toward forward-looking work. And I definitely did not anticipate the need to beg Sam for one extension after another. Most of all, I did not imagine that the search for the future would take me to the dumpsters of Rhodes Hall—but let's start from the beginning.

I cleaned my desk and, equipped with a blank pad of paper and a sharpened pencil, I sat down to write. However, after sitting for over an hour trying to imagine how the wireless world will turn out in 10 or so years, I realized three things: first, that the occupation of a seer is not an easy one; second, that I definitely should not quit my academic position for a career as a writer; but, third, above all, that I must either come up with a different and effective way to get some ideas about this article, or I am in big trouble.

So, being an engineer in soul (after all, I did spend over nine years of my life working for industry), I decided to take a more pragmatic approach. What would I consider to be sufficiently imaginative and innovative as ideas for a prediction of the future? And, mind you, no wireless brain transplants, no communications among interplanetary colonies, and none of those cute extraterrestrial creatures running around with antennas on their heads. After all, I was supposed to be a seer and not a wizard. I wanted my prediction about the wireless communications future to be feasible and at least reasonably probable but also tough enough to attain with today's state-of-the-art technologies. I came up with three characteristics on my notepad:

1. It has to be something *challenging*; no "2-dB" improvements—you do not need to be a seer to come up with those, just open any technical journal or conference proceedings; today's world is full of "2-dB seers" and I did not intend to ruin my reputation as a seer.

2. It has to be *feasible* to achieve and likely to happen within, say, the next 10 years or so, since I want to become a famous seer well before I retire (Clif, do not worry—I do not intend to retire before I am 75 years old, unless, of course, I am offered the Master Seer position or I become a famous writer, neither of which is highly likely in the near future, as is clearly demonstrated by this article).

3. It has to be *technology-driven*, that is, impossible to realize with today's state-of-the-art technologies, but feasible after significant technological advances are made.

Hmmm, so where was I going to find "It"?

"I know—the *folder*!" I exclaimed. "The folder must have the answer!" Now, what I need to tell you is that the folder is a three-and-a-half-inch thick binder in which I have collected material since I graduated with my Ph.D. degree in 1988. Each time that I saw something interesting, something that I was impressed with as being challenging and futuristic, I would clip and add it to the folder. I grabbed the folder from the shelf. "This is it!" I told myself. "All I have to do is to go through this material and I will find my fame as a seer."

Surprised I was, when after an hour or so of paging through fading papers, everything in the folder seemed to be either already done, could easily be done at present, or is unnecessary to do because we have already implemented better things. Even the relatively recent articles seemed to contain only "2-dB" advances. I was surprised and disappointed: the folder appeared to be closely related to a collection of "infinitely" many standards issued by various international standardization bodies and associated with technologies such as wireless high-speed data, ubiquitous access, intelligent mobile networks, self-organized networks, sensor networks, wireless local area networks, cellular systems, quality of service wireless communications, reliable and survivable communications, and efficient transmission schemes. Many acronyms of current or already former technologies were there: 2G, CDPD, 2.5G, GSM, GPRS, IS54/136, EDGE, IS95, cdmaOne, 3G, cdma2000, WCDMA, Mobile IP, MANET, 4G, etc. All these standards clearly show how much progress has been made in the recent 10 to 15 years in the field of wireless and mobile communications and networks. These standards represent an impressive heritage that was made possible by the scientific progress and the engineering genius of our technical community. So is there anything left to be invented? Is it the end of the line or is there a next challenge?

Suddenly, I felt dismayed. I tossed the folder on my desk, which came to a sudden stop at the edge of the table, paused for a moment as if asking "Do you really want to get rid of me?" and continued its course downward to the garbage can below, which was already half full of my never-to-be-published seer's ideas. A few moments later, the cleaning person, on her daily round of emptying garbage cans, knocked on my door. The trash was gone and my garbage can was shining again with a new white plastic liner.

Sitting by my desk, clueless now on how to proceed, I glanced at the second shelf on my wall. Neatly organized copies of wireless standards caught my eye. "Yes, these are the standards that the folder was all about," I mulled over in appreciation, "but there are so many of them." A thought crossed my mind. I recalled one of my colleagues saying a long time ago, "The good thing about standards is that there are so many of them to choose from. And the bad thing about the standards is—that there are so many of them to choose from." I recall having a long conversation with him late into the evening, discussing why standards, although being able to guide the industry in developing compatible products and to allow customer-beneficial competition, also hinder the progress of technology and give unfair advantage to bigger and wealthier businesses. So the impact of standards is like a double-edged sword.

While looking at my shelf, I asked myself, "What if, as in *Alice Through the Looking Glass*, everything were reversed? What if, instead of too many standards, there were one single wireless communication standard?" This single standard would be like a general framework that would be the basis for the design and implementation of idealistically every, and more realistically nearly every, wireless network. Well, for one, it would allow me to save some shelf space and make my office a more habitable place. Not to mention that I could probably reduce the height of the stack of "to be read one day" papers, making my office a safer place, too. But would such a concept be feasible, be challenging, and require a technology-driven change? Above all, is it really possible that it would happen? And if so, why would it be probable? Indeed, the "why" is probably the most interesting part: why would the industry support such a framework effort, an effort that would appear to conflict with the ability of a particular company to promote a specific technology that could allow product differentiation and an advertising edge to the company?

As any student who took my Wireless Networks course could tell you, multiple standards are essential to cover different communication environments, different networking requirements, different economic goals, different spectral use rules (e.g., in different countries), etc. Well, this is a "correct" answer in the sense that it may earn you a passing grade in that course. But this is also only part of the truth. The fact is that many standards are created to promote one technology as opposed to another, often when the engineering (and scientific) advantages of one technology have little to do with the technology selection process. Frequently, the choice is made by a company, for example, to support a technology because the company's past products would fare better with proliferation of one particular technology. And here the "Golden Rule" applies quite well—"whoever holds the gold, rules."

"But wait, there was something about this in the folder," I realized suddenly. "Yes, definitely there was something about *technology unification*." My eyes glazed as I saw the empty garbage can. "I have to find the folder!" I rushed to find the cleaning person, but she was already long gone. "Where do they keep the garbage collected from offices?" I suddenly recalled that there are dumpsters on the basement level of Rhodes Hall near the loading docks. I did not wait for an elevator but charged down the stairs to the basement and to the loading docks. (Definitely this qualified as my workout for the day.) "Yes, here they are: the dumpsters are in their usual place," I said to myself, taking a

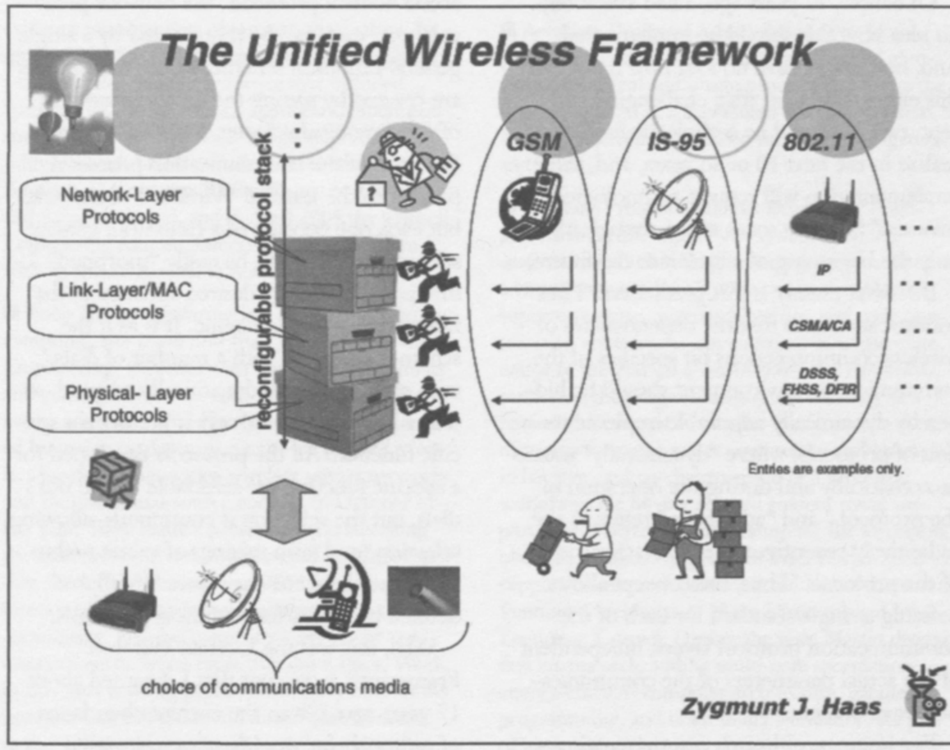

Figure 4. The definitive vu-graph. Sketch courtesy of Zygmunt Haas.

cursory look at their insides. All the dumpsters were empty except for one, which contained transparent plastic garbage bags that revealed their contents. A closer look at some of this content extinguished my enthusiasm quite rapidly. "No, no! A respectable seer would never go so far as to climb inside a dumpster and go through the trash to find his or her prophecy." I started wondering whether I should have recruited an apprentice—you know, like most famous wizards have—before embarking on the mission of writing this piece. But the fact is that I did not have an apprentice and I had to get to the bag that contained the folder and the sooner the better, as I had only a very vague idea about the time-decay constants of the materials inside some of those plastic bags.

What I realized that afternoon is that human ingenuity has no boundaries. I noticed another empty dumpster nearby and drove it down below the loading dock. Then I moved and tilted the full dumpster onto the loading dock, just above the empty dumpster, and placed a large wooden platform on top of the empty dumpster. By tilting the full dumpster more and more each time, some of the garbage bags were discharged on the wooden platform. Quick examination was needed to determine whether the current batch contained the remains of the wayward folder. If not, the batch was "released" to the empty dumpster and a new batch was delivered by an additional tilt of the upper dumpster.

It took three batches to discover the correct garbage bag. Excited, I pulled page by page from the reclaimed folder. (For those who wonder, yes, I put on rubber gloves, which I borrowed from a janitor who did not even try to hide his amusement.) Not too long thereafter I found what I was looking for—a vu-graph. . .no, not simply a vu-graph. It was *my* vu-graph that I made for myself just before my Ph.D. graduation, 17 years ago (see Figure 4)! The vu-graph presented the concept of a *unified wireless framework*, one that can adaptively support communication in any propagation medium, with a single

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A Quest for the Future of Wireless Communications

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medium-access control, for any user-application requirements and characteristics, etc.

Of course, 17 years ago, I had absolutely no idea how this should be implemented. And, honestly, I have no idea now how to do this either. But, one, it's a challenging concept, two, it should be technically feasible to realize in the next 10 or so years, and, three, implementation will require technological advances. So, it's a seer's vision though it's only the beginning of a look into the future.

But what exactly is this prediction? The concept advocates that the dependencies of wireless communications on specifics of the communication environment should be hidden by dynamically adjustable implementation of protocols, where "dynamically" means "automatically and during the operation of the protocol," and "adjustable" refers to the "adaptively reconfigurable" characteristic of the protocols. Thus, the concept allows defining a single standard for each of the communication protocol layers, independent of the actual parameters of the communication environment.

For instance, although communication through a wireless medium depends on the carrier frequency, transmission through media nearly always involves excitation of waves within the media. (And most often, the waves are in the electromagnetic fields, but there are exceptions, such as acoustic or underwater communication.) Yes, if the excitation is at high frequencies, it will produce light, while at lower frequencies, it is radio waves. While the basic concept of generation of propagating energy remains the same, the differences are in the implementation itself (i.e., frequency of excitation, in this case).

Now take a look at the modulation schemes. There are many different types of modulations; for instance, in the digital modulation keying domain some examples include: amplitude shift (ASK), phase shift (PSK), frequency shift (FSK), and quadrature phase shift (QPSK). Yes, but the basic notion of modulation is the same, with the different schemes differing in the details of how and what is modulated.

I could go on, telling you that pulse encoding schemes, framing schemes, medium access control protocols, the network protocols, etc., each can be represented by a single general canonical scheme, where the variants are created by setting the input parameters of this canonical scheme. Thus, all of the elements of the communication process are present in the Unified Wireless Framework, but each one consists of a canonical, generic scheme, one that can be easily "morphed" into performing any desired variance of the functionality of the scheme. It is as if the schemes are boxes with a number of dials, with each dial being dynamically adapted, so that a box changes the way it performs a specific function. All the protocols developed for a specific function are selectable by the box's dials, but the selection is continuous, allowing selection (and even mixing) of values within the "gaps" between the values "rigidly" defined by the variants of these protocols.

Well, this was the Unified Wireless Framework, a concept that I dreamed about 17 years ago. Given the current abundance of protocols for wireless communication, the concept is still to a large degree a dream, but not totally a dream. Software radio is an example—it is the framework concept in its infancy.

So my prediction to you, my friends, is that in 10 to 15 years we will see a clear convergence of standards, both in terms of their functionalities and of how they address the overall system design. We will see standards being merged together as technologies evolve, allowing construction of significantly more capable systems with larger data rate and larger processing rates. We will see systems being more dynamically (i.e., autonomously) adaptive; i.e., systems that can sense the environment and its limitations and adapt the operation of the protocols in a continuous way, rather than switching from one scheme to another. And, finally, systems based on comprehensive cross-layer design (rather than two-adjacent-layer cross-layer design), automatically updating and adjusting the settings across, what we consider, the traditional layered design.

But wait, I swept something under the rug here. In my reasoning of why the Unified Wireless Framework is a seer's forecast I "forgot" to explain why the concept is not only feasible but also is probable. Yes, I do believe that the industry itself will be the driving force behind this convergence of technologies and, consequently, their standards. Although there are several rationales for this prediction, let's just examine one: the increased technical difficulties in implementation of very large and complex systems. We are on the path to realizing the "pervasive and ubiquitous" vision, where everything can communicate with everything else. With no unification in the design of the various systems, conversion and translation between the various protocols will become a nightmare. And with no autonomous adaptivity in the selection of the protocols used, the interaction and the interference at the various layers of the communications process will result in total chaos.

Essentially, most of the communication resources will be wasted on the control of the communicating systems, concentrating on avoiding interference and oscillations, with few resources left to support the actual communication goals. Unification and dynamic adaptivity across a continuous range of protocol implementation will be the only way to cope with such a complex world of future wireless communication, thereby ensuring efficiency and stability.

And that's all from your seer, folks. Was it worth the adventure and the embarrassment? Only the future can reveal the answer. But I did learn a lesson—try first our own dreams, before exploring others'.

Recent Faculty Accomplishments

Excellence in Teaching and Advising Awards were announced at the College of Engineering Fall 2004 Awards Ceremony on November 2, 2004, in the Memorial Room of Willard Straight Hall. All award recipients in the ECE School are designated by a colored square (■).

■ **Alyssa B. Apsel** (opto-electronic very-large-scale integrated systems), the Clare Booth Luce Assistant Professor of Electrical and Computer Engineering, reports that she has achieved most of her projected goals for the past year including co-authorship with her students of two journal papers published and one accepted for publication. She also acquired funding through a subcontract to MIT on the Defense Advanced Research Projects Agency (DARPA EPIC program), arranged funding for a departmental VLSI seminar series through contacts with Cornell alumni at Analog Devices, Inc., and strengthened a relationship with industry through contact with both BAE Systems and Analog Devices. She also has given numerous invited talks this year at conferences and universities in an effort to promote her laboratory and Cornell ECE. Her research group has demonstrated the benefits of optical interconnects at very short distances through use of optical isolation, has made progress in development of some of the first practical monolithic silicon receivers, and is making advances in the construction of low-power RF circuits in silicon on sapphire for a variety of applications. Apsel has been named one of the top 100 young innovators for 2004 in *MIT Technology Review*. She is a member of the technical program committees for the International Society for Optical Engineering (SPIE) Optics East, Photonics West, IEEE Lasers and Electro Optics Society (LEOS) meeting, and IEEE International Symposium on Circuits and Systems (ISCAS), and serves as associate editor of *IEEE Transactions on Circuits and Systems II*. An article in the spring 2005 issue of *Cornell Engineering* describes her work in the relatively new field of photonics.

■ **John C. Belina** (bioelectronics), assistant director of the ECE School, M.Eng (Elec.) lecturer, worked in the fall semester with a 40 percent larger class size in ECE 210, Introduction to Circuits for Electrical and Computer Engineering, and added solid-state material to prepare students for ECE 315, Introduction to Microelectronics, taught by Professor **Dick Shealy** in the spring semester. Student feedback indicated that the additional content eased the transition to the more intense treatment of devices in ECE 315. An enhanced ethics component was added to ECE 210 with the assistance of Professor **Ron Kline** and **Park Doing**, postdoctoral associate in science and technology studies. A videotape of the class discussion was made to help with Accreditation Board of Engineering and Technology (ABET) direct-evidence requirements of instruction in ethics. In spring 2004, ECE 402, Biomedical System Design, a culminating design experience that included "professional components," significantly increased student exposure to ABET design requirements. John received the 2004 College of Engineering Kenneth A. Goldman '71 Excellence in Teaching and Advising Award, and in April 2005 the Cornell Engineering Alumni Association presented him with its annual Academic Achievement Award.

■ **Toby Berger** (information theory and communications), the Irwin and Joan Jacobs Professor of Engineering, together with his graduate students and colleagues, has co-authored several journal paper submissions and had over six papers accepted by major conferences on the subjects of wireless local-area networks, wireless sensor networks, and multiterminal source coding. In October of last year, Toby made a presentation concerning the interface between neuroscience and information theory at Neuroscience 2004, the main conference of the international neuroscience research community. He also lectures widely about the interactions between these two disciplines. Work in this area is being pursued currently both in his group at Cornell ECE and in the Salk Institute in San Diego. At present Toby is expanding his research into certain neuroinformation theory models and is creating new models that he hopes will enhance further the synergies of this interdisciplinary research area that he helped to create. He has a pending research proposal in this area in the Theoretical Foundations category of the NSF Computer and Information Science and Engineering (CISE) Division. Toby is co–principal investigator on an NSF grant on wireless sensor networks with Professors **Servetto**, **Tong**, and **Wicker**, and together with Professors **Wicker** and **O'Rourke** (civil and environmental engineering), and researchers at Georgia Tech, he is co–principal investigator on a proposal submitted to the NSF Sensor Interdisciplinary Research Groups (SIRG). Toby and his graduate student **Doug Chan** have submitted a provisional patent disclosure to the U.S. Patent and Trademark Office concerning the use of carrier sensing (CS) and collision detection (CD) in wired and wireless networks that have multipacket resolution (MPR) capability. They anticipate that the advantages gained by combining CS, CD, and MPR will allow this patent disclosure to secure the intellectual property rights to a thriving area of commercial networking equipment. In addition to his other duties, Toby has worked extensively on a specific appeal case as a member of the University Committee on Academic Freedom and Professional Status of the faculty. Toby has been named the recipient of the 2006 IEEE Leon K. Kirchmayer Graduate Teaching Award for "sustained excellence in graduate education and research in information theory."

■ Associate Professor **Adam Bojanczyk** (computer engineering, parallel architecture, and algorithms for signal and image processing) reports the implementation of a distributed computer system for target detection based on the back propagation algorithm.

■ Assistant Professor **Martin Burtscher** (high-performance microprocessor systems) reports major activity in his field, including acceptance of a large number of publications on such subjects as supercomputing, microarchitecture, and code optimization conferences, appointment as an associate editor of the *Journal of Instruction-Level Parallelism*, service on the program committee and duty as a session chairman of a compiler conference, reviewer of papers for many major conferences and journals in his area, and co-chairmanship of a successful workshop. He further secured student travel support from Microsoft Corporation for his workshop, obtained a monetary gift from Intel Corporation to support his research, and attracted one of the main Pentium 4 architects to give a Distinguished Intel Lecture at Cornell. During the year, Martin diversified his research, adding multi-core speculation, energy-efficient computer architecture, parallel programming, and brain injury simulation. As part of his teaching duties he created a successful rigorous undergraduate course, ECE 473, Optimizing Compilers.

■ Professor **Hsiao-Dong Chiang** (analysis and control of nonlinear systems with applications to electric-power networks) reports satisfactory progress with ECE 451, Electric Power Systems I, with a significant number of students enrolled. He has filed two U.S. and Patent Cooperation Treaty (PCT) patent applications on a nonlinear indices–based lung-cancer diagnosis system that is under extensive testing at Ruei-Jin hospital in Shanghai, China. Another patent application has been filed with the U.S. Patent Office on "Group-based BCU Methods (boundary of a stability region based on controlling the unstable equilibrium point) for Online Dynamical Security Assessments and Energy Margin Calculations of Practical Power Systems." Hsiao-Dong is continuing research on design of a novel paroxysmal atrial fibrillation identification system that achieves very high diagnostic sensitivity with acceptable specificity and requires very short duration, say 30 minutes, of heart rate variability (HRV) signals. This work, performed jointly with a former Ph.D. student, is under serious evaluation for patent applications through the Cornell Research Foundation. His research group also has achieved significant results on global optimization technologies.

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■ Associate Professor **David F. Delchamps** (control and system theory and member of the Center for Applied Mathematics) has assumed the new position of undergraduate advising coordinator for the ECE School. He is continuing his research on applying game-theoretic reasoning (coupled with dynamical-systems ideas and insights from the theory of mechanism design) to problems in the theory of evolutionary computation. He also is examining more general problems in the modeling and analysis of systems involving many interacting agents with limited shared information and conflicting objectives. Last fall, Dave taught a senior-level special-topics course on evolutionary computation and its points of contact with evolutionary game theory that helped him to crystallize many of the research ideas he has been pursuing. He has secured a grant from the new Faculty Grants for Undergraduate Research Initiative in the College of Engineering that will support some undergraduate assistance with the simulation work associated with this research. At the university level, Dave is continuing his position on the Faculty Engagement in Residential Communities Executive Committee. His principal responsibility is to facilitate and promote faculty involvement with the Greek system along the lines of the Faculty Fellow and House Fellow programs associated respectively with the North and West Campus components of the Residential Initiative.

■ **Lester F. Eastman** (compound semiconductor materials, devices, and circuits), the John LaPorte Given Professor of Engineering, received the 2003 IEEE Microwave Theory and Technique Society Distinguished Educator Award. In recent research Lester has determined the lifetime of longitudinal optical phonons in high-electric fields for various (Ga) AlN/GaN heterojunctions. This is the key parameter, ranging from 350 to 800 femtoseconds, that limits electron channel velocity. This work was done in cooperation with Prof. Matulionis of Vilnius, Lithuania, with students **Yun-Ju Sun** and Alexei Vertiatchikh.

■ **Donald T. Farley** (radio wave and upper atmospheric physics), the J. Preston Levis Professor of Engineering, now is in phased retirement. He hopes to finish his book on incoherent scatter probing of the ionosphere soon. Professor **David Hysell**, earth and atmospheric sciences, now has taken over from Don as the principal investigator of the National Science Foundation Cooperative Agreement on the Jicamarca Radio Observatory in Peru, but Don is continuing his involvement with the research program there as co–principal investigator. His last Ph.D. student now has finished her thesis and is working on a paper on ionospheric plasma instabilities. Don is still an active runner and racer and finds himself doing very well in the 70 to 74 age group. Longevity is a key element to success in competition, it seems. Even though your times get slower as you age, your ranking gets higher!

■ Professor **Terrence L. Fine** (inference and decision making in the presence of uncertainty) reports that he was able to return to service on March 18, 2005, after treatment for lymphoma that caused him to resign as director of the Center for Applied Mathematics. His text *Probability and Probabilistic Reasoning for Electrical Engineering*, published by Prentice-Hall on March 17, 2005, was based closely on course notes used over several years in teaching ECE 310, Probability and Random Signals. Dissertation research conducted with his former student **Leandro Rego** was written up in this time period and was presented at the Fourth International Symposium on Imprecise Probabilities and Their Applications held in late July 2005. Terry also participated in the revision of a paper with his recent Ph.D. student **Chin-Jen Ku** that appeared in the May 2005 *IEEE Transactions on Signal Processing*.

■ **Zygmunt J. Haas** (wireless and mobile networks, wireless communication systems), associate director of academic affairs in the school and the director of the Wireless Network Laboratory (WNL), was promoted to full professor on July 1, 2004. The WNL (wnl.ece.cornell.edu) has been extensively involved in research into the various aspects of ad hoc networking technology in areas such as routing, medium access control design, security, multicast, scalability, and topology control. The ad hoc networking community has exhibited strong interest in the WNL publications and, in particular, in the release of the second version of WNL's scalable network simulator (JiST) that is capable of simulating hundreds of thousands of nodes orders of magnitude larger than any other tool publicly available until now. Indeed, JiST's performance significantly advances the state-of-the-art simulation capability. In the area of stochastic routing, WNL has proposed and developed algorithms for "gossiping," a technique that allows highly efficient coverage of very large networks. These practical low-complexity algorithms are implementable with efficiency close to the theoretical bounds. The WNL's first paper on gossiping in wireless networks was the eighth most cited in 2003 according to CiteSeer, the Scientific Literature Digital Library. Zygmunt's research group also continues to study a number of biologically inspired networks whose operations (e.g., routing, topology control) are inspired by phenomena from the biological world. In particular, WNL researchers have shown that animal mobility could be used to implement "delay-tolerant" networks with considerable efficiency by trading storage for delay and delay for energy. Several invited book chapters on this topic contributed by the WNL members demonstrate the interest of the scientific community in this new networking paradigm. WNL also has been involved recently in research into large and complex systems and networks.

■ **David A. Hammer** (plasma physics, controlled fusion, intense ion beams), the J. Carleton Ward, Jr. Professor of Nuclear Energy Engineering, completed his term in November 2004 as chair of the Division of Plasma Physics of the American Physical Society. His research group has completed installation of the COBRA pulsed-power generator and has started to use it for wire-array Z-pinch experiments and X-pinch experiments. Diagnostic instruments are being added to improve the ability to understand these high-energy-density plasmas. At present, six M.S./Ph.D. students (two with Professor **Bruce Kusse**, applied and engineering physics) are working on the COBRA project. Dave has two other students working on the X pinch.

■ Associate Professor **Sheila S. Hemami** (application-specific compression techniques for packet networks, networking aspects of visual communication, and multirate coding and transmission) has three current National Science Foundation projects: one for modeling the human visual system using signal-processing techniques; one for developing technology so American Sign Language users (the hearing impaired) can use cellular telephones; and one to create mentoring programs for junior faculty in the College of Engineering. In this academic year, three of her Ph.D. students completed their degrees. She designed and taught a highly successful version of ECE 220, Signals and Information, a brand new sophomore-level digital signal processing course that was well received by her students. Professor Hemami was awarded the Constance E. Cook and Alice H. Cook Recognition Award, which honors individuals who are committed to women's issues and have demonstrated significant contributions to changing the climate for women at Cornell. In addition, she has been named the first recipient of the College of Engineering Faculty Diversity Award for contributions to climate, retention, and the recruitment of women, minorities, and others who bring diverse elements to the engineering college.

■ Professor **C. Richard Johnson, Jr.** (adaptive signal processing) has been awarded a Fulbright Scholar grant for the latter half of 2005. He will lecture and conduct research on adaptive signal processing algorithms and communication systems at the Conservatoire national des arts et métiers in Paris, France. Rick also has been named a Stephen Weiss Presidential Fellow this year. Weiss Fellowships are awarded to faculty who have made an outstanding contribution to our undergraduates. During the 2004–2005 academic year, Rick supervised the doctoral studies of two graduate students: **A. G. Klein** in the creation of the first blind equalizer for m-ary bi-orthogonal keying (a pulsed modulation suggested for use in ultra-wideband links for wireless local-area networks), and **J. M. Walsh** in the generation of the first proof of convergence of turbo decoders for finite-length data records. With the assistance of Walsh, he also completed development and first delivery of a new version of ECE 220 Signals and Information, with focus on telecommunication and biomedical applications.

■ Associate Professor **Edwin C. Kan** (modeling and fabrication of nanometer-scale devices) reports on five major developments of his research group during the past year, as follows:

For complementary metal-oxide semiconductors (CMOS) as a universal sensor pixel array for chemical, molecular, pressure, light, and temperature sensing, a complete CMOS integration scheme has been demonstrated experimentally with sensitivity, range, power consumption, and bandwidth of the various sensors found to be better than or very competitive with various proposed sensors that do not have structures that can be directly integrated to CMOS platforms. The chemical and molecular sensing also demonstrated good specificity with generic coatings, and exceptional specificity with functionalized coatings.

For nonvolatile memory, pioneering effort has occurred in the use of nanoscale structures, including metal nanocrystals, carbon-based structures (bucky balls and nanotube), and their hybrids, to enhance the device and system characteristics. Low-voltage, long-retention, high-density, low-power, and high-endurance operations all together have been achieved. A paper on carbon-based integration won an Outstanding Paper Award in the 2004 Material Research Symposium of the Materials Research Society.

For transistor scaling, more pioneering arose in the use of aggressively scaled independently driven double-gate CMOS for new digital, analog, and RF circuits. New circuit topologies have been developed for voltage controlled oscillators, cross-coupled differential amplifiers, and mixers. A design methodology has been formed and fundamental advantages have been determined.

For interconnect, the design and operations for pulse-wave interconnect have been demonstrated for the first-time on a CMOS platform. This development has many advantages over the conventional optimal buffer insertion, most importantly, lower power consumption and signal cross talk. Nonlinear interconnect on CMOS substrate has also been demonstrated for soliton generation, waveform conditioning and amplification, and impedance matching. The pass band of soliton is as high as 21–24 GHz, with less than 1 ohm per cm resistive loss on a silicon-on-insulator substrate.

For Si/SiGe/SiGeC heterostructures, a low-noise intraband avalanche diode has been demonstrated experimentally for integrated amplification of deep infrared sensing. The gain and noise figures are the highest in its operating ranges, thereby improving understanding for use of Si-based heterostructures for quantum-cascade THz sources.

■ **Michael C. Kelley** (upper atmospheric and ionospheric physics), the James A. Friend Family Distinguished Professor of Engineering, reports that his publication rate remains high and he continues to be active in directing several students in their doctoral studies, two of whom are scheduled to graduate this year. He is particularly pleased with the progress being made by his blind graduate student, **Victor Wong.** Mike, an associate of the National Academy of Sciences, was the chairman of the National Academy Decadal Study of Atmosphere-Ionosphere-Magnetosphere Research. He also completed study in Greece under his Fulbright fellowship award. In teaching, Mike initiated an active learning program in ECE 210, Introduction to Circuits for Electrical and Computer Engineering, as he did in ECE 303, Electromagnetic Fields and Waves, and the now college-wide Academic Excellence Workshop program (AEW). The ECE 210 students and the course staff appear to be very appreciative of the AEW program.

■ Professor **Paul M. Kintner** (atmospheric plasma physics) continues to be active in the space science community with a recent appointment to the National Research Council Committee on Solar and Space Physics, and organization of an American Geophysical Union session titled "Physical Processes Causing Space Weather Extremes in the Midlatitude Ionosphere." Paul also responds to frequent requests from NASA to present invited talks about its programs as well as to consult on critical instrumentation issues for large programs. During this academic year he received substantial funding from the Defense University Research Instrumentation Program, a multi-agency DoD program within the University Research Initiative designed to improve the capabilities of U.S. institutions of higher education to conduct research and to educate scientists and engineers in areas important to national defense by providing funds for the acquisition of research equipment. Paul has spent considerable time recently helping Cornell representatives to lobby Congress and providing support to NASA headquarters scientists in their arguments for NASA to continue to fund space science. In continuing his research, Paul, in cooperation with Professor Kristina Lynch of Dartmouth, launched an auroral sounding rocket in March of this year, led his group in development of global positioning systems (GPS) receivers that are in place as scientific instruments in several countries around the world, and produced a number of publications and a pending patent. A variety of organizations (such as the FAA) call upon Paul and his group frequently to provide input for life-critical system designs.

■ Professor **Ronald M. Kline** (history of technology and electrical engineering) created and taught a new undergraduate course, ENGRG 357, Engineering in American Culture. He also directed the Bovay program in History and Ethics of Engineering.

Figure 5. View of CUAUV entry in August 2004 competition. Photo by CUCUV team. Courtesy of Kevin Kornegay.

■ Associate Professor **Kevin T. Kornegay** (computer-aided design for VLSI circuits), director of the Cornell Broadband Communications Research Laboratory (CBCRL), is the recipient of the 2004 Dr. Janice A. Lumpkin Educator of the Year Award from the National Society of Black Engineers. This award recognizes an active classroom collegiate faculty member with demonstrated commitment to advancing education in engineering, science, and mathematics. Kevin received his award at the eighth Annual Golden Torch Awards Ceremony, held in Boston in March 2005. An article, "Teaching Real-World Lessons" by Erica Vonderheid in the June 2005 issue of *The Institute of the IEEE*, comments on this award and other aspects of Kevin's career. Kevin also was selected as one of the "50 Most Important Blacks in Research Science" for 2004 by the editors of *Science Spectrum* and *U.S. Black Engineer* and *Information Technology* magazines. The top 50 were chosen for this annual list based on their work in making science part of our global society. Kevin and his family attended an awards recognition luncheon with the other honorees in Nashville on Friday, September 17, 2004, during the Emerald Awards Conference. Kevin also has been named by *Science Spectrum* magazine as one of the top minorities in science today. The honorees are described as "Science Spectrum Trailblazers." In this academic year, three of his Ph.D. students completed their degrees. The Cornell Autonomous Underwater Vehicle (BRAIN) team, directed by Kevin, placed second in the seventh International Autonomous Vehicle Competition in San Diego, July 28 to August 1, 2004 (see Figure 5). Cornell's second-place finish was quite an accomplishment, especially for a group of first timers who completely rebuilt the submarine electronics infrastructure just before the competition. Kevin's work with CBCRL

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and the BRAIN team is described in an article that appeared in the spring 2003 issue of *Cornell Engineering*. In addition to his research and teaching duties during this academic year, Kevin was associated with recruiting efforts that included mass mailings to prospective undergraduates and attendance at development/recruitment events such as National Society of Black Engineers conferences.

■ Associate Professor **Amit Lal** (application of ultrasonic pulses to microelectromechanical systems [MEMS]) reports formation of close research links with the urology department at Weill Medical College of Cornell University. A joint proposal has been submitted to the National Institutes of Health, and two more are anticipated in the coming year. Awards and subsequent establishment of studies in "Radioisotope Micropowered Systems," a multimillion dollar program, would involve several companies and could lead to a startup by Cornell. In this academic year Amit developed ECE 598, Special Topics in MEMS, with subject matter on advanced MEMS frequency synthesis. The course was very successful in generating new ideas for future projects and also in conveying information not covered elsewhere.

■ Senior Lecturer **Bruce R. Land** (electronics design and computer techniques), with the Department of Neurobiology and Behavior, received the 2004 Robert '55 and Vanne '57 Cowie Award for Excellence in Teaching. Bruce's course ECE 476, Digital Systems Design Using Microcontrollers, has become one of the most popular courses in the ECE School with an average enrollment of 120 students each spring over the past three years. For his instruction in this course Bruce also received the 2005 Cornell IEEE Outstanding Professor of the Year Award.

■ Assistant Professor **Michal Lipson** (nanophotonics, optical nanostructures, optical telecommunications), director of the Cornell Nanophotonics Research Group, reports receiving and maintaining a funding level of approximately $1 million per year. In February 2004, Michal received a National Science Foundation Faculty Early Career Development (CAREER) award of $450,000 over a five-year period for her proposal "Overcoming the Limitations of Microelectronics Using Si Nanophotonics: Solving the Coupling, Modulation, and Switching Challenges." During this academic year, with members of her research group she has developed and published research results in *Nature*, *IEEE Journal of Lightwave Technologies*, *IEEE Photonics Technology Letters*, and *Applied Physics Letters* on approaches for guiding elements in submicron-size features, switching and modulation on silicon, the use of novel computation techniques for developing new photonic structures, and the use of submicron-size devices for detection of single molecules in biophotonics applications. These results are based on submicron-size highly confined structures. Manipulation of light by confinement is the basic principle that has enabled her group at Cornell to control light on silicon. This year Michal's first Ph.D. student, **V. R. Almeida,** completed his degree.

■ Associate Professor **Rajit Manohar** (asynchronous VLSI design, computer architecture, parallel computing), co-founder of the Cornell Computer Systems Laboratory, was awarded a Michael Tien '72 Award for Excellence in Teaching in 2004. He served as co-chairman of the IEEE 11th International Symposium on Asynchronous Circuits and Systems held in New York City in March 2005. In research his group completed the testing of a high-performance asynchronous field-programmable gate array (FPGA) that demonstrates correct operation over a wide range of voltages and temperatures. His group also has submitted an ultra-low-power asynchronous processor for fabrication, with completed chips scheduled for June delivery. Based on previous disclosures, the Cornell Research Foundation has decided to process four patents submitted by the group. One has been filed and three are in the works at present. In this academic year three of Rajit's graduate students have completed their degrees. One is now an assistant professor, one is working for a national laboratory, and the third is starting his own company.

■ Assistant Professor **José Martínez** (multiprocessor architectures, microarchitecture, and hardware-software interaction) and three of his students—**Nevin Kirman, Meyrem Kirman,** and **Mainak Chaudhuri** (who has since graduated and joined the faculty of CSE at IIT Kanpur)—received the Best Paper Award for their paper "Checkpointed Early Load Retirement" at the 2005 International Symposium on High-Performance Computer Architecture (HPCA), one of the top venues in computer architecture. José has served as a member of the program committee for the 2004 International Conference on Parallel Architecture and Compilation Techniques (PACT), as a member of the program committee and student advocate for the 2005 International Symposium in Microarchitecture (MICRO), and as workshops chair for the 2005 International Conference on Parallel Architecture and Compilation Techniques (PACT). During the past academic year he has had three papers accepted for publication in major journals and archival conferences in his field, and has been invited to speak at Princeton University, University of Michigan-Ann Arbor, Intel Microprocessor Research Labs, and IBM Austin Research Lab. Finally, José, as sole principal investigator, has obtained a grant of $190,000 from the National Science Foundation to study checkpointed processor architectures.

■ Assistant Professor **Sally A. McKee** (computer architecture, memory system architecture, high-performance computing), in cooperation with colleagues from Cornell University, University of Oregon, University of Florida, and Georgia Institute of Technology, was awarded three grants from the National Science Foundation in the following programs: Systems Modeling and Analysis (SMA), Information Technology Research/Next Generation Software (ITR/NGS), and Software and Tools for High-End Computing (ST-HEC), with a Lawrence Livermore National Laboratory subcontract in the latter program. During this academic year she has also received an Intel Research Foundation equipment donation and an Intel Corporation academic equipment donation, and continues a productive collaboration with Professor **Keshav Pingali's** Intelligent Software Systems group. Sally secured summer internships for undergraduate students **Engin Ipek** and **Vincent Weaver** at Lawrence Livermore National Laboratory, and in the past year received four $2,000 Cornell Learning Initiatives for Future Engineers (LIFE) awards for her students.

■ Professor **Thomas W. Parks** (signal theory and digital-signal processing) and his graduate students have developed new algorithms for digital cameras. Demonstration of the effectiveness of the algorithms in actual digital cameras was accomplished in cooperation with Texas Instruments, Inc. (TI). Two of his students were trained at TI and programmed the new algorithms on TI hardware.

Director Pollock asked Tom to speak at an ECE Colloquium in October 2004 so that the faculty could become better informed about the signal processing area and to celebrate his receipt of the IEEE Jack S. Kilby Signal Processing Medal. Tom's subject was "The Parks-McClellan Algorithm, a Personal History." During this academic year he taught ECE 425, Digital Signal Processing, conducted research with his graduate students, and did consulting on digital cameras and on laser doppler techniques for early detection of diabetes.

■ **Clifford R. Pollock** (lasers and optoelectronics), the Ilda and Charles Lee Professor of Engineering and director of the School of Electrical and Computer Engineering, spent one month at Coherent Technology, Inc. in Boulder, Colo., working on lasers for remote sensing. During that time he developed a versatile mid-infrared laser, useful for LIDAR applications, that can produce controlled-duration pulses ranging from picoseconds to nanoseconds. In addition to duties as director, Clif returned to the classroom to teach ECE 430, Optical Electronics, to fill in for Professor **Michal Lipson** who was on maternity leave. Throughout the year Clif and the faculty worked diligently to develop a vision for future hiring and research directions in the ECE School.

■ Assistant Professor **Farhan Rana** (semiconductor optoelectronics, device physics, ultra-fast optics, and quantum optics) reports establishment of a research group in semiconductor optoelectronics. A large portion of the effort was devoted to bringing in sponsored research grants, setting up laboratories for semiconductor optoelectronics research, and developing the necessary coursework for students interested in his research area. Novel research directions that will be the focus of the group's research in the coming years were identified, and the innovative character of the research was recognized with Farhan's receipt last year of a National Science Foundation Faculty Early Career Development Award. Current research funding amounts to $370,000 per year. During this academic year Farhan developed two completely new courses, ECE 531, Applied Quantum Optics for Photonics and Optoelectronics, and ECE 533, Semiconductor Optoelectronics.

■ Associate Professor **Anthony P. Reeves** (parallel computer systems, computer-vision algorithms), on sabbatical leave during this academic year, reports that his main achievements during this period resulted from the ongoing group collaboration with C. Henschke and D. Yankelevitz at the Weill Medical College of Cornell University. This activity resulted in three patent applications over the last year with two more in progress, and establishment of a new research program funded by the Cancer Research and Prevention Foundation to create a Public Lung Database to Address Drug Response. The web-based tools to develop this unique database resource are available and will be able to provide an initial public database within a few months. The National Cancer Center has awarded the group a grant for a new project to develop methods for detecting lung nodules in computed tomography (CT) scans. In addition, the group's previous research program on nodule characterization has been renewed, and an early start is planned for a new lung cancer screening clinical trial that will include smoking cessation. A major milestone of the Early Lung Cancer Action Project (ELCAP) to establish the efficacy of screening for lung cancer was announced at the meeting in Nara, Japan, in April. Last year the French and Dutch national cancer trials used the groups' web-based clinical trial system, and two Italian projects intend to use this system this year.

■ Assistant Professor **Anna Scaglione** (statistical signal processing, communication theory), supervisor of the Cornell Communications Research in Signal Processing Group (CRISP), was general co-chair of the sixth IEEE International Workshop on Signal Processing Advances for Wireless Communications (SPAWC) that was held in June 2005 at the Italian Academy for Advanced Studies in America at Columbia University in New York City. The workshop is devoted to recent advances in signal processing for wireless and mobile communications. For the first time in its series, SPAWC 2005 included selected emerging areas in wired-lines. In this academic year Anna's first Ph.D. student, **Yao-Win Hong**, completed his degree. Yao-Win will join the faculty of the National Tsing Hua University in Taiwan. In fall 2004, Anna taught ECE 411, Random Signals in Communication, and in spring 2005, ECE 508, Mobile Communications.

■ Assistant Professor **Sergio D. Servetto** (networks, information theory, signal-processing applications) has been invited to join the editorial board of *Foundations and Trends in Networking*, a new journal by Now Publishers, Inc. that will publish high-quality survey and tutorial monographs of the field. Although Sergio is trying to decrease his editorial commitments, he agreed to accept the invitation because he believes the new publication will have major impact in his field. He also was one of the guest editors for a special issue of the *IEEE Journal on Selected Areas in Communications*, published in August 2004, on the topic "Fundamental Performance Limits of Wireless Sensor Networks." He presented tutorial lectures on "Efficient Architectures for Information Transport in Wireless Sensor Networks" at the fifth Association for Computer Machinery (ACM) International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc 2004), and at the second European Workshop on Wireless Sensor Networks (EWSN 2005). In fall 2004 Sergio taught ECE 662, Network Information Theory, and in spring 2005 he taught ECE 446, Digital Communications over Packet-Switched Networks.

Figure 6. New micromanipulator probe station in Duffield Hall for power microwave measurements of semiconductors on prototype microchip wafers. Graduate student **Rick Brown** is showing checking adjustments. Photo by William C. Mutch. Courtesy of J. Richard Shealy.

■ Professor **Charles E. Seyler, Jr.** (space plasma physics, theoretical and computational plasma physics) concentrated his teaching efforts on improvement of ECE 210, Introduction to Circuits for Electrical and Computing Engineers. He taught the course in both fall 2004 and spring 2005. In research he elucidated the process by which small-scale electromagnetic turbulence is initiated under a wide variety of conditions in the auroral magnetosphere. This is a high-priority activity for the geospace sciences initiatives of both the National Science Foundation and NASA.

■ Professor **J. Richard Shealy** (development of compound semiconductors) reports that wide-bandgap materials like AlGaN are being synthesized for high-power microwave transistors and associated integrated circuits. Within the past year his group has demonstrated a new device-processing scheme that allows for the high-voltage operation of these devices. In the move of the organometallic vapor-phase epitaxy (OMVPE) laboratory from the Tompkins Regional Airport to its new location in Duffield Hall, the semiconductor processing tools have been upgraded to allow further improvements in this device technology (see Figure 6). His group is also working on techniques to integrate dense ultraviolet-light-emitting diode arrays for solid-state lighting on silicon. During the fall 2004 semester, Dick taught ECE 315, Introduction to Microelectronics.

■ Professor **Michael G. Spencer** (growth of compound semiconductors and fabrication of discrete devices from these materials), associate dean of research, graduate studies, and professional education in the College of Engineering, reports the following several achievements of his research group in multiple areas of materials and device-related work during the past academic year.

Scanning probe microscopy using Scanning Kelvin Probe Microscopy (SKPM) was used to characterize nitride materials and active semiconductor devices. A technique has been developed for eliminating the effects of the cantilever on the voltage measurements. The procedure is being applied to measurement of the work function of nanometal particles.

SiC microwave devices: Continued work in this area has resulted in the fabrication of some of the world's best SiC microwave devices. Their power densities have been found to be greater than 2W/mm with maximum short-circuit current gains in excess of 22 GHz . Their stability was studied in an attempt to understand and explain the effect of parasitic and physical parameters on their performance. This work has led to collaboration with Professor Matunionis in Vilnius, Professor **Les Eastman**, and Professor Brian Ridley in England on the effects of hot phonons in these devices. SiC heteropolytype junctions have been fabricated, and evidence has been seen for the first time of two-dimensional electron gas in these structures. Additional measurements are being made to confirm this result.

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Growth of bulk GaN: GaN materials are important for optical and microwave applications whose speed of development would be increased with bulk substrates of GaN. The group has produced a process for the growth of bulk GaN based on GaN with growth rates greater than 250 um/hr and dislocation densities of less than $106/cm^2$. A better understanding of the process has been developed with the knowledge that it is based on oxygen transport. A patent on this process has been produced and first articles have been submitted for publication.

Biomimetic sensors: In collaboration with investigators at Wadsworth Center of New York State, Department of Health, the group has developed a procedure to detect toxins by means of a biomimetic sensor based on controlling ion channels imbedded in a lipid bilayer that mimics cell function. The group has developed a porous alumina process that is used to fabricate test structures designed to measure fundamental properties of these devices.

Nanofiltration technology: A technology based on the electrochemistry of aluminum has allowed development of a porous alumina membrane that is being used by the group in many experiments.

SiC radiation batteries: The group has constructed a SiC radiation battery with 2 percent efficiency that represents the first fabrication of such a device.

GaN rare earth-doped particles: In collaboration with Professor **Michal Lipson's** group, measurements have been made of the optical properties of rare earth-doped GaN particles. Applications of this material are being explored in conjunction with a local company.

SiC materials growth: The group has been able to increase the growth rate of SiC by the addition of HCl to the growth gases.

■ **Chung-Liang Tang** (lasers, optoelectric devices, nonlinear and coherent optical processes), the Spencer T. Olin Professor of Engineering, reports completion of a comprehensive textbook on quantum mechanics for solid-state electronics and optics (Cambridge University Press, 2005). Chung taught ECE 306, Quantum and Solid-State Electronics, in spring 2005.

■ Professor **Robert J. Thomas** (analysis and control of nonlinear systems with applications to large-scale electric utility networks) has received the 2005 IEEE Power Engineering Society Outstanding Power Engineering Award "for outstanding contributions to teaching and research in the field of power systems engineering, for an ability to inspire students to enter the field and for leadership among peers." This award is significant because the recipient is chosen from a highly competitive international pool of candidates. Many past recipients are members of the National Academy of Engineering. Bob also received the Wayne State University Distinguished Alumni Achievement Award in November 2004. Bob reports that the National Science Foundation (NSF) Power Systems Engineering Center (PSerc) now consists of 13 universities with support from NSF and industrial support from 40 companies for a total of about four million dollars. Bob taught ECE 551, Electricity Markets, in fall 2004, and ECE 452, Electric Power Systems II, in spring 2005.

■ Professor **Sandip Tiwari** (electronic and optical-semiconductor devices and compound semiconductors), the Lester B. Knight Director of the Cornell Nanofabrication Facility(CNF), reports that measurements of a novel transistor structure employing dual gates on front and back of a nanoscale thin silicon channel have shown that electron transport can be superior to that of bulk transistor structures. The observed property, which appears to be universal down to five nm-length scale, is a surprise and points to the length scales of Coulombic interactions. These devices appear to have excellent properties at nanoscale dimensions and are suitable for power-adaptive devices, circuits, and architectures—an area of focus in current research effort at CNF. At the other end of the spectrum, studies of massive integration, in collaboration with Professor **Martin Burtscher,** have now established at least one particular embodiment where significant performance benefits can be derived through three-dimensional integration of parallel layers of devices and circuits stacked vertically. These observations at the science and engineering end are central to the potential use of nanoscale electronics where small and complex features come together.

■ Professor **Lang Tong** (signal processing, wireless communications and networks, information theory), director of ECE graduate studies M.S./Ph.D. Program, was named a fellow of the IEEE "for contributions to statistical signal processing for communications and wireless networks." During the past academic year Lang received the 2004 Best Paper Award from the IEEE Signal Processing Society, and the 2004 Leonard G. Abraham Prize Paper Award from the IEEE Communications Society. Two of his graduate students won separate student paper contests at the 2005 IEEE International Conference on Acoustic, Speech, and Signal Processing. Three of his Ph.D. students completed their degrees in May 2005. Lang has been awarded an unrestricted gift by Analog Devices, Inc. in support of his research in 2005 and 2006, and has negotiated a new Office of Naval Research contract under a Telcordia Technologies, Inc. subcontract. As director of graduate studies he has successfully recruited 10 candidates with offers of accompanying fellowships, and initiated and implemented an Annual Graduate Review Program. Lang taught ECE 567, Digital Communications, in fall 2004, and ECE 564, Detection and Estimation, in spring 2005.

■ Professor **Stephen B. Wicker** (wireless information networks and digital systems) is the principal investigator for the Cornell component of this year's successful $20 million National Science Foundation (NSF) Science and Technology Center (STC) Team for Research in Ubiquitous Secure Technology (TRUST) research proposal, with the University of California at Berkeley as the overall leader. ECE Professors **Lang Tong** and **Rajit Manohar** and CS Professors **Kenneth Birman, Fred Schneider,** and **Emin Sirer** complete the Cornell team. The Cornell ECE portion of the funding will be $3 million over the next five years. Steve's proposal to NSF for a Networking Technology and Systems—Networking of Sensor Systems (NSF Nets-NOSS) project was funded last year at $2.5 million. The project is now under way with Professors Manohar, Tong, Birman, and Sirer brought into the sensor networking effort that Steve began with his successful NSF Information Technology Research (ITR) proposal two years ago. During the past academic year, construction of a sensor networking testbed began, several papers were published, some ideas regarding self-configuring networks were developed, and one of Steve's Ph.D. students completed his degree (Steve's 27th). Steve taught ECE 320, Networks and Systems, for the first time in spring 2005 and is accumulating comments for suggested revisions from students and interested faculty.

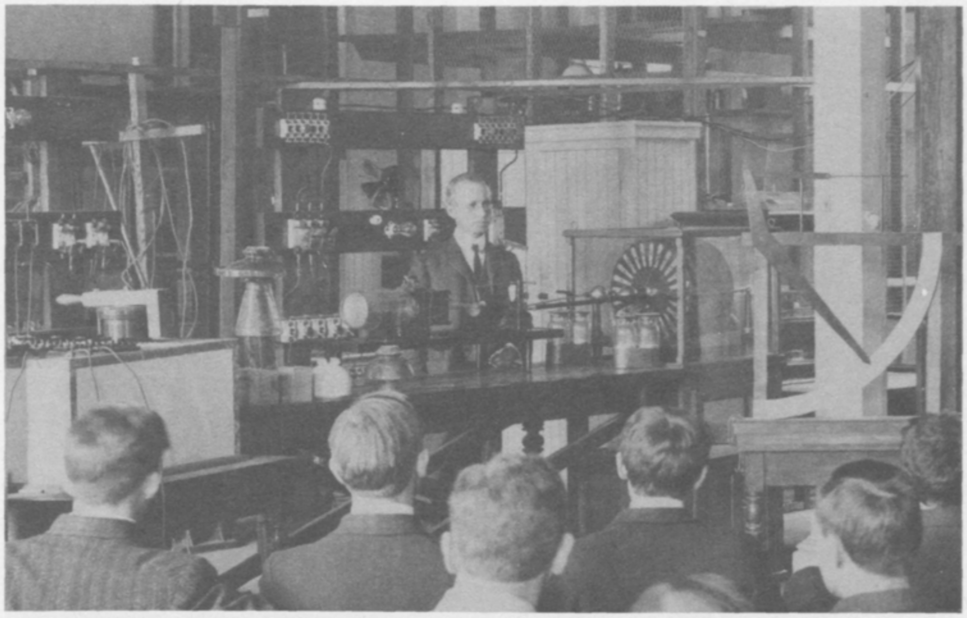
More Tales from the Past

Your tales from the past are always welcome. Send us your favorite stories about professors, labs, classes, projects, stunts, or whatever you think made the EE/ECE School a special place. We'll print 'em as space allows.

The memory disk display in the spring 2004 issue of *Connections* apparently created considerable discussion and brought forth the following interesting note of historical significance from **Randy Little,** B.E.E. '63, who writes:

Your collection of memory disks, past and present, was a very interesting and thought-provoking exhibit that reminded me of Moore's Law and one of my own experiences with computers. But first, an alternative hypothesis on the etymology of "floppy" disk: floppy, as flexible, in contrast to the then-prevalent rigid disks that were the mainstream of online storage devices. The computer experience that I wish to share comes from that same dynamic era of the 8-inch floppy. My first project at Bell Labs upon graduation from Cornell was development of the memory subsystem for the Stored Program Control System No. 1A (SPC1A), the first solid-state system to supplant electromechanical control in the long-distance telecommunications network. Granted, a modest amount of speed and volume was sacrificed to gain real-time, non-stop, 9-9s reliability, but the SPC1A was still a veritable speed demon at the time, which was the late '60s.

The fast mainframe storage medium of the time was "core" memory, an array of ferrite cores that could be accessed randomly for reading and writing data at electronic speeds. (Remember the "core dump" that occurred when a bug caused your program to crash?). Conventional core memory, however, exhibited destructive readout and total loss of memory in the event of power failure. Such ephemeral memory may have been good enough for most commercial computer installations, but fail-safe control of the national long-distance network demanded a nondestructive readout solution. The Piggyback Twistor Store was it—an ingenious application of two layers of remnant magnetic material, one upon the other in piggyback fashion, in a spiral wrap along a read-write wire.



Rare and Manuscript Collections

Figure 7. Professor Harris J. Ryan (circa 1900) presents a lecture on high-voltage phenomena to a class of EE students.

Sparing further details of the construction, the final result was a memory subsystem of 2.5 MB capacity clocked at 160 kHz—quite ho-hum by modern standards, yet more than sufficient to handle the peaks of toll telephone traffic for areas such as Dallas, Detroit, or Miami. A total of about 100 SPC1A installations teamed up to serve the entire nation.

If the capacity and speed seem pale, as they should, by today's standards, the physical size and power consumption are sure to draw your breath. Those 2.5 MB of storage occupied 155 linear feet of 7-foot-high equipment rack space and consumed 30 kW of power, not exactly fit for your personal digital assistant (PDA)!

This retrospection certainly reminds us of the great improvements that have been made in computing speed, size, and power efficiency but would be incomplete without also reminding us of just how large a task could be accomplished with only 2.5 MB of memory and a 160 kHz central processing unit.

Sam Linke reporting: Here is a tale that really is from the past—an update on a 100-year-old high-voltage transformer built by the late professor of electrical engineering **Harris J. Ryan,** B.E.E. 1887, sometime before 1905 when he transferred to Stanford after a 17-year career at Cornell. Alumni from the mid-1950s may recall seeing the large, somewhat ungainly device on display for several years in the south corner of the Phillips Hall lobby before the submicron facility was established in that end of the building. Eventually, it was transferred to an alcove in the basement where it remains today.

Now that Duffield Hall and accompanying reconstruction in Phillips is completed, appropriate space is available to bring our venerable artifact to the light of day once again. Recent inspection of the transformer revealed that it was in reasonable condition for display, but certainly not for actual operation at its 10 kV rating, or at any voltage. Five large white porcelain pole-top insulators also are missing and may be serving as antique paper weights somewhere on campus. In Figure 7, the transformer probably is located in the safety cage behind the professor, since a white insulator is clearly visible.

At present I am engaged in a search of the literature for elusive writings by Professor Ryan about the transformer, so far without success. Perhaps at the time he was more concerned with his notable invention of the placement of vertical and horizontal plates in a cathode-ray tube that made the cathode-ray oscilloscope possible. (A crude Lissajous figure can be seen in a print of his original patent.) An attempt is being made to replace the insulators, and other rehabilitation is planned. Look for the transformer on your next visit to the campus in a few months or at reunion time.

Alumni: Please fill out this coupon for the *Positive Feedback* feature and return to:

John Belina, Cornell University, School of Electrical and Computer Engineering, 201 Phillips Hall, Ithaca, NY 14853; belina@ece.cornell.edu

Name ______________________________

Position title ______________________________

I am employed by ______________________________

(street) ______________________________

(city, state, zip) ______________________________

My current activities in ECE (or related to ECE) are:

Optional:

I would like to explore possibilities in the following areas:

( ) Contributions to the Eminent Professors' Fund

( ) Contributions to the Joseph L. Rosson (Papa Joe) Memorial Fund

( ) Establishment of one-year fellowships for professional master's students

( ) Engineering Coop Program

( ) Job placement of Cornell ECE seniors or graduate students

( ) Other ______________________________

ECE School Research Funding

Total research funds expended in 2001-2002	$16,416,782
Total research funds for 2002-2003	$19,403,956
Percent increase	18.2%
Total research funds expended in 2003-2004	$20,681,114
Percent increase	6.6%

The research funds for 2002–2003 show a substantial increase over figures reported for previous years because funding for the Cornell Nanofabrication Center, the Laboratory for Plasma Studies, and the Power Systems Engineering Center are included in the totals. The 2003–2004 funding also includes these additional figures. During the past academic year the school has received gifts and equipment valued at over $1.4 million in support of faculty research, teaching, and special projects. In addition to the National Science Foundation and the Office of Naval Research, these sponsors include Sensor Systems, Advanced Micro Devices, BAE Systems, BF Goodrich, Emcore, Fuji Electric, General Electric, GTE/Verizon, Lutron Corporation, IBM, Intel, Microsoft Corporation, Northrup Grumman, Nova Crystals, NxtWave, Rockwell Scientific, RF Micro Devices, Triquent, Tiawan Power, Zepton Networks, and many others. These generous grants from foundations, and corporations, coupled with equally commendable gifts from many individuals, aid the recipients in their teaching and research and make it possible for the ECE School to establish and maintain a leading edge in the discipline.

Staff News

Sutapa (Su) Ghosh, B.A. '04 (Cornell), Asian studies, joined the ECE School on January 25, 2005, as an administrative assistant to work with Paula Solat and Kim Cotton in Rhodes Hall. Su, a native of New York City, moved to Kolkata, India, at the age of 14. In January 1999, she graduated from Calcutta International School with honors in physics, chemistry, and pure mathematics, came to Cornell in the same year to study engineering, and soon thereafter transferred to Asian studies with Japan as her regional concentration. During her undergraduate years Su was a work-study student with Engineering Advising for two years, worked at the East Asia Program for a year, and in her final year received a travel grant for summer study in Japan. She is reasonably proficient in spoken Japanese and is a native speaker of Bengali. Her aspirations are predominantly academic and, in due time, she hopes to obtain a doctorate in East Asian languages and literatures and become a professor of Japanese studies. Su enjoys reading, cooking, and swing dancing when time allows. Eventually, she would like to travel as much as possible.

Jamie Dal Cero, administrative assistant in the ECE School for the past five years, accepted a position in December 2004 with the Cornell College of Veterinary Medicine as a coordinator of sponsored projects. This deserved promotion for Jamie was made possible by her excellent work in the school and her willingness to assume increasing amounts of responsibility. We wish her all success in her new position.

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In Memoriam

Mrs. Rita Anne Thomas, wife of Professor Robert J. Thomas, died suddenly of natural causes on Monday, July 12, 2005, at her home in Dryden, N.Y., at the age of 61. Rita and Bob were married for 43 years and lived in the Ithaca and Dryden area for 32 years. Rita received her nursing degree from Tompkins Cortland Community College. For many years she was a devoted homemaker, active in the Dryden United Methodist Church and in the Dryden Library where she enjoyed her participation in an ongoing reading program for children. In addition to her husband, Rita is survived by two children, Lori, B.S.E.E. '84 (Cornell), Timothy, and four grandchildren. Her many friends long will remember her warm personality and her dedication to family and community activities.

A Link Between Alumni and the School of Electrical Engineering

In this issue we continue the Positive Feedback feature of previous years. The first 13 issues of *Connections* triggered a gratifying number of responses. We hope that this issue will stimulate even more letters or reports on your recent activities.

The ECE School home page may be found at www.ece.cornell.edu. The College of Engineering home page is www.engineering.cornell.edu. The e-mail address for *Connections* is belina@ece.cornell.edu.

Note: Our alumni file is somewhat incomplete. If you know of EE School alumni who are not receiving *Connections,* please urge them to send their names and addresses to **Jeanne Subialka,** B.S. '99 (ILR), Engineering Public Affairs, 248 Carpenter Hall.

Positive Feedback

Donald N. Ewart, B.E.E. '54. M.S.E., Union College, now retired from his consulting firm and living in Scotia, N.Y., writes of his long absence from the campus but recalls the inspiration he received from his professors and the influence his Cornell education had on his long career in the power engineering field. Among other hobbies, Don enjoys riding his motorcycle. He has ridden across the country five times and at the time of his letter was planning another trip this summer.

Thomas W. Parks, B.E.E. '61, M.S. '64, Ph.D. '67, professor of electrical and computer engineering at Cornell, was the speaker at the ECE Colloquium Series on October 5, 2005, on the topic "The Parks-McClellan Algorithm, a Personal History."

Randolph S. (Randy) Little, B.E.E. '63, M.S.E.E., Ohio State U., M.S.Mgmt., Pace U., retired venture manager, and hiatus member of the Board of Directors of the Cornell Engineering Alumni Association (CEAA), submitted an interesting commentary on a previous article in Connections. Randy's remarks appear in "More Tales of the Past" on page 21 of this issue.

Alan Esserman, B.S.E.E. '64, M.S. '66, retired from Bell Labs in 1995, and from IBM in 2001, and residing in Malalapan, N.J., writes of his extremely fond memories of his years at Cornell. He became involved with computers in his sophomore year and went on from there to an extensive career in the computer engineering field.

Michael Ury, B.E.E. '64, M.E.E. '65, retired from Fusion Lighting, Inc., and residing in Great Barrington, Mass., visited the campus in October 2005 with his daughter, Emily, in hopes that she may be interested in Cornell in due time. Afterwards he wrote of his visit and his career and recalled his experiences with the members of the Laboratory of Plasma Studies at the Mitchell Street Laboratory.

Jamil F. Sopher, B.S. '65, M.E.E. '66, staff associate, World Bank Group, Washington, D.C., attended his 40th reunion in June 2005. Jamil returns to the campus from time to time to visit his daughter, Margaret, who is a senior in the College of Arts and Sciences.

H. William (Bill) Fogle, B.S.Engr. '70, M.S.C. Cambridge U., senior staff engineer with TRW Safety Systems, Inc., in Mesa, Ariz., visited the campus in April 2005, renewed old acquaintances, and checked out Duffield Hall.

Justin R. Rattner, B.S.E.E. '71, Intel senior fellow and director of Intel's Corporate Technology Group, conducted an ECE Special Seminar on Wednesday, April 20, 2005, at 4:30 p.m. in Hollister B14 titled "Imagine the Future: Platform 2015," in which he described Intel's research and development efforts in planning for future computing needs.

Mark G. Adamiak, B.S. '75, M.E.E. '78, M.S.E.E. Polytechnic Institute of New York, General Electric Multilin Power System manager in Malvern, Pa., was named an IEEE fellow in January 2005, "for contributions to power system protection, communications protocols and standards for power system substations." Congratulations, Mark!

James C. Rautio, B.S.E.E. '78, M.S. Systems Engineering, University of Pennsylvania, Ph.D. in E.E., Syracuse University, founder of Sonnet Software, Inc., in 1983, was the speaker at the ECE Colloquium on November 2, 2004, at 4:30 p.m. in 101 Phillips Hall. His talk was titled "The Life of James Clerk Maxwell."

Edward P. Einhart, B.S.E.E. '79, Central Square, N.Y., writes that he is a technical sales engineer with SMAC Northeast, a company that manufactures voice-coil actuators.

Jeffrey C. Hawkins, B.S.E.E. '79, chief technology officer for palmOne, Inc., executive director and chairman of the Redwood Neuroscience Institute, member of the Scientific Board of Directors at Cold Spring Harbor Labs, and member of the National Academy of Engineering, gave a lecture titled "On Intelligence" on October 7, 2004, in Upson Hall. We recall that in 1992, Jeffrey developed hardware and software that resulted in the invention of the Palm-Pilot.

Daniel S. Simpkins, B.S.E.E. '80, M.Eng.(Elec) '81, president and CEO of Hillcrest Communications, Inc., in Rockville, Md., was the first speaker on April 21, 2005, at the CEAA Engineering Conference on Engineering as a Foundation for Business Leadership: Tales from the Frontlines. His talk was titled "The 10 Rules of Entrepreneurship."

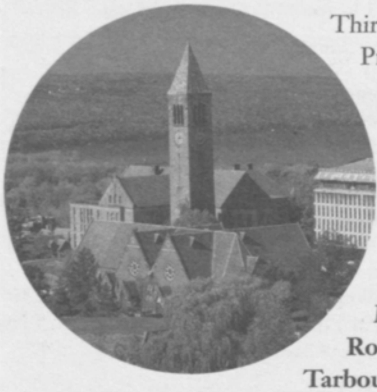
Edward G. Liu, B.S.E.E. '84, presented the 2004 Spencer T. and Ann W. Olin lecture at Newman Arena, Bartels Hall, on June 11, 2004. His talk was titled "Rocketships, Asteroids, Dinosaurs, and Immortality." Ed showed images from his most recent space flight during the lecture.

Ellen Grant Picciolli, B.S.E.E. '86, M.S. U. of Michigan, transferred to Intel Corporation in Stowe, Mass., in July 2003 where she now holds the position of hiring manager. She is a new member of the ECE School Advisory Council.

Jennifer T. Bernhard, B.S.E.E '88, M.S. and Ph.D., Duke U., associate professor of electrical and computer engineering at the University of Illinois at Urbana-Champaign, was the speaker at a special seminar, Friday, March 11, 2005, in 403 Phillips Hall. Her talk was titled "Multifunction Antennas and Antennas for Sensor Applications."

Joshua Kablotsky, B.S.E.E. '90, team leader of the Digital Media Technology Center with Analog Devices, Inc., was the ECE colloquium speaker on November 9, 2004, in 101 Phillips Hall. His talk was titled "They Never Taught That in Engineering School."

Eminent Professors' Fund



Thirteen years ago the EE School established the Eminent Professors' Fund to honor the memory of notable members of the EE faculty of past years such as professors **Paul D. Ankrum, Ralph Bolgiano, Jr., Henry Booker, Nelson H. Bryant, L. A. Burckmyer, Walter W. Cotner, Casper L. Cottrell, William H. Erickson, Clyde E. Ingalls, M. Kim, J. Peter Krusius, Charles A. Lee, Michel G. Malti, Malcolm S. McIlroy, True McLean, Wilbur Meserve, B. K. Northrop, Robert Osborn, Joseph L. Rosson, Howard G. Smith, Everett Strong, Joseph G. Tarboux, Stanley W. Zimmerman,** and others whom alumni may recall. The objectives of the fund are twofold: (1) to acquire specific grants to improve laboratory and research facilities in the ECE School and (2) to establish endowments to provide ongoing financial support for undergraduate and graduate students. The ECE School has given high-priority status to the following activities:

- Establish an endowment fund to supplement the operating costs of the undergraduate computing center and the undergraduate teaching laboratory.
- Establish an endowment fund to provide financial support, on a yearly basis, for graduate and undergraduate students who serve as teaching assistants in our laboratories.
- Establish one-year fellowships to support professional-master's candidates for the M.Eng.(Electrical) degree.
- Establish a fund to support M.Eng.(Electrical) research projects.

Alumni who would like to contribute to the Eminent Professors' Fund should contact Professor **Clifford R. Pollock** in care of the School of Electrical and Computer Engineering, 224 Phillips Hall.

ece ONLINE NEWS

New ECE Web Page Is Now Online

The ECE School web page has been extensively modified. The current version contains a guide for enrolled and prospective students, an updated alumni section, and general information about the school and faculty. Check it out at

www.ece.cornell.edu

Alumni Breakfast

The annual ECE School alumni breakfast was held on Saturday, June 11, 2005, from 7:45 to 9:30 a.m. in the Phillips Hall Lounge. Over 100 alumni, companions, and friends joined members of the ECE School faculty and staff for an event that is *always a festive and memorable occasion.*

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