Annual News from the MIT Department of Electrical Engineering & Computer Science

the MIT EECS Connector

Spring 2012

Contents

The EECS Connector is published annually by the Department of Electrical Engineering and Computer Science at MIT to keep our alumni and friends informed about the department's research and educational events and milestones, and provide a yearly update of the department faculty, staff and student accomplishments.

This newsletter will act as a print (and online pdf) reference to be supplemented with bi-semester online department newsletter updates in the *eecsReflector*. We value your news and comments. Please send these to: newsletter@eecs.mit.edu

MIT EECS
ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

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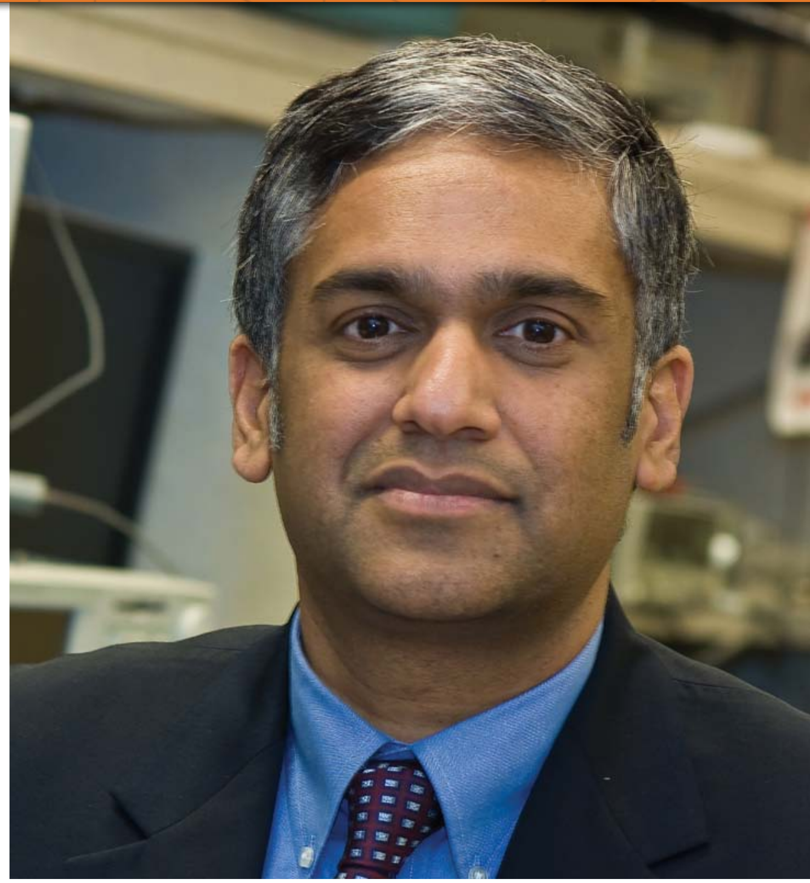
Message from the Department Head



It is my pleasure to welcome you to the 2012 edition of the annual Electrical Engineering and Computer Science newsletter, *the MIT EECS Connector*. This issue marks the beginning of a new identity for EECS along with a new website which we plan to launch later this spring.

It is also my first opportunity as Department Head to share with you the exciting news and accomplishments that distinguish the department as a whole and its faculty, students and staff. Currently, our department has 124 faculty members, 1050+ undergraduates and MEng students, and 600+ SM/PhD students. Our faculty, students and staff have been recognized with many significant awards and you can read about them in this issue. In particular, the selection of Professor Millie Dresselhaus by President Obama as co-recipient of the Enrico Fermi Award is a great honor for our department and the Institute.

In the summer of 2011, we initiated a strategic and operational planning exercise for the EECS Department. We formed 14 task forces which included 85 faculty members, 9 students and 10 staff (appearing in the lower photo collage on this issue's cover). The topics for these groups were generated based on issues identified in the Department Head Search Advisory Committee report and through my discussions with members of our faculty and the Department Leadership Group (DLG). The task forces met from June through December 2011 and generated about 25 exciting initiatives for MIT EECS. The ideas broadly fit into four categories: focusing on the excellence of our faculty, enhancing the undergraduate experience, enhancing the graduate experience, and increasing the visibility of EECS through global outreach. We are now developing a strategic plan based on the output of these groups, prioritizing the various initiatives and aligning them with the department's and the Institute's broader goals. We have already initiated action on several ideas, and expect to realize more key projects starting in Fall 2012.

I would like to acknowledge the inputs to the strategic plan and various other departmental initiatives from the new Undergraduate Student Advisory Group in EECS (USAGE, appearing in the upper photo collage on this issue's cover). These undergraduate students take part in monthly sessions looking at ways to improve the academic and overall Course VI experience. Their inputs have been extremely valuable as we set the vision for EECS. As the department moves forward, we plan to build new opportunities for undergraduate students in EECS through advanced research and teaching programs leading to publication possibilities and exposure to entrepreneurship, expanded access to hands-on facilities, expanded interactions with industry and alumni, and curriculum (e.g., focus on medical in EECS).

We also want to ensure continued excellence in our graduate program, building greater opportunities for our graduate students to explore the cross-disciplinary wealth of research in our affiliated laboratories and research areas in EECS, and in related disciplines across MIT. A number of inter-disciplinary centers have been created in our affiliated labs, including the Connection Science And Engineering Center at MIT, the MIT/MTL Center for Graphene Devices and Systems, and the Medical Electronic Device Realization Center (MEDRC). You can read about some of the exciting faculty research in these centers and our affiliated labs, online and in the pages ahead.

Our international collaborations in partnership with MISTI have been extremely beneficial to our students and faculty. Last year more than 100 EECS students participated in international experiences. This issue features two international outreach programs that have been initiated by EECS students and graduates—the AITI Program (Accelerating Information Technology Innovation) and the IIH (Innovators in Health), a nonprofit formed in 2007 by three EECS graduates. Building on its global visibility, the EECS Department continues to develop its ties internationally for students and faculty.

I am excited about opening additional avenues for MIT EECS alumni to interact with our students. In fact, some Course VI software development classes are already using local alumni for code reviews, with overall excitement and appreciation for these collaborative experiences. Moving forward, we hope to scale up this effort, creating a virtual environment that allows our alumni to share their experience with our students. For example, EECS alums Sal Khan and Drew Houston generously gave lectures this year to our students, on charting a successful path from MIT to impacting society. We are pleased to feature several highly accomplished and thoughtful EECS alumni in this issue. Support like this from our alumni will be critical in building the next generation of engineers. I am eager to hear your thoughts on how we can engage our alumni further in our department.

I invite you to enjoy this newsletter, keeping in mind that this is just a sampling of the exciting and evolving EECS at MIT. We are proud that our faculty, students and alumni are driving the next generation of technology and making a broad societal impact. With the upcoming launch of our new website, we look forward to strengthening your connection to MIT EECS.

—Anantha P. Chandrakasan
Joseph F. and Nancy P. Keithley Professor of Electrical Engineering
Department Head, MIT Electrical Engineering and Computer Science

EECS Faculty in the News

Mildred S. Dresselhaus is named for the Enrico Fermi Award

Photo credit: Ed Quinn

courtesy MIT News Office, Jan. 12, 2012

President Obama named MIT EECS and Physics Institute Professor Emerita Mildred S. Dresselhaus for the Enrico Fermi Award, one of the nation's oldest and most prestigious honors for scientific achievement. Secretary of Energy Steven Chu will present the award to Dresselhaus and co-winner Stanford University's Burton Richter on May 7 in Washington D.C. Dresselhaus is cited "for leadership in condensed matter physics, in energy and scientific policy, in service to the scientific community, and in mentoring women in the sciences."

In a career spanning more than 50 years at MIT and its Lincoln Laboratory, Dresselhaus has made extensive research contributions and fundamental discoveries in condensed matter physics. She is also widely recognized for her considerable devotion to mentoring students, raising community awareness, and promoting progress on gender equity. She is widely respected as a premier mentor and advocate for women in science.

Dresselhaus has also served in many scientific leadership roles, including as the director of the DOE Office of Science; president of the American Physical Society and the American Association for the Advancement of Science; chair of the American Institute of Physics Governing Board; and co-chair of the most recent Decadal Study of Condensed Matter and Materials Physics.

Born and raised in New York City, Dresselhaus was inspired as an undergraduate at Hunter College by future Nobel Laureate Rosalyn Yalow, who recognized her talent and encouraged her to pursue science. She received an AB summa cum laude from Hunter College in 1951, an AM from Radcliffe College in 1953 and a PhD in 1958 from the University of Chicago. She was a Fulbright Fellow at Newnham College at the University of Cambridge from 1951 to 1952.

"The scientists being recognized today with the prestigious Enrico Fermi Award have provided scientific leadership throughout their careers that has strengthened America's energy and economic security," Secretary of Energy Steven Chu said in a statement. "I congratulate them for their achievements as pioneers in innovative research and thank them for their service."

Awards & Recognition

Wojciech Matusik was awarded Sloan Research Fellowship for his work in computer graphics, particularly in data-driven materials, virtual humans, and computational photography and display.

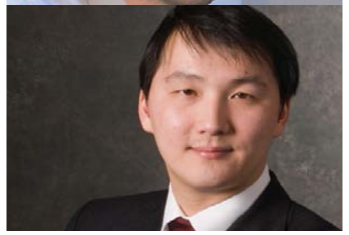
Dana Weinstein was awarded the NSF Early Career Award to explore multi-GHz MEMS resonators using electromechanical transduction.

David Gifford was selected as a 2011 ACM Fellow. He is recognized "for contributions to distributed systems, e-commerce and content distribution."

Tomás Lozano-Pérez was named a 2012 IEEE Fellow for "contributions to robot motion planning."

Hal Abelson received the 2012 ACM SIGCSE Award for Outstanding Contribution to Computer Science Education at the 43rd SIGCSE Technical Symposium.

Tomás Palacios was awarded the Presidential Early Career Award for Scientists and Engineers.



Tim Lu was awarded the NIH Director's New Innovator Award toward his work in synthetic biology and nanotechnology. He was also named for the MIT Dougherty Professorship.

Jack Dennis was inducted into the ACM Special Interest Group on Operating Systems (SIGOPS) Hall of Fame for his intellectual and institutional contributions to the advancement of the Internet.

Pablo Parrilo received the IEEE Antonio Ruberti Outstanding Young Researcher Award for fundamental contributions to optimization theory and its applications.

Manolis Kellis was awarded the 2011 Niki Award for his distinguished contribution to science and his research into the human genome.

Li-Shiuan Peh was named an ACM Distinguished Scientist for her work on on-chip networks, parallel architectures and mobile computing.

Barbara Liskov was awarded the Katayanagi Prize for Research Excellence for many fundamental contributions to computer science.

Fatih Yanik received the NIH Director's Pioneer Award as the youngest recipient and the only recipient of all the other top NIH Awards.

David Clark received the Oxford Internet Institute Lifetime Achievement Award for his intellectual and institutional contributions to the advancement of the Internet.

New Faculty Chairs in EECS

Hari Balakrishnan is named for the Fujitsu Chair

Professor Hari Balakrishnan has been named for the Fujitsu Chair, donated by the Fujitsu Corporation.

Hari Balakrishnan's research is in networked computer systems. His current interests are in system software, network protocols, and data management for a world of "truly mobile" connected devices. Previous work includes the RON overlay network, the Chord DHT, the Cricket location system, the CarTel mobile sensing system, and cross-layer wireless protocols such as snoop TCP and SoftPHY. He has also contributed to verifiable Internet routing, congestion control, network security and privacy, energy-efficient protocols, stream processing, and data management systems.

He is an ACM Fellow (2008), a Sloan Fellow (2002), an ACM dissertation award winner (1998), and has received several best-paper awards including the IEEE Bennett prize (2004) and the ACM SIGCOMM "test of time" award (2011). He has also received awards for excellence in teaching and research at MIT (Spira, Junior Bose, and the Harold Edgerton faculty achievement award).

In 2003, Balakrishnan co-founded StreamBase Systems, the first high-performance commerical event stream processing (aka complex event processing) engine. Between 2000 and 2003, he helped devise the key algorithms for Sandburst Corporations's (acquired by Broadcom) high-speed network QoS chipset. He is advisor to Meraki and on the Board of Trustees of IMDEA Networks in Spain.

Hari has taught the graduate class 6.829 (Computer Networks), 6.033 (Computer Systems Engineering), taken by almost all CS undergrads, and 6.02 (Intro to EECS-II: Digital Communication Systems), taken by all Course VI undergrads.

George Verghese is named for the Henry Ellis Warren Chair

George Verghese has been named for the Henry Ellis Warren Chair in Electrical Engineering. The chair is designated for "interdisciplinary research leading to application of technological developments in electrical engineering and computer science, with their effect on human ecology, health, community life, and opportunities for youth".

As a Principal Investigator with MIT's Research Laboratory of Electronics, George heads the Computational Physiology and Clinical Inference Group, which focuses on "bedside informatics", using physiologically based computational models to enhance real-time clinical monitoring. His research interests and publications are broadly in applications of dynamic systems, modeling, estimation, signal processing, and control. Before turning to biomedicine, George worked on power systems and power electronics.

George Verghese received his BTech from the Indian Institute of Technology, Madras in 1974, his MS from the State University of New York, Stony Brook in 1975, his PhD from Stanford University in 1979. He joined the EECS Department at MIT immediately after.

George was elected IEEE Fellow in 1998. He is also a MacVicar Faculty Fellow since 2011. He served as EECS Education Officer for several years, and is currently the co-chair of the EECS Awards and Recognition Committee.

The Henry Ellis Warren Chair was set up as a memorial to a 1894 alumnus of MIT, one of the Institute's first graduates in electrical engineering. Warren is best known for the invention (among his 135 patents) of the electric clock and its application to frequency control in power systems.

Given George Verghese's connection to power systems and biomedical signal processing, Dept. Head Chandrakasan noted how fitting it is for George to be appointed to the Warren Chair.

Faculty Research Innovation Fellowships

To recognize EECS faculty members for outstanding research contributions and international leadership in their fields, the department has established the EECS Faculty Research Innovation Fellowship (FRIF) program. Winners of these fellowships will receive three years of gift funding and typically three awards will be made per year. Awards will typically be made to senior faculty members who do not currently hold endowed chairs. Award nominations are made by Department faculty and the DLG, and final decisions are made by the DLG with input from the EECS Personnel Committee. Read about the inaugural FRIF winners as announced by Department Head Chandrakasan (below).

Vladimir Bulović joined the faculty of MIT in July 2000 where he is now a Professor of Electrical Engineering leading the Organic and Nanostructured Electronics Laboratory (ONE Lab) and co-directing the MIT-ENI Solar Frontiers Center. As of Oct. 1, 2011 Vladimir Bulović is the Director of the Microsystems Technology Laboratories, MTL. As MIT Energy Initiative council member, Bulović is co-heading the Energy Education Task Force and co-directing the MIT Energy Studies Minor. In 2008 he was named the Class of 1960 Faculty Fellow in recognition of his contributions to energy education, and in 2009 he was named the Van Buren Hansford (1937) – Margaret MacVicar Faculty Fellow, MIT's highest teaching honor.

Tommi S. Jaakkola received an MSc in theoretical physics from Helsinki University of Technology, 1992, and his PhD from MIT in computational neuroscience, 1997. Following a postdoctoral position in computational molecular biology (Sloan postdoctoral fellowship, UCSC) he joined the MIT EECS faculty in 1998, where he is now Professor. His research interests include many aspects of machine learning, scalable statistical inference and estimation, and analysis and development of algorithms for modern estimation problems such as those involving predominantly incomplete data sources. His applied research focuses on problems in computational biology, inference problems in natural language processing, and behavioral modeling problems in a mobile context.

Dina Katabi is a Professor in the EECS Department, and a member of the Computer Science and Artificial Intelligence Laboratory. She joined the MIT faculty in March 2003, after completing her PhD at MIT. Katabi's work focuses on wireless networks, mobile applications, network security, and distributed resource management. She has award winning papers in ACM SIGCOMM and Usenix NSDI. She has been awarded the IEEE William R. Bennett prize in 2009, a Sloan Fellowship in 2006, the NBX Career Development chair in 2006, and an NSF CAREER award in 2005. Her doctoral dissertation won an ACM Honorable Mention award and a Sprowls award for academic excellence.

Muriel Médard is a Professor in the EECS Department at MIT where she is a principal investigator in the Research Laboratory of Electronics. She was previously an Assistant Professor at the University of Illinois Urbana- Champaign. From 1995 to 1998, she was a Staff Member at MIT Lincoln Laboratory. Médard received BS degrees in EECS and in Mathematics in 1989, a BS degree in Humanities in 1990, a SM degree in EE in 1991, and a ScD degree in EE in 1995, all from MIT. Médard leads the network coding and reliable communications group at RLE. He work ranges from information theoretic characterization of wireless systems to applications of network coding for increased performance and security in mobile ad-hoc, peer-to-peer, cellular, proximity, home and satellite networks.

Adam Chlipala joined the EECS Department in July 2011 as Assistant Professor and principal investigator in the Computer Science and Artificial Intelligence Laboratory. He received his bachelor's degree in computer science from Carnegie Mellon in 2003 and his PhD in computer science from UC Berkeley in 2007. Prior to joining MIT, he was a postdoctoral fellow at Harvard.

Adam's research focuses on applications of machine-checked formal logic, particularly to improve processes for software development and analysis. Many of his projects rely on computer proof assistant technology, which supports algorithmic checking of rigorous mathematical proofs. Adam has built mechanized correctness proofs for compilers, program analyzers, and runtime systems, with a focus on minimizing the human cost of designing water-tight proofs through use of domain-specific proof automation. He is also interested in the design and implementation of functional programming languages. In particular, his new Ur/Web language brings strong mathematical guarantees to the world of Web application programming. His compiler for Ur/Web applies automated theorem proving to check once and for all that particular programs are free of common Web programming errors, including serious security flaws.

Yury Polyanskiy joined the EECS department in September 2011 as an Assistant Professor and a principal investigator in the Laboratory for Information and Decision Systems (LIDS).

Yury received the BS and MS degrees (with honors) in applied mathematics and physics from the Moscow Institute of Physics and Technology (MIPT) in 2003 and 2005, respectively. In 2010 he obtained his PhD in electrical engineering from Princeton University, where his final year was supported by the Dodds Honorific Fellowship. His thesis work, supervised by Vincent Poor and Sergio Verdú, initiated a systematic approach to studying the impact of finite delay constraint on information theoretic fundamental limits. The accompanying journal paper won the 2011 Best Paper Award from the IEEE Information Theory Society. Yury was also a recipient of the Best Student Paper Awards at the 2008 and 2010 IEEE International Symposiums on Information Theory (ISIT) and a Silver Medal at the XXXth International Physics Olympiad (IPhO) in 1999.

Generally, his research interests include information theory, coding theory and the theory of random processes. His current work focuses on non-asymptotic characterization of the performance limits of communication systems, optimal feedback strategies and optimal codes. In his spare time he enjoys playing with algebraic structures in geometry and topology and hacking the Linux kernel.

Nir Shavit received BSc and MSc degrees in Computer Science from the Technion – Israel Institute of Technology in 1984 and 1986, and a PhD in Computer Science from the Hebrew University of Jerusalem in 1990.

Shavit is a co-author of the book *The Art of Multiprocessor Programming*, and is a winner of the 2004 Gödel Prize in theoretical computer science for his work on applying tools from algebraic topology to model shared memory computability. He is a past program chair of the ACM Symposium on Principles of Distributed Computing (PODC) and the ACM Symposium on Parallelism in Algorithms and Architectures (SPAA).

Shavit's research interests focus on techniques for designing, implementing, and reasoning about algorithms for multiprocessor machines, and in particular concurrent data structures.

From Virtual To Real

Wojciech Matusik
Associate Professor
Computer Science and Artificial Intelligence Lab

Computer-aided design (CAD) – a research area with a long history in graphics – revolutionized 2D and 3D drafting in the 1970s due to the benefits of reduced drawing errors and reusability. Recently, fast, accurate and affordable prototyping and manufacturing devices such as multi-material printers have become capable of not only manufacturing static geometry designed with CAD software, but also approximating a wide variety of appearance effects and mechanical properties. However, while there has been tremendous progress in the hardware development of these output devices, the provided digital content creation software, algorithms, and tools are largely underdeveloped. These software limitations make it difficult to take full advantage of the capabilities of these devices. It is often not possible to accurately simulate and preview the output of the devices, or to determine the whole range of outputs they can generate. This makes the conversion from digital content to the best possible physical output difficult, and typically reliant on heuristics or trial and error. Furthermore, each device manufacturer develops their own software and tools, and there is no universal framework in place that can be reused across different output platforms. The overall situation is analogous to the digital printing and content creation revolution of the early 1980s before the advent of PostScript, except that today we already have a mass market for the applications and the output devices.

Wojciech Matusik, a new faculty member in EECS and a member of CSAIL, focuses his research efforts on bridging the gap between the virtual (i.e., the computer models) and the real (i.e., the physical output). The first research area where he has made significant contributions is designing mathematical models that accurately represent and predict physical properties of real world materials. The problem is challenging because real world materials exhibit extraordinary variety and complexity. He has approached this problem by constructing acquisition devices to measure properties of real world materials and then deriving accurate computational models from these measurements. In particular, he has developed data-driven representations for both material appearance and mechanical material properties. In addition to being used in traditional computer graphics applications, these data-driven representations allow highly accurate simulation of materials manufactured by a given output device. These predictive simulations virtualize output devices and they constitute the first important step in conversion from computer models to physical output.

Matusik has been taking this research further by constructing examples of complete digital manufacturing processes. These processes translate digital objects expressed using device-independent mechanical and appearance specifications to output device specific computer programs that produce the best possible approximation of the digital object. The goal is to deliver tools not only for replicating existing physical objects but also for manufacturing completely new materials with user-specified properties.

More specifically, Matusik has introduced processes that

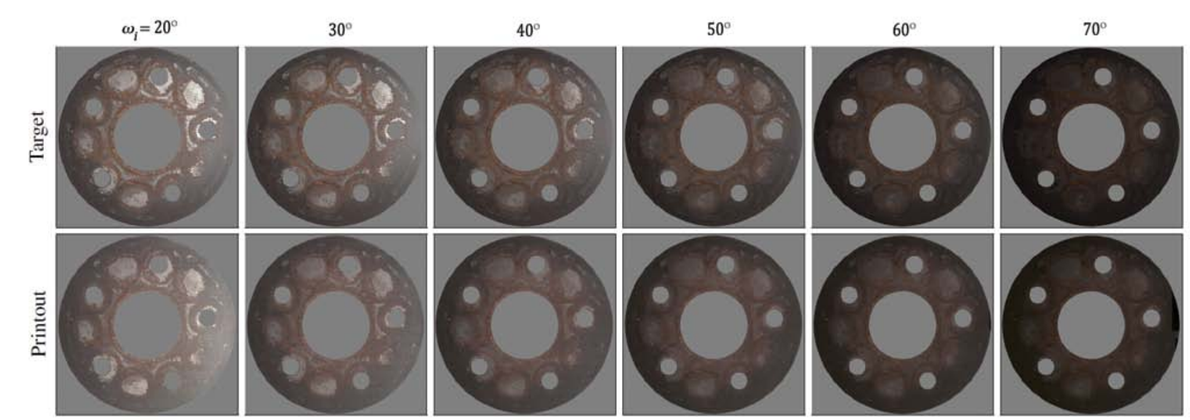


Figure 1: A virtual model of a rusty wheel with spatially-varying reflectance (top row, computer renderings) is converted to a physical copy (bottom row, photographs) with a similar appearance. Different columns show different directions of the incident light.

From Virtual to Real, continued

allow designing and manufacturing surfaces with complex appearance, which is often determined by small-scale surface structure, or microgeometry. Because these geometric features, typically called microfacets, are too small to be seen individually, the surface appearance is dictated by their aggregate distribution in combination with the behavior of the underlying material. Matusik has developed a process for printing arbitrary reflectance functions through a novel half-toning algorithm. This process arranges tiny tiles of different materials to produce the desired cumulative reflectance properties (Figure 1). He has also formulated algorithms for designing and fabricating surfaces with a desired distribution of microfacets. The microfacet manufacturing process is able to create surfaces with highly controllable reflectance and refraction properties (Figure 2).


Figure 2: A physical sample reshapes incident light onto a collection of Gaussian caustics, to approximate the Lena image.

More recently, Matusik has introduced a process for efficient and accurate manufacturing of materials with desired subsurface scattering. Subsurface scattering arises when light enters inside the object, scatters, and reemerges at a different point. Most real materials have significant subsurface scattering. This property gives them their inherent softness or translucency. Matusik's process starts with measuring scattering properties of a given set of base materials. These measurements are used to obtain an accurate simulation of subsurface scattering for a multilayer composite made of base materials. Finally, an optimization algorithm efficiently searches the space of possible multilayer composites to derive a combination that best approximates desired subsurface scattering. The final composite material can be printed using a multi-material 3D printer.

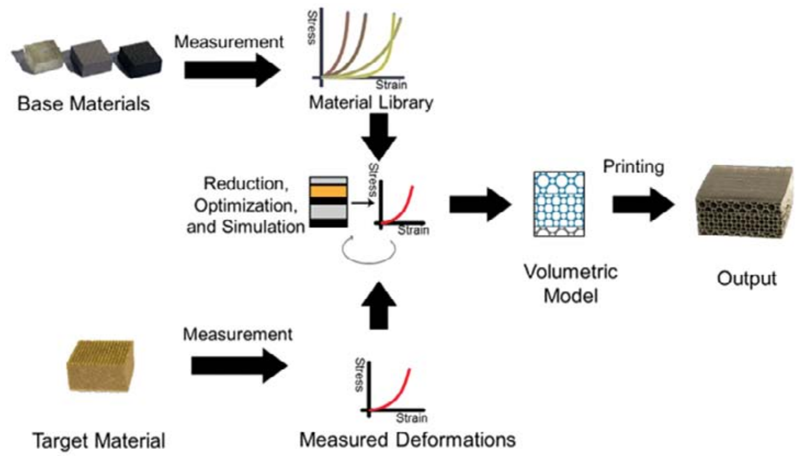


Figure 3: A process for designing and manufacturing materials with specified elastic properties.

Matusik has also designed a complete process for manufacturing materials with specified elastic deformation properties. The process combines materials with known elastic properties into a multi-layer composite. Similarly, the space of material composites is searched to obtain a multi-layer material that best matches input specifications (Figure 3).

These example processes provide a blueprint for constructing future processes that translate other material properties to physical output. The goal is to lay down the foundations on how the interface between a computer model and an output device should be designed. As a result, this research has a potential to allow a wider adoption of novel types of output devices by a large population of users and therefore it could bring us closer to the democratization of content creation.

How Hard Is It to Approximate?

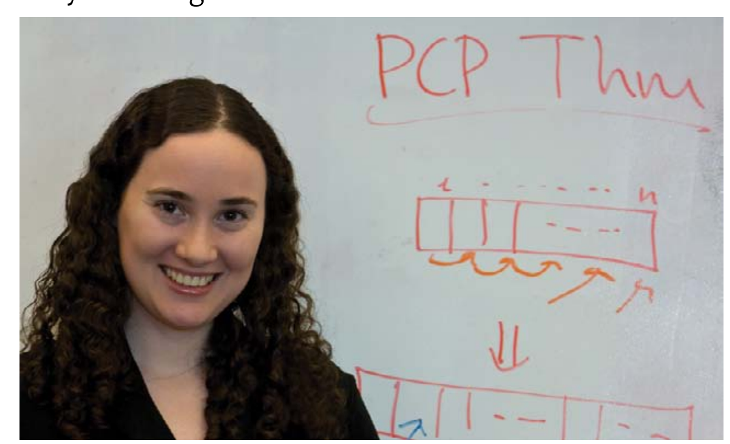
Dana Moshkovitz
Assistant Professor
Computer Science and Artificial Intelligence Lab

In the 1970's the landscape of algorithms research changed dramatically with the discovery that many natural optimization problems were "NP-hard". This means that an efficient algorithm for them could be used to design a "too good to be true" algorithm that, given a provable mathematical statement, efficiently finds the shortest proof for the statement.

A second revolution happened in the 1990's, with the introduction of the "PCP Theorem" ("Probabilistically Checkable Proofs"). This theorem implied that even approximating many NP-hard problems was NP-hard. In the past seven years, Dana Moshkovitz's research has focused on some of the open problems that remain regarding the PCP theorem.

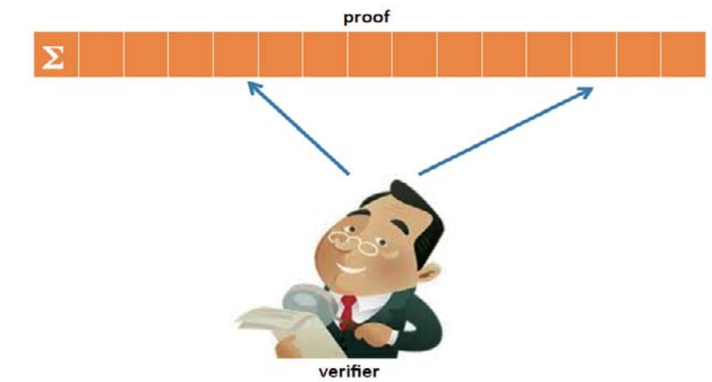
The PCP theorem asserts something that sounds almost impossible to anyone who ever wrote or checked a mathematical proof: "Every mathematical proof can be written in a format that can be checked probabilistically by reading only two statements (no matter how many statements there are in the proof)."

A standard proof of size n is an ordered sequence 1,…,n of statements. Every statement is implied by some of the previous statements and the premise. The last statement is what we want to prove. Importantly, the only way to make sure the statement is correct using the proof is to follow the reasoning, statement by statement. If there's a mistake in any one of the implications, the statement may be wrong.



Professor Dana Moshkovitz

In contrast, many statements in the new format can each imply the same statement. For example, it is possible that the statement in the 5'th position determines the statement in the 10'th position, but also that the statement in the 16'th position determines the statement in the 10'th position. This structure makes the following "robustness" property possible: even if only a small fraction of all implications in the new format hold, one can still deduce the entire reasoning of the original proof.



How Hard is it to Approximate? Checking a proof by making two queries.

This robustness property implies probabilistic checking: To check the proof, one picks a random pair of positions such that the statement in the first position is supposed to imply the statement in the second position. One then tests that this is indeed the case. For a correct proof, this is so. On the other hand, if what is being proven is false, and there is no reasoning that implies it, then almost all implications do not hold. Hence, the probability that the first statement actually implies the second is low.

What open problems remain? For one, we don't know how to achieve minimal error probability. If there are N implications total that the verifier might check, one cannot expect the error probability to be better than 1/N. A widely believed conjecture, first made by Bellare, Goldwasser, Lund and Russell in 1993, is that one can get close to 1/N, and obtain error probability $1/N^c$ for some constant c. The conjecture is known as "the sliding scale conjecture" (the "sliding scale" refers to the ability to set the error probability as one pleases). Moshkovitz's PhD thesis showed the lowest error probability known today, $1/(\log N)^c$ for some $c>0$. If one considers verifiers that read more than just two statements, lower error probability is known. Moshkovitz's new project is to get that error probability down to $1/N^c$.

Another problem that has been getting a lot of attention recently is the "unique games conjecture" suggested by Khot in 2002. Here, the idea is to have equivalences instead of implications (that's the reason for the "uniqueness" in the name; the "games" are there for historic reasons). How is it possible to prove much when all your statements are equivalent to each other? The idea is that

How Hard is it to Approximate? continued

they won't be! A valid proof will be one that contains up to, say, 0.001 fraction of equivalences that don't actually hold. This trick makes it conceivable to have unique probabilistic checking. If it is indeed possible, it will imply a spectacular set of optimal hardness of approximation results. In particular, we will know the approximability of all optimization problems that optimize subject to a (large) set of constraints, such that each constraint depends only on a constant number of variables.

Does the unique games conjecture actually hold? No one knows for sure. So far, no one was able to prove or disprove it. Moshkovitz spent a couple of years trying to prove the conjecture together with Khot. Their work yielded what might be a starting point for a proof, but is still far from unique checking.

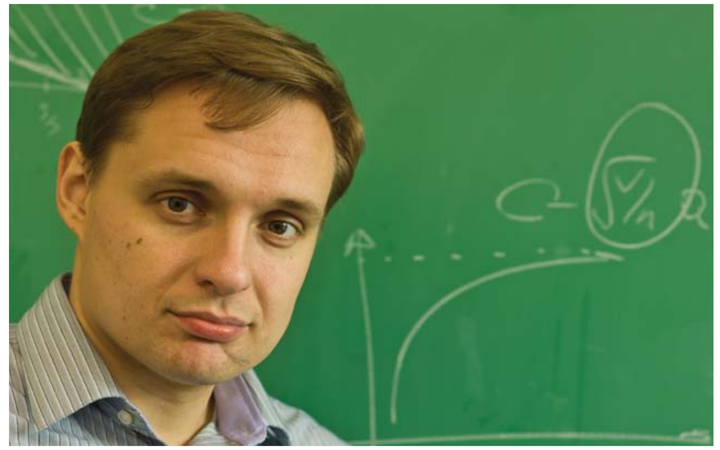
Performance of Optimal Error Correcting Codes

Yury Polyanskiy

Assistant Professor
Laboratory for Information and
Decision Systems

It is hard to overestimate the importance of high-speed communication in the modern world. Telephony, TV, digital computing, deep space probes, satellites (and weather forecasts), Internet, hard disk and flash drives -- all these technologies inherently rely on mechanisms (called error correcting codes) ensuring quick and reliable transmission of information. Although state-of-the-art codes are doing an increasingly better job at combating the effects of noise, there is still a lot of room for improvement: pages can download faster, calls can be dropped less often and batteries can last longer. Investigating the ultimate performance limits of error correcting codes and, more generally, the subject of information theory, constitutes the core research interest of Yury Polyanskiy.

The design of an error correcting code typically involves choosing a set of bandlimited waveforms of a given duration. The set must be such that any waveform after being contaminated by a white Gaussian noise could still be



Professor Yury Polyanskiy

distinguished (with high probability) from all others. The binary logarithm of the cardinality of the set gives the total number of information bits that the code is capable of transmitting. It turns out that asymptotically the best code can transmit a number of data bits proportional to the number of degrees of freedom (a product of bandwidth and duration), with the coefficient known as the Shannon capacity of the channel.

Classically, information theory was concerned with either computing the Shannon capacity for a given channel model, or with studying the behavior of the probability of error in the asymptotics of infinite degrees of freedom. In his research, Yury Polyanskiy focuses on what happens when the number of degrees of freedom is finite.

One of the immediate problems of going back from infinity is that classical tools, which were designed with the asymptotics in mind, frequently loose their teeth in the non-asymptotic regime. Surprisingly, however, the key principles of information theory, such as data-processing and random/maximal coding, when modified appropriately turn out to be quite sharp even non-asymptotically. As an example, Fig. 1 (opposite page top) shows the upper and lower bounds for the performance of the (yet to be discovered) optimal code as a function of the number of degrees of freedom. Evidently, one can describe the non-asymptotic performance limits quite well—at least numerically.

It turns out that a simple analysis based on the central-limit theorem (CLT) can be applied to these new bounds, leading to a convenient closed-form estimate (marked on the figure as "normal approximation") of the non-asymptotic fundamental limit. To compute the estimate one needs to know two characteristics of the channel:

Performance of Optimal Error Correcting Codes, continued

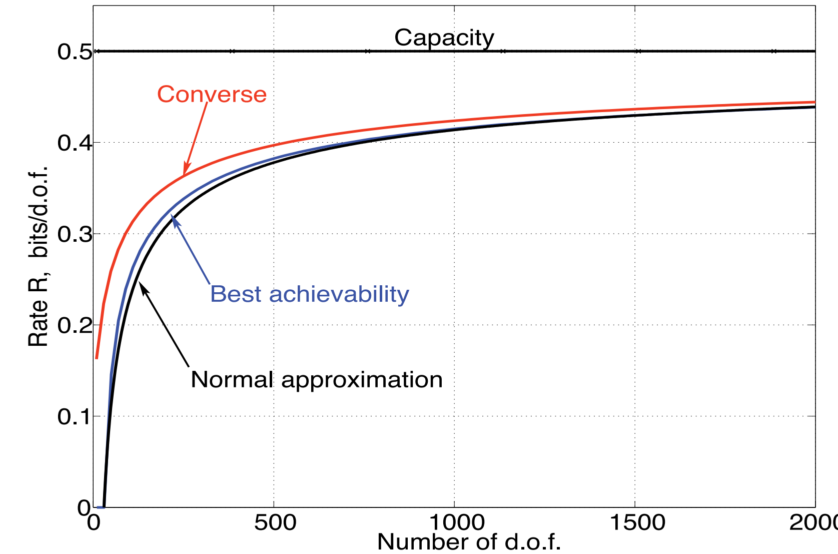


Figure 1 (above)

the channel capacity and the channel dispersion. The former, as was explained, describes the asymptotic limit of the communication rate, while the latter measures how long a delay is required for the limiting behavior to kick in. This approach is in contrast to the classical fixed rate one, which relies on the large deviations estimates rather than the CLT.

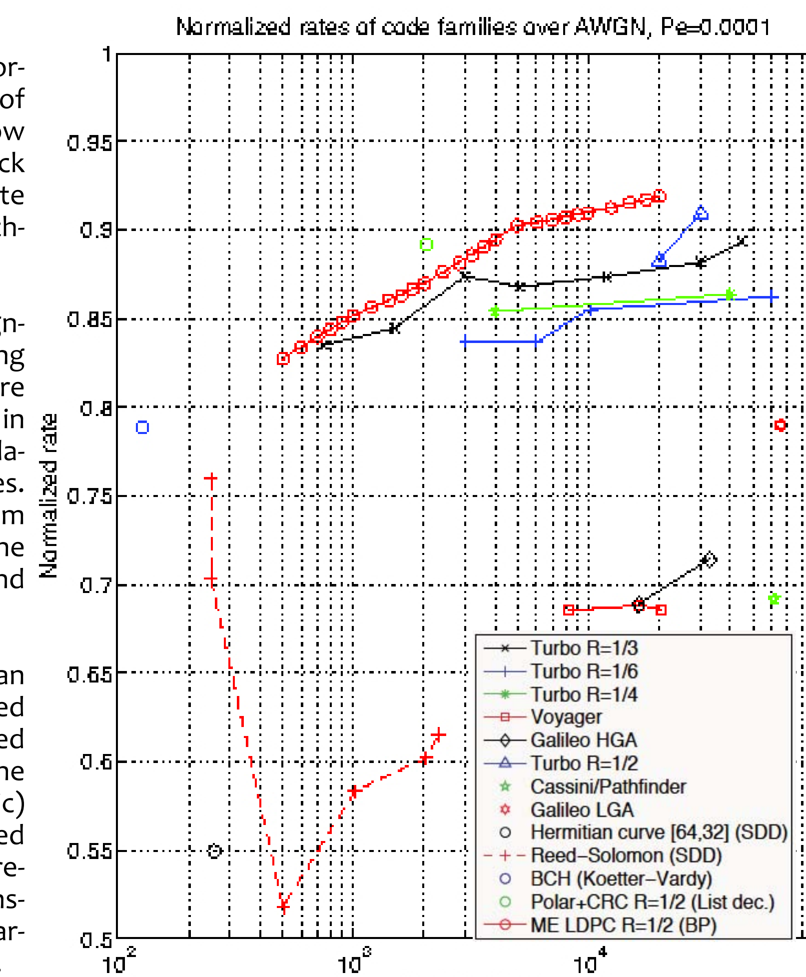
One application of our results is helping system designers in assessing the quality of available error correcting codes. For example, on Fig. 2, (opposite) we compare performance of various popular real-world codes in terms of the percentage of the non-asymptotic fundamental limit (in information bits) that the code achieves. [The data on the codes' performance was obtained from various sources, for example the "Polar+CRC" is the list-decoding modification of the polar codes by Tal and Vardy.]

Having addressed the simple model of white Gaussian noise, one is naturally led to study more complicated communication models. For example, it was discovered that availability of feedback from the receiver to the transmitter, although unable to change the (asymptotic) capacity of the channel, turns out to reduce the required coding delay by more than an order of magnitude. Moreover, availability of a reliable way to terminate the transmission (on a forward channel, such as by cutting a carrier) reduces the delay by another order of magnitude.

It is a classical result in information theory that in the presence of fading, the capacity is not sensitive to the dynamics of the fading process. In other words, no matter how slow the instantaneous signal-to-noise ratio (SNR) varies, the Shannon capacity is determined by the average channel gain (assuming ergodicity). This effect clearly exploits the asymptotic nature of the capacity and cannot be true for any finite delay constraint. Indeed, our recent work demonstrates that non-asymptotic fundamental limits are very sensitive to the dynamics of the fading process.

[continued on page 12]

Figure 2 (below)



Performance of Optimal Error-correcting Codes, continued

As an example, we estimated that in order to come within 90% of Shannon capacity of the mobile GSM channel, one is required to code over blocks spanning a few seconds, thereby showing that over this channel asymptotic capacity carries little meaning for problems of sending real-time data (such as voice).

Being able to tightly characterize the performance limits of communication systems does not shed much light on what the optimal codes should look like. In this regard, however, we were recently able to obtain several necessary conditions for the code to be optimal. For example, for communication in white Gaussian noise, it follows that the closer the code approaches the optimum, the more its constituent waveforms should resemble those obtained from a Gaussian process. This result is important because the best known codes are indeed constructed from samples of Gaussian processes. Our result shows that there is essentially no other alternative.

Good Vibrations: Resonating Transistors in Standard CMOS

Dana Weinstein
Assistant Professor
Microsystems Technology Laboratories

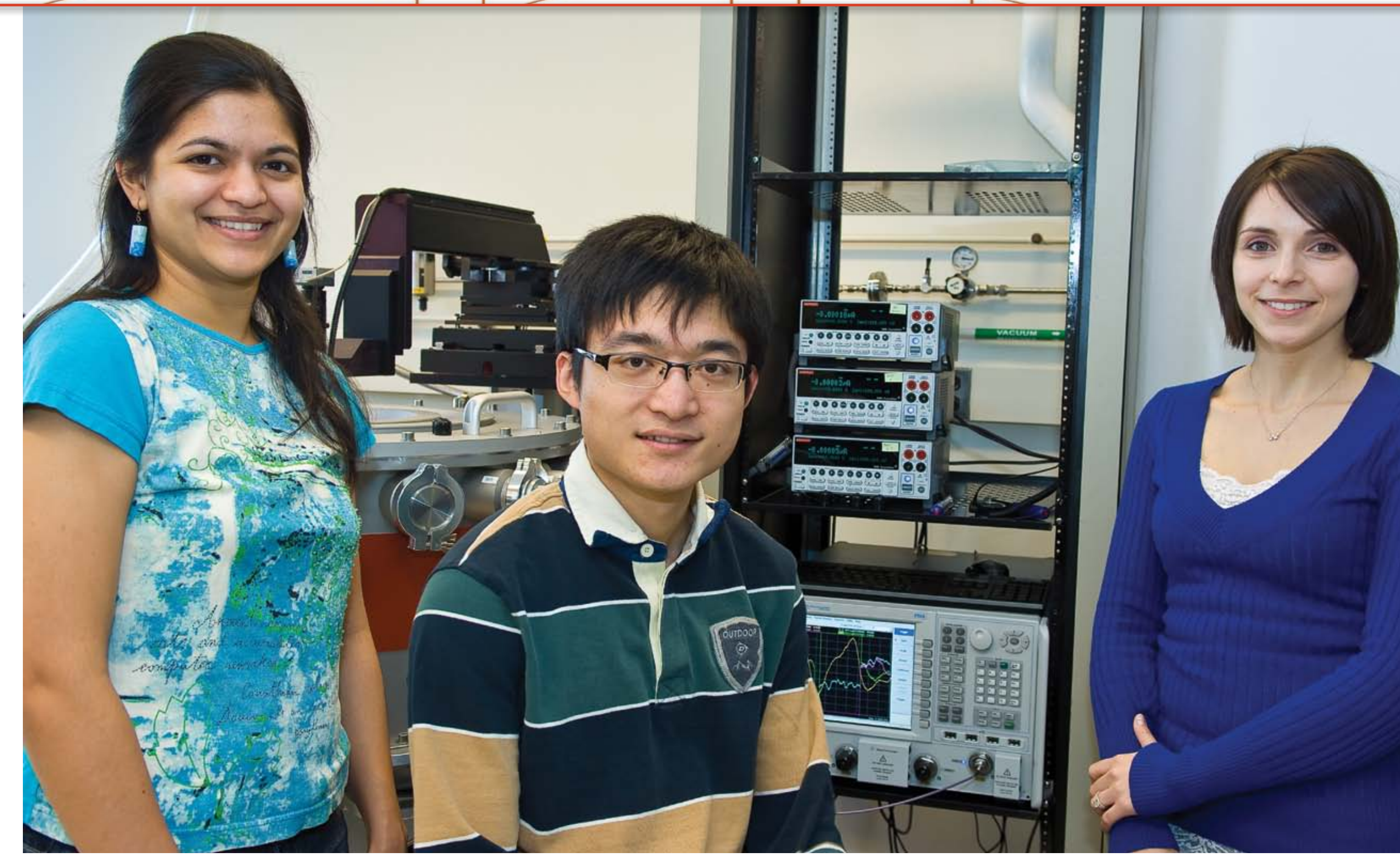
Pry open a laptop, iPhone, remote control, or your grandparents' old transistor radio. Besides finding someone angry that you broke their stuff, you will find all sorts of clocks used for computation and communication. To build a clock, you need an element that stores energy at a particular frequency. Using simple electronic components, the easiest way to do this is with an inductor and capacitor, which slosh electric charge between them at a particular resonance frequency. In general, these electronic resonators are too lossy since charge moving inside them is subject to resistance. One alternative is electromagnetic (EM) resonators which trap EM waves in a reflective cavity. But because these waves travel at the speed of light, the EM cavity has to be quite large – about 6 inches for your phone's ~1GHz radio. Taking advantage of the slow speed of sound, acoustic resonators which trap pressure waves in a vibrating structure can generate excellent clocks at mm-size and even at micro and nano scale devices.

For almost a century, quartz crystal oscillators have functioned as clocks in a wide range of electronic gadgets. Placing a voltage across the crystal causes it to resonate at a frequency determined by its geometry, allowing all components of a circuit to operate in unison. But these quartz clocks are relatively bulky, their size a significant barrier to shrinking circuits. Over the past 15 years, researchers around the globe have been developing micromachined acoustic resonators in materials which are easier to miniaturize and integrate with circuits. There have been several success stories with products spanning communication, industrial, and automotive applications.

Despite the maturity of the RF Micro Electro-Mechanical Systems (MEMS) field, intimate integration with integrated circuits (ICs) has not been possible due to fundamental device limitations resulting in complexity and cost of integration. There is also often a large disparity between sizes of MEMS devices and transistors, the basic building blocks of any circuit. The majority of electromechanical devices requires a release step to freely suspend the moving structures. This necessitates costly complex encapsulation methods and restricts MEMS fabrication to back end-of-line (BEOL) processing of large-scale metal devices on top of the transistors.

To overcome this obstacle, the HybridMEMS Lab in the Microsystems Technology Lab (MTL) at MIT led by Prof. Dana Weinstein is exploring a new approach to multi-GHz MEMS resonators using electromechanical transduction with IC transistors. Graduate students Radhika Marathe and Wentao Wang in the HybridMEMS Lab recently demonstrated the first unreleased Silicon-based RF MEMS resonators in standard CMOS technology. They found a way to electrically excite and detect vibrations in individual Silicon transistors. Using Silicon instead of metal to trap acoustic energy means better energy storage in the resonator, leading to clocks with lower noise and lower power consumption. These devices allow for seamless integration into Front End of Line (FEOL) processing with no post-processing or packaging, and can provide low power, low cost, small footprint building blocks for on-chip signal generation and processing.

With special design of acoustic reflectors using the standard CMOS processing steps, these resonators do not require any release step to freely-suspend the moving



Prof. Dana Weinstein with graduate students Radhike Marathe and Wentao Wang in the Hybrid MEMS Lab in the Microsystems Technology Lab at MIT.

structure. Instead, the Silicon resonators are completely surrounded by other solid materials including SiO_2 and and Cu. These unreleased bulk acoustic resonators are driven capacitively using the thin gate dielectric of the CMOS process, and actively sensed with a Field Effect Transistor (FET) incorporated into the resonant body. FET sensing using the ultrafast, high performance transistors in CMOS amplifies the mechanical signal before the presence of parasitics. This enables RF MEMS resonators at orders of magnitude higher frequencies than possible with passive devices. First generation CMOS-MEMS Si resonators with Acoustic Bragg Reflectors (ABR) are demonstrated at 11.1 GHz using IBM's 32nm SOI technology. Marathe will present the first results of these devices at the upcoming IEEE Micro Electro Mechanical Systems conference in Paris in early February.

The fabrication of resonators side-by-side with CMOS circuitry greatly reduces parasitics of off-chip access, constraints of limited input/output lines, and power consumption associated with impedance matching networks. These benefits result in increased system speed and dynamic range, particularly at RF and mm-wave frequencies of operation. Using existing technology already implemented for all microelectronic components, these new clocks have a very low barrier-to-entry into many commercial applications.

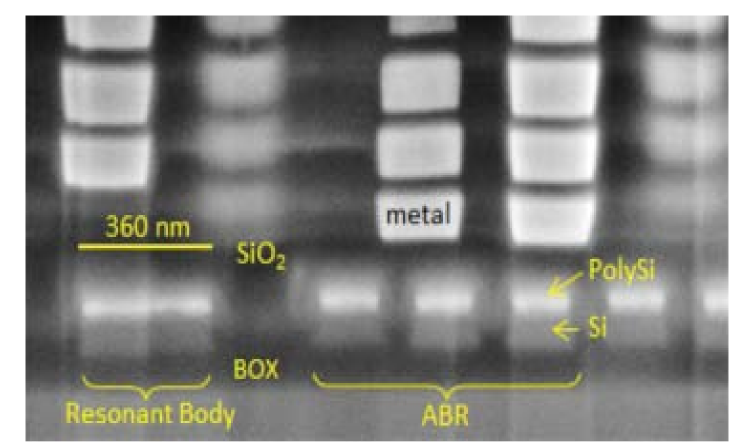


Figure 1. Scanning Electron Micrograph of the cross section of the CMOS stack, showing the Si device layer used to make transistors, and the acoustic resonator and acoustic reflectors (ABR) formed in that Si layer. Metal layers above the device are used to route signals within the CMOS circuit.

Engineering Circuits – in Living Cells

Timothy K. Lu
Assistant Professor
Research Laboratory of Electronics

Living cells are amazing yet challenging substrates for engineering, as they are complex, energy efficient, evolvable, and self organizing. The programs which govern the operation of living systems are primarily encoded in DNA and enable an immense set of behaviors in diverse organisms ranging from viruses to unicellular microbes to multicellular animals. Deciphering these genetic programs is a challenging task which has begun to be met by the molecular biology and systems biology revolutions of the last several decades. Molecular biology and systems biology are fields primarily focused on understanding natural biological systems. Systems biology leverages high-throughput strategies to collect biological data in concert with computational algorithms to understand biological systems from a top-down network perspective. As a complement to molecular biology and systems biology, synthetic biology is emerging as a new discipline for constructing artificial biological systems or engineering natural ones.

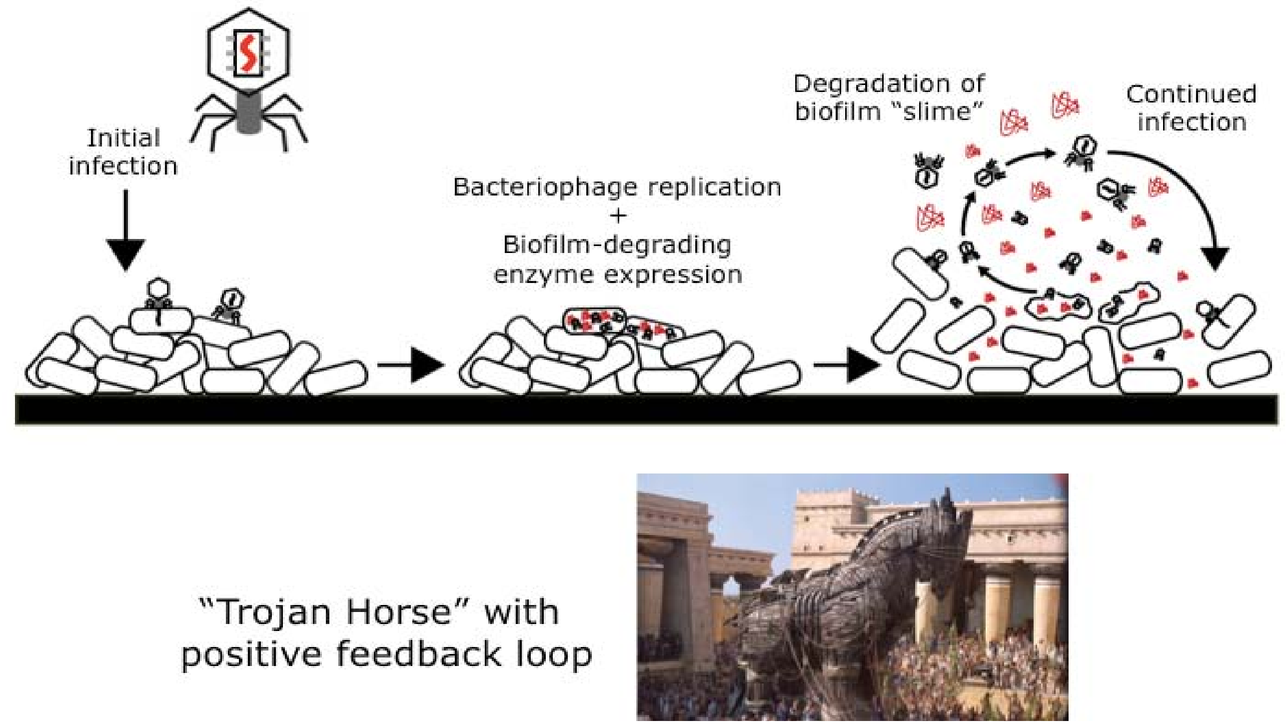
In the past decade, biological engineers have crafted simple synthetic biological devices by engineering DNA, RNA, and proteins, including switches, oscillators, counters, memory devices, and logic gates. Despite these exciting proof-of-concept studies, the field of synthetic biology remains in a nascent stage of development that is reminiscent of the early days of the semiconductor industry. Exponential advances in DNA synthesis and sequencing are being realized each year at rates that are on par with or exceed Moore's Law. However, our ability to harness these technologies to create useful biological systems has not kept pace. Several roadblocks to progress include the non-modularity and poor characterization of existing biological devices, an incomplete understanding of fundamental biological processes, and inadequate tools for modeling and programming the behavior of man-made circuits. As a result, the current biological design cycle is not well suited for the design of scalable synthetic systems.

To tackle these problems, the Synthetic Biology Group in the Research Laboratory of Electronics (RLE) and the Synthetic Biology Center at MIT led by Prof. Timothy Lu is engineering scalable platforms for synthetic biological systems and applying these platforms to address challenging applications in basic biology, medicine, and biomanufacturing. With M.D. training and a background in electrical engineering, computer science, and synthetic biology, Prof. Lu is building a lab of multidisciplinary scientists and engineers to tackle these research problems.

Many concepts for engineering scalable computation from electrical engineering and computer science can be applied to synthetic biological systems. For example, Prof. Lu created stable DNA-encoded memory devices that operate in living cells which can be switched between states using proteins known as recombinases (named Single Invertase Memory Modules or SIMMs). Since >100 independent DNA recombinases are known, these devices are modular and extensible. Not only can these engineered memories be used as research tools, but they can also be used to program engineered organisms. For example, cellular memory devices are being adapted to record the incidence of toxins and to build artificial memory networks. To demonstrate the usefulness of synthetic memory in complex circuits, Prof. Lu implemented the world's first biological counters that function in living cells and are capable of counting and recording events in a digital and non-leaky fashion. These counters could serve many applications, including in vivo computation and studying the cell cycle and embryonic development in higher organisms.

The Lu lab is also pursuing biomedical applications that are enabled by synthetic biology. For example, bacterial biofilms are surface-associated bacterial communities that are responsible for significant clinical, industrial, and food-processing infections and are poorly treated with existing antibiotics or antimicrobials. Examples include persistent bacterial colonization in cystic fibrosis patients, catheter-associated infections, and biofouling of industrial pipes. To combat biofilms, Prof. Lu developed a modular design for synthetic enzymatic bacteriophage — viruses which only infect bacteria and not human cells — to express biofilm-degrading enzymes during infection. This dual-pronged strategy enables >99.997% removal of bacterial biofilms, which is significantly enhanced over natural phages.

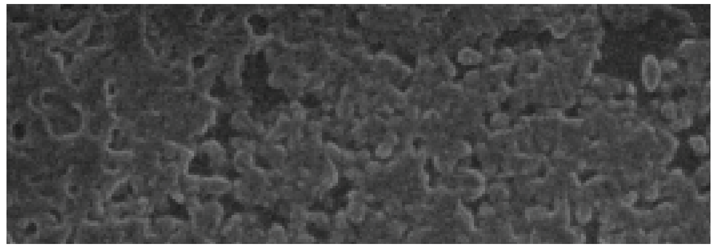
In addition, Prof. Lu created antibiotic-adjuvant bacteriophage to combat antibiotic resistance, a pressing medical problem which has received recent attention due to the dramatic rise of "superbugs" such as methicillin-



Engineered enzymatically-active phage (above). Lu, Collins *PNAS* 2007
[Image credit: http://www.themediadrome.com/content/reviews/troy.shtml]

resistant *Staphyloccus aureus* (MRSA). To combat antibiotic resistance, engineered antibiotic-adjuvant bacteriophage were created to attack intracellular bac-terial defense networks in a "Trojan Horse" manner.

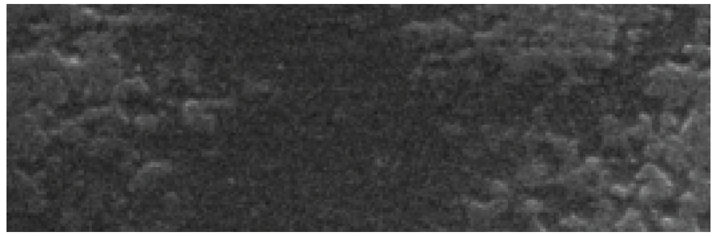
Untreated biofilms. Lu, Collins *PNAS* 2007



Treatment with unmodified phage. Lu, Collins *PNAS* 2007

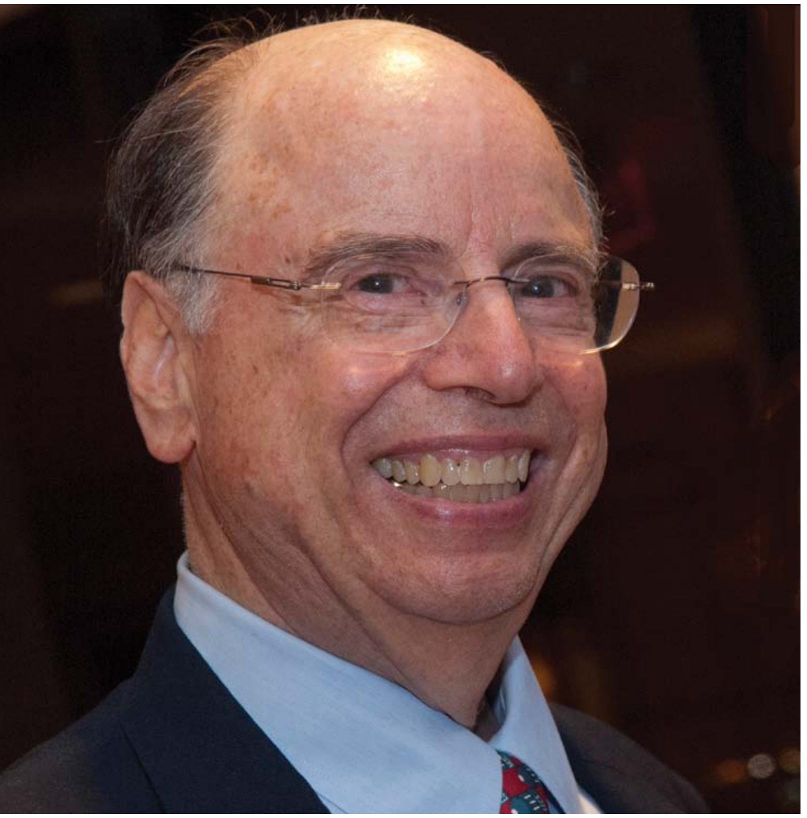
This strategy enhances the ability of quinolone, β-lactam, and aminoglycoside antibiotics to kill bacteria by 1000-fold to 100,000-fold and dramatically reduces the evolution of antibiotic resistance by 600-fold. In the animal trials, combination therapy with adjuvant bacteriophage and antibiotics increased survival of infected mice to 80%, up from 20% with antibiotics alone.

Ultimately, the central philosophy of the Lu lab is that one can learn a great deal about biology by building it — a bottoms-up strategy called constructive biology that complements the top-down approach of systems biology. By understanding biological systems from the ground up, one can more reliably create synthetic circuits and networks to spec (for example, to treat diseases or manufacture useful biomolecules). With such capabilities in hand, synthetic biology promises to revolutionize our way of life, just as semiconductor technologies have-done over the last several decades.



Treatment with modified phage. Lu, Collins *PNAS* 2007

In Memory of David H. Staelin, 1938 - 2011



"You can accomplish a great deal in life if you don't feel the need to take credit."
— a quality David Staelin embodied

Memories of David Staelin, courtesy of the MIT News Office, MIT colleague Joel Moses' comments at the Memorial Service, Dec. 3, 2011, and the *Boston Globe*, Dec. 12, 2011 article by J.M. Lawrence, titled "David Staelin, 73, scientist, discoverer, entrepreneur"

Professor David H. Staelin, member of the department of Electrical Engineering and Computer Science, and the Research Laboratory of Electronics, passed away Nov. 10, 2011 of cancer. He was 73 years old.

Driven by a deeply felt sense of responsibility to MIT, the nation, and society as a whole, Staelin dedicated his long career to basic science, technology development, service, education, and entrepreneurship. His career was that of abundant accomplishment, and widespread impact.

Staelin's career as a junior faculty member started in radio astronomy. Among his first accomplishments, in 1968 he developed a computationally efficient algorithm that enabled him to discover the Crab Nebula Pulsar, helping to confirm the existence of neutron stars predicted by theoretical physics.

Over time, his interests expanded to include remote sensing to enable climate monitoring, to which he brought a strong command of electromagnetics, signal processing methodology, and computational methods. Among the many examples of his leadership in this field, he was principal investigator in the development of the first two Earth-orbiting microwave imaging spectrometers launched in 1975 for mapping global temperature and humidity through clouds. He was also a co-investigator on the 1977 NASA Voyager 1 and 2 spacecraft missions, studying non-thermal radio emission from the outer planets. Later still, during 1998-2011 he co-developed techniques for using operational millimeter-wave sounding satellites for more frequent and complete mapping of global precipitation.

In subsequent years, he turned his attention to diverse collections of important emerging problems that required the application of sophisticated signal processing and estimation theory. These included the development of practical image and video compression technology, advanced methodologies for data-rich manufacturing problems, which he pursued under the MIT Leaders for Manufacturing program, heterogeneous and wireless communication architectures, and, most recently, neuronal computation models.

Staelin was an active member of the MIT community. He served on numerous committees and took on important leadership roles. Later in his career, Staelin served as Assistant Director of MIT Lincoln Laboratory for 11 years (1990-2001), where he focused on helping both enhancing the long-range focus of the laboratory and strengthening its ties to campus. He also served as a member of the President's Information Technology Advisory Committee (2003-2005).

Staelin was a dedicated teacher who helped educate generations of electrical engineers. His focus for many years was the undergraduate electromagnetics curriculum. He co-authored the 1993 Prentice-Hall text Electromagnetic Waves with Ann W. Morgenthaler and Jin Au Kong.

Staelin was a thoughtful and patient mentor, greatly loved and admired by his students. He supervised many doctoral, masters, and undergraduate student theses (almost 150 graduate theses alone), and a large number of alumni of his group have gone on to careers of great distinction and striking impact in academia and industry as researchers and scientists, entrepreneurs, technical leaders, and executives—a testament to his skillful training.

Highly entrepreneurial, Staelin started and directed three pioneering companies with colleagues and students. One of them, Environmental Research and Technology (ERT, now part of AECOM), was one of the first and largest environmental services companies, specialized initially in air quality but went on to address the full spectrum of environmental issues. PictureTel (now part of Polycom, itself founded by one of Staelin's former students) pioneered cost-effective video conferencing systems based on sophisticated video compression technology. This technology ultimately formed the basis for the ubiquitous video compression standards that today enable the widespread availability of video content over networks.

Following these experiences, in 1998 Staelin co-founded MIT's pioneering Venture Mentoring Service to help early-stage MIT companies and aspiring MIT entrepreneurs benefit from the advice of experienced MIT alumni, and more generally to support entrepreneurial activity within the MIT community as a furthering of MIT's educational mission. VMS has served more than 1000 companies to date, helping them raise almost $1B in capital, and has become a model for other similarly oriented university and government agencies.

Staelin's last project was a collaboration on neural computation with his son Carl H. Staelin. Their work resulted in a monograph currently in press, entitled *Models for Neural Spike Computation and Cognition*.

StaelinFest, an event held at MIT in July to celebrate Staelin's extraordinary career, was widely attended by many faculty, colleagues, and former students from all over the country. At the event, he also received the distinguished 2011 John Howard Dellinger Medal, awarded to him by the International Union of Radio Science (URSI) for profound contributions to remote sensing over his career.

Joel Moses became assistant professor in computer science in 1967, just two years after Dave Staelin became assistant professor of electrical engineering in the Department of Electrical Engineering. They remained mutually respectful colleagues, sharing their deep and broad pursuits as researchers, dedicated teachers and seekers of knowledge. On the occasion of the Dec. 3, 2011 memorial service for David Staelin, Joel said, "One vivid memory I had of Dave was the day he walked into my office in the 1980's. I was the department head at the time, and Dave asked me to go to the conference room next door to see a demonstration of a system he and his students had worked on. What he demo'd was an early version of the PictureTel system, a cost-effective video-based telephone conference system. This later led to a successful company."

Joel and David's paths continued to cross over the years — including David's giving talks at a faculty seminar that Joel helped to run. "I told you that he was remarkably broad," Joel related, "but he was also remarkably deep and willing to take intellectual risks. His initial talk at the seminar was on answering the question of how many bits of information could be stored in the human brain. Normally this issue would be one for brain scientists or cognitive scientists, but Dave looked at it from the point of view of an electrical engineer who is an expert in signal processing and communications. He read a great deal of the extensive literature on neurons and their interconnections in the brain in order to obtain limits on their use in communication, computation and storage. His talk was a tour de force on this subject."

From the *Boston Globe*, Dec. 12, 2011 article:
David Staelin's family described him as an unflappable problem-solver who kept his head while others might panic, and always searched for the best solution for everyone. In a meditation he penned for his memorial service, titled "In Praise of Life," David Staelin wrote:

"To understand eternal joy is to desire to enhance all life and humanity. This quest, even when beset by immediate needs and uncertain victory, is our daily rhythm and brings joys and sorrows that can never be undone. And what cannot be undone lives forever, beyond time itself, even as our own times and lives slowly slip from the intensity of the present into the calm of eternal peace."

Please note the establishment of the David H Staelin Fund to honor and celebrate the memory of Professor Staelin and his remarkable five decade career in RLE from graduate student to faculty member.

The fund will provide first-year RLE research assistantship support in the recruitment of outstanding graduate students with the greatest potential to realize the personal and professional qualities Prof. Staelin embodied and sought to instill through his mentoring.
http://www.rle.mit.edu/staelinfund/

Donald E. Troxel, 1934 - 2011

Professor Emeritus Donald E. Troxel passed away Jan. 18, 2011, following a protracted illness.

Don Troxel, born March 11, 1934, in Trenton, New Jersey, received the BS degree in electrical engineering from Rutgers University in 1956. He followed with studies in electrical engineering at the Massachusetts Institute of Technology earning the SM and PhD degrees in 1960 and 1962 respectively. Don remained at MIT, first as a Ford Foundation Postdoctoral Fellow and then joining the EECS Department as Assistant Professor in 1964, reaching full Professor in the Department in 1985. He retired as Professor Emeritus in July, 2004.

Troxel's early research interests were concerned with tactile communications and sensory aids for the blind. Since 1968 his principal research interests focused on digital systems design and image processing, including bandwidth compression, enhancement and graphic arts applications. Troxel was principal investigator with both the Research Laboratory of Electronics, RLE, and with the Microsystems Technology Laboratories, MTL. His teaching activities centered on electronics and digital systems laboratories. Prof. Troxel was noted for teaching 6.111, Introductory Digital Systems Laboratory, for nearly twenty years.

Jerome Lettvin, 1920 - 2011

Jerome Lettvin, Professor Emeritus of electrical and bioengineering and communications physiology, and principal investigator with the MIT Research Laboratory of Electronics, died on April 23 in Hingham, Massachusetts. He was 91.

As noted in the MIT News Office, April 29 obituary, Lettvin came to MIT in 1951 under Jerry Wiesner, then-director of the Research Laboratory of Electronics and later MIT president. Along with Lettvin, Wiesner also hired Walter Pitts and Warren McCulloch, creating what would become a prolific team of neurophysiology researchers.

Lettvin is most noted for publication in 1959 of the paper "What the frog's eye tells the frog's brain." The paper became one of the most cited papers in the Science Citation Index. Lettvin and his team, including mathematician (and lifelong associate) Walter Pitts, Humberto Maturana, Warren McCulloch and Oliver Selfridge, demonstrated how specific neurons respond to specific features of a visual stimulus. Early skepticism on this new explanation gave way to a profound and lasting impact on the fields of neuroscience, physiology and cognition.

In addition to his work on vision, Lettvin carried out many important studies of the neurophysiology of the spinal cord and information processing in nerve cell axons. Though he is best known for his work in neurology and physiology, he also published on philosophy, politics and poetry. Lettvin was one of the early directors of the Concourse Program, a freshman learning community that bridges the humanities and the sciences by exploring connections between disciplines such as literature and physics, or history and mathematics.

Jerome Lettvin, left, with Walter Pitts.

Bootstrapping technology entrepreneurship in Africa & Sri Lanka
Healing through innovative technology in India

EECS students apply intelligence and passion to areas of opportunity and need

EECS International

The Department of Electrical Engineering and Computer Science continues to build its international presence, engaging—and in some cases collaborating—to support major academic and research centers worldwide. EECS students are encouraged to take advantage of international opportunities—just as they are encouraged to take part in the UROP Program. The options for EECS students include VI-A International and the MISTI (MIT International Science and Technology Initiatives). In 2011, over 100 EECS students took advantage of both summer and IAP opportunities through these programs working and/or studying in Europe, Latin America and Asia.

In addition, other programs have sprouted over the past ten or more years, allowing hands-on experience to teach and live in communities abroad—often resulting in significant benefit to these communities. Two such programs—one created within the EECS/CSAIL community and another (nonprofit) created by former EECS students as a response to need—are highlighted in the next two articles in this newsletter. AITI (Accelerating Information Technology Innovation) was formed in 2000 by two EECS undergraduate students interested in building technology education in their native African country. IIH (Innovators in Health) a nonprofit organization was started by three recent EECS graduates in response to the inaugural Yunus Challenge to Alleviate Poverty in 2007.

From mobile apps to global apps, AITI takes hold in Africa

In 2006, EECS graduate student Michael Gordon was well on his way to earning his PhD in computer science under Professor Saman Amarasinghe. But he felt the need to add another dimension to his learning and energy.

"It was a personal journey. I was doing computer science research in Saman Amarsinghe's group. It was traditional research, parallel programming languages and compilers. I was looking for more direct and human impact... but still wanted to continue with my PhD research. My officemate and I brainstormed about how we could have more of an impact. We looked at some of the technology changes that were happening in the developing world and noticed that mobile phones were just beginning to penetrate. Then, I became involved in a few interventions involving mobile phones in developing countries: healthcare applications, mobile commerce, and Internet access initiatives.

Having attempted interventions in India and the Philippines, I came to appreciate the difficulties. The technological aspects were appropriate, but we had difficulties with deployment, training, sustainability, language, and existing stakeholders. This experience motivated me to start thinking about how one can stimulate homegrown technology innovation. Locals know the conditions best. They know the problems and opportunities. We just need to arm them with the appropriate technology and entrepreneurial skills to create businesses that address local and regional needs."

— Michael Gordon, PhD, 2010

Gordon's budding ideas found a perfect vehicle in an existing program at MIT, the MIT African Internet Technology Initiative (AITI). AITI began long before Gordon knew about it—in 2000, when two EECS undergraduates, Paul Njoroge and Martin Mbaya, on their graduation returned to their native Kenya with a fellow alum and a graduate student in Linguistics, to conduct a six-week course on Java and Linux for 45 undergraduates at Nairobi's Strathmore University. Over the next six years, the program continued to send MIT students (mostly undergraduates) to African universities and high schools to teach basic programming, Internet technologies, and operating systems.

In 2007 Michael was selected as an AITI instructor at Strathmore University in Kenya. Michael notes about his immediate approach to this assignment, "I added a mobile app development curriculum. And, I got students over there to start thinking about mobile phones as little connected computers, little devices for which they could develop applications. We taught the students that with

AITI, continued

minimal capital there are opportunities for entrepreneurship in the mobile phone market right in their own communities."

Five years later, Michael Gordon, now Postdoctoral Associate under Prof. Amarasinghe, is the director of AITI (known since 2008 as Accelerating Information Technology Innovation). Michael took control of the program in 2007, and has introduced curricular and structural changes, added new partner universities, and engaged new corporate sponsors. Michael has overseen the expansion of AITI and is now organizing a permanent home for AITI in MIT's International Science and Technology Initiative (MISTI).

In the four years as director of the program, Gordon's goal of stimulating entrepreneurship predicated on Internet and mobile technology at universities in developing countries faced many challenges. "Students at some of the African partner universities had learned computer programming on paper because of various systemic issues. Entrepreneurship was not encouraged; students wanted the safe job with a corporation; networks to foster entrepreneurship did not exist."

AITI's success in 2007 as one of the first programs teaching mobile application development in Africa caught the attention of Google. They expressed interest in offering support. Buoyed by a subsequent $30k grant from Google, Gordon trained another group of 4 teaching assistants at MIT, taking them to Kenya where they delivered a mobile application incubator course. Plied with presentations about what the students were doing and ultimately with enthusiastic elevator pitches and business plans from the students, the Google team, as Gordon describes it, "...was blown away by what the students were doing. This was in 2009 when that kind of stuff wasn't really happening in East Africa."

Yet another and larger round of funding from Google as well as MIT funding through MISTI, the Deans of Undergraduate and Graduate Education, and EECS Professor and MIT President Emeritus Paul Gray enabled Gordon to run two programs in 2010 in Kenya and Rwanda. In both locations, the AITI courses culminated in startup showcases, similar to the MIT $100k competition; the exposure from the showcase resulted in a team becoming one of the first mobile services startups in Rwanda.

The resulting support, $150k from Google and enough money from other sources to run three additional programs in 2011 including Sri Lanka as well as four African

2007 AITI Kenya Class Photo at the Strathmore University in Nairobi. Michael Gordon is pictured front left center.

countries (Ghana, Nigeria, Kenya and Rwanda), became the strongest measure yet of AITI's success. With the growth of the entrepreneurial element in the program, Gordon was able to recruit and train 18 student instructors from Sloan and MIT CSAIL with an entrepreneurial spirit and a desire to make an impact on the world. He notes: "The model seems to have proved that as long as you train instructors here and send them over there with some context—they take the structure and run with it. The instructors take ownership of the course and do incredible things."

Over his four years of involvement with AITI, Gordon is pleased that the MIT students who apply and are selected as instructors are successfully affected—often aiming for far more diverse careers when they graduate. "It's a great experience for students from here—especially for undergraduates. There's a world of difference when they return. They come out of their shells, more outgoing and assertive because it is a dynamic and demanding environment. There is a lot of mentorship and public speaking and pitching." Typically one Sloan MBA, one CS graduate student and two undergrads in either management or computer science form a team at one location. As for qualities required for AITI instructors, Gordon notes, "As long as they have programming or entrepreneurship experience, they are outgoing and can organize, they will adapt very well on site."

Gordon has also been developing ways to find good students in Africa—opening the programs up to multiple universities in each country and asking instructors and professors at these universities to send their best students. He notes, however, "There are systemic issues with a scientific education in Africa and I don't see us as an organization going in and making a huge impact teaching basic skills. We're a small organization. What we can do is make a huge impact with top students who already have skills. We push them towards entrepreneurship and make them leaders and examples. Then they can affect change—a trickle down effect." So, the selection process of students and universities with which AITI partners has been refined through better recruitment practices and selective scholarship support.

Gordon also notes that things are changing in Arica. There is a greater sense of opportunity. He says, "There's a lot of developing industry, a lot of low hanging fruit, and there's a lot of money to be made because there's a mobile phone in just about everybody's hands and they don't have a mature ecosystem of mobile services as in the U.S." A lot of multinational organizations such as Google look at Africa and see opportunity and market growth.

2011 also provided great inroads to establishing AITI in Sri Lanka, effectively a part of the huge Indian market. Gordon notes that although some of the top Sri Lankan universities produce students who can program, there is no curricular inclusion of entrepreneurship and innovation—particularly problem solving. "In Sri Lanka there does not exist a culture of risk-tolerant innovation among the students; furthermore, entrepreneurial support structures fostering startups are nascent."

The right connections in Sri Lanka

With the goal of raising entrepreneurial instincts, Gordon says that, "AITI offered one of the first incubator courses in Sri Lanka with tremendous outcomes. We had their biggest newspaper putting out articles on the course as it was unfolding. We had the three largest mobile operators intimately involved in the course, bidding to incubate the startups. As a result three startups were funded from the course." Besides the recognition of the MIT name, Gordon credits his advisor, Saman Amarasinghe (who hails from Sri Lanka). "He was always supportive of what I did, but once he saw what I had done, he gave contacts and helped build the model to be effective in Sri Lanka. In fact, the first year was so successful in large part because he called up influential business leaders to reach out for help and publicity. I appreciate the freedom that one gets at MIT when an advisor provides the flexibility to innovate."

Gordon has learned through his experience and computer science training to think in terms of scalability and sustainability while building local teaching skills. Local instructors are attached to AITI courses to participate in the instruction. After experiencing positive outcomes, local instructors see the benefit of teaching incubator style courses, and can continue without direct support from MIT AITI.

Students working an their startup pitches during AITI's 2011 Sri Lanka program at the University of Moratuwa.

Ultimately Gordon seeks to help establish regional entrepreneurship centers. Funding is brought in—from the World Bank, for example. Gordon has sat in on a number of boards as this process plays out. Kenya, the inaugural location for AITI, will no longer be part of the program—a kind of planned graduation. Since the first AITI mobile training in 2007 at Strathmore University, the Kenyan university now offers its own two-year Master's course in mobile-application entrepreneurship. Also Strathmore is opening its own entrepreneurship lab, for which Gordon sits on the board. Gordon reported for the MIT News Office in late 2011: "We're done in Kenya. They have enough local talent and resources to offer these incubator-type classes without direct intervention. That's a huge outcome in my opinion."

As it continues to mature, AITI in 2012 will see further changes, including the addition of programs in West Africa and Southeast Asia. The other change for 2012 will result as Google increases its annual contribution – enough that AITI can hire a coordinator. Michael Gordon is eager to see the program come under permanent coordination—as he transitions into an advisory role. He looks back, "I wouldn't say we were pioneers; but we were bootstrapping technology entrepreneurship where there is a lot of potential."

http://aiti.mit.edu/

Innovators in Health

enabling data-driven healthcare delivery and co-founded by three EECS graduates

Manish Bhardwaj, CEO and co-founder of the nonprofit Innovators in Health (IIH), http://www.innovatorsinhealth.org/, has lived in many locations around the globe, including his native India, and in Singapore, Indonesia, Austria and the U.S. On completing his SM degree in Electrical Engineering in 2001, he joined and became vice president of Engim, Inc., a private venture-backed wireless semiconductor startup. Manish returned to EECS in 2005 for his PhD, which he earned in 2009.

What moved Manish to found and lead a non-profit? The project started in response to the inaugural Yunus Challenge to Alleviate Poverty, an initiative of MIT's Jameel Poverty Action Lab (J-PAL), Public Service Center, D-Lab and International Development Initiative (IDI). The challenge was to improve adherence to tuberculosis (TB) medication. Manish describes this stage: "It turned out that the Buddhist chaplain at MIT, and now Director of the Dalai Lama Center for Ethics and Transformative Values, the Venerable Tenzin Priyadarshi, was working on TB in the Indian state of Bihar. So, we got a group together with Ven. Priyadarshi's foundation (Prajnopaya Foundation, based at MIT) and started work." This was in 2007 when the group responded to the Yunus Challenge, winning the IDEAS Competition in May. Manish, who was new at the time to public service, had teamed with fellow EECS graduate students Bill Thies ('09) and Goutam Reddy ('05), both of whom had previous public service experience.

On another level, Manish describes the motivation for becoming involved. "It was hard to grasp that 50 years after drugs for TB were invented, about 2 million people were still dying of the disease. It seemed to make no sense. Having been part of a start-up (between my SM and PhD), knowing that we had a strong community partner (Prajnopaya), a very supportive staff at the Public Service Center and MIT D-Lab, and most crucially, a strong team at MIT, gave us confidence that we could make a contribution."

Innovators In Health, as noted on its website, develops technology to electronically record, authenticate, wirelessly relay, and analyze delivery of medication, with the goal of lowering costs and improving cure rates, thus helping programs scale.

From their initial 'debate in a room in Cambridge' approach, the team's intervention design has evolved to an iterative, community-driven one. Manish notes, "The first iteration was a detailed plan based on copious theoretical data and some limited community interaction." Then this thinking was rolled out in 'fully-baked form' in the target areas. "We did this in 2008 with poor results," he admits. The next attempt in 2010, was undertaken first with the team living in communities, spending 2-3 months walking around their target villages, conducting more than 200 long-form interviews with residents, patients, private and public healthcare providers. "What we learned," Manish relates, "led to Aahan - a TB control program that we now run jointly with our partners."

A health worker in New Delhi, India scans a patient's fingerprint to prove that tuberculosis medications have been administered on schedule.

In the past year and a half, one of IIH's most successful interventions has been mobilizing the government's female community health workers (called "ASHA") to deliver TB drugs. Manish describes a process that has been challenging but promising. "From afar, literature and conversations (crucially, not people from the community) indicated that the ASHA were a lost cause. But detailed conversations with the ASHA themselves and the broader community painted a more complex picture. ASHA were not active in the TB program because of inadequate training, motivation and delays in compensation. Despite these barriers, about 10-15% ASHA displayed great dedication and skill, and were trusted by their communities more than any other healthcare agent. In concert with the public health system, we retrained the ASHA, and now have periodic meetings to understand their difficulties in the field, recognize and reward their efforts, and advocate for higher and timely wages on their behalf. As a result, this past year, 32 ASHA workers delivered drugs to about 150 patients, an order of magnitude improvement."

IIH co-founder Bill Thies has led a team at Microsoft Research India and IIH to develop uPrint, a biometric technology. uPrint establishes, with a high degree of confidence, that patients received their drugs from providers by linking to a database to identify and authenticate the user. Each provider is equipped with a unit including a fingerprint reader attached to a processing device running custom software. Patients and providers register their prints to establish the meeting. Despite the expense of the reader devices, single providers can serve on the order of a hundred patients a year.

IIH co-founder Goutam Reddy started Abiogenix, Inc. to commercialize the uBox, a technology developed by an IIH and Prajnopaya team led by Reddy. The uBox enables patients to take medication themselves, alleviating the need for patients to travel to providers.

All of the IIH interventions are targeted towards TB, but have implications for other diseases. For example, strategies for improved adherence apply in the more challenging context of HIV/AIDS as well. They also apply to mental health, where patients may stop taking medication. In terms of geography, one of the states in India where IIH works is Bihar, which has a population of 103 million. "So," Manish notes, "it'll keep us busy for a while!" And, in terms of transference, he notes, "People working in other regions may find some of the principles underlying our interventions useful, though the specifics would have to be tailored, perhaps significantly, to incorporate local culture and dynamics."

IIH is very much an MIT alumni-instigated entity with significant roots in EECS. Three of IIH's four co-founders are EECS alumni, including Bill Thies, Goutam Reddy and Manish Bhardwaj. The organization includes two full-time staff in a biometrics program in Delhi, supervised by Bill Thies. The program in Bihar has 10 full-time staff and all full-time staff are local. At least 18 students at MIT have made substantial contributions to Innovators In Health from its start in January 2007. Of these, eight are from EECS (5 PhD, 2 MEng, one senior).

"EECS has played a big role directly." Manish says. "It has also played an intangible role. The faculty, staff and our fellow EECS and MIT alumni/ae have contributed to an education that ranks among the best in the world. The mere act of standing as one with our patients sends a powerful message. It says that the poor and illiterate patient in a village is equally worthy of the attention of society's best institutions. To borrow a favorite phrase of mine, "much is asked of those to whom much is given." I think the gift of an MIT education probably asks for a lifetime of public service."

Manish Bhardwaj (seated left) with a resident of the Keota village, Bihar, as p art of a survey on health-seeking behavior.

With entrepreneurship so strongly established at MIT, Manish talks about nonprofits and the meaning of choosing public service as a career. "First, the number of graduates choosing public service as a career remains small, perhaps even zero in many years. This is not because people don't want to serve, but because it is difficult to find appropriate opportunities and examples of others who have done so.

"Second, there is a significant gap between a student initiative and a viable organization, profit or non-profit. The ecosystem at MIT for non-profit ventures is in its formative stages, compared with a highly mature environment for for-profit entrepreneurial ventures. Students don't see a clear path to making that jump. The development community is aware of this gap and working to fix it.

"Third, there is a healthy debate about whether the promise of technological interventions and social entrepreneurship has been oversold. We need to have that debate at MIT, since as engineers and entrepreneurs, we have an unquestioned faith in technology and free markets and, to put it bluntly, the profit motive. We have invited Kentaro Toyama (Bill's former boss), who will give a talk at MIT in March 2012 to ignite that debate. The point is not whether technology and for-profits have a role in development – they absolutely do -- but whether they are always appropriate.

"So, we need several things in place if we want to see lasting change by university initiatives or student groups. We need to question some orthodoxies and we need more people picking service as a career, with support systems at MIT to make that easier. With all this, and a lot of luck and hard work, we have a shot at real change."

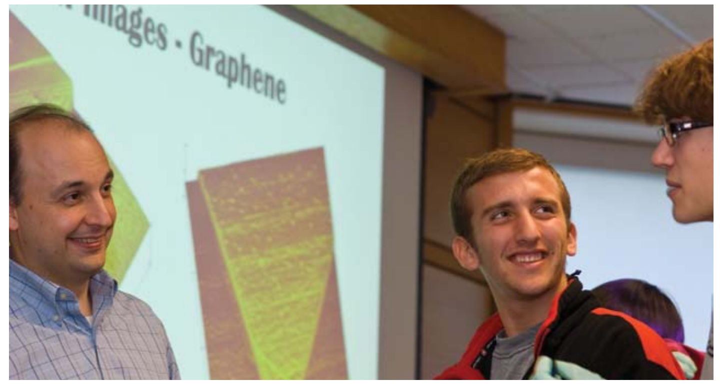
Nanomaker: Freshmen Seminar in EECS

taught by Vladimir Bulović and Dr. Katey Lo

"Nanomaker," the weekly Freshmen Seminar led this Fall term, 2011, by Dr. Katey Lo and Prof. Vladimir Bulović and initially designed by Prof. Rajeev Ram, Dr. Joe Summers and Dr. Lo, equips first-year undergraduate students with hands-on techniques used to fabricate microscale and nanoscale devices. Students build their own AC-driven light-emitting diodes from glow-in-the-dark face paint, dye-sensitized solar cells from titania nanoparticles and juice of mushed rasberries, they ink-jet print microfluidic chemical sensors on common paper, and use DVD disks as high-resolution dispersive gratings to characterize optical spectra using their cell-phone cameras..

Dr. Katey Lo, left, encourages EECS undergrad Jody Fu in extracting the fine graphene layer from graphite following the method used by Physics Nobel winners Andre Geim and Konstantin Novoselov.

All of the devices and structures students construct harvest or consume energy, and issues of energy use/generation and how those relate to the device design are highlighted throughout the class. Through these practical uses the labs teach the fundamentals behind top-down and bottom-up nanofabrication, accessing the physical concepts of the nano-scale world on a common bench-top.



Prof. Bulović discusses the class with students Logan Mercer, far right, and Erik Waingarten, center.

The "Nanomaker" gives the first view to the basics of semiconductor device fabrication – lithography, doping, etching, metallization – as well as the application of molecules, polymers and nanocrystal quantum dots to the fabrication of devices that operate at the nano-scale.

This coming Spring you will be able to find videos and written instructions for many of the "Nanomaker" labs on MIT's Open Courseware. Funding for the development of the "Nanomaker" has been provided by the MIT Energy Initiative Energy Studies Program.

Parker Chambers is making silicon solar cells with phosphorous spin-on dopants to create a P-N junction. He then used Armour Etch to remove oxide for electrical contact.

6.172 lands a winning final project

This past Fall term, 2011, saw the aligning of some perfect stars in the realm of class projects in the EECS Department. One of the brightest was the decision by Professors Charles Leiserson and Saman Amarasinghe, instructors of 6.172, Performance Engineering of Software Systems, to select a new final project based on a strategy game. The idea was to find a game where students would implement a game-playing program followed by a tournament to test which program was the strongest.

Having been given the laser-chess game Khet by his son several years ago, Leiserson decided to enquire about adapting it for the class. Searching online, he not only discovered how well it would fit the need, but that its designer, Prof. Michael Larson, now at the University of Colorado, is an MIT graduate (MechE PhD, '92) who first introduced the game at MIT in 2005. In fact, Larson, a professor at Tulane University in New Orleans at the time, ran the first Khet tournament, then known as Deflexion, during IAP at MIT. Larson was given a visiting appointment at MIT following Hurricane Katrina in 2005.

"When Katrina hit, 5200 units of the game had to be rerouted from China to MIT while New Orleans recovered," Larson explained. Having reverse-engineered games with Hasbro, Larson and his graduate students came up with the idea of laser interactions (hot in research at the time) to design a game. Larson described the rationale, "I liked the idea of something to help educationally that engaged with scientific principles, yet gave a tangible and visceral experience." The Egyptian word 'Khet', meaning fire or flame, was appropriately assigned to the game in 2006. The game's use of laser beams provides a demonstrative (but harmless) way to indicate a well-placed move, eliminating an opponent's player piece if undeflected by an opposing mirror. The playing pieces for Khet include ancient Egyptian characters (the Pharaoh, the Djed, the Pyramid and the Obelisk) and the strategy is akin to that of chess.

Delighted at having another application of his game at MIT and grateful for his temporary stay at MIT in 2005, Larson generously donated 24 game units of Khet 2.0 to 6.172 and came to introduce the final project by playing the first demonstration game in mid November. Leiserson also engaged the services of Donald Dailey, a world-renowned chess programmer and formerly an employee working with him in the MIT Laboratory for Computer Science as systems administrator and research technician working on a new parallel program called Star Socrates in the 1980s. Dailey also came for the kickoff event, giving a guest lecture on the programming required for making the project and upcoming tournament possible.

Readying the infrastructure to run the 6.172 final project was no small engineering task. As they prepared the students to undertake the necessary programming to compete, Leiserson and TAs Ekanathan Palamadai Natarajan, Ruben M. Perez, Tao B. Schardl, and (Yod) Phumpong Watanaprakornkul had to prepare the 12 dedicated multicore computers (donated by Dell and Intel) to be used by the individual class teams, in addition to building the user interface for viewing the matches.

Ruben Perez (setting up the demo match as Prof. Leiserson looks on in the photo above) described the class preparation: "A game can be modeled as a tree graph, where a node in the graph is a game position, and there is a connection to a node for every possible game position you could get to by making a move. Algorithms for

EECS classes are enterprising, and sometimes

playing games like chess or Khet try to search this tree quickly to see which moves will lead to the best possible state."

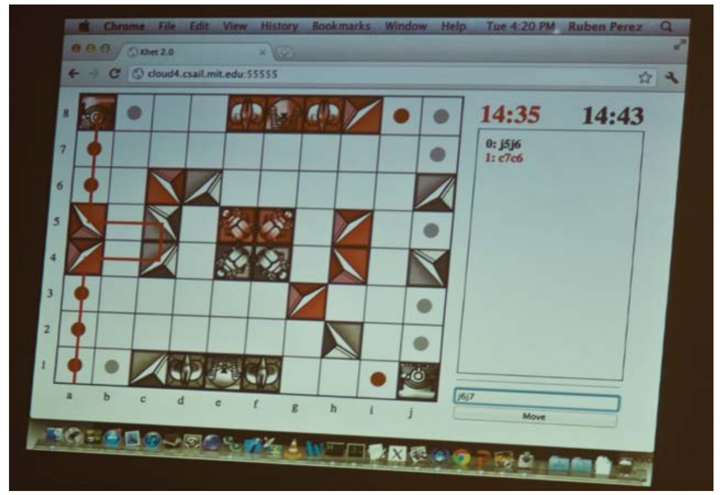
"The tricky part" Ruben added, "is how to effectively employ more processors to do the work faster." This is where parallel programming, one of the deeper elements of 6.172, comes in. Each team (of either 3 or 4 students) is given access to a dedicated machine that has 12 processors (as compared to a personal computer that might have two). Understanding the subtleties of assigning the search tasks to these processors is where the strategies of each team were tested.

For simple games, the tree can be completely generated, allowing for perfect knowledge. For complex games like chess and Khet, the tree is far too large to generate completely. The branching factor, defined as how many states are possible from a given state, is 81 for the opening move of Khet. The height of the tree is the number of moves from start to finish, which is probably in the area of at least 50. The size of the tree is the branching factor raised to the power of the height, which is impossible to generate in any reasonable amount of time.

Mike Larson (seated left), Khet creator, readies for the Nov. 15 game match as TA Yod Watanaprakornkul finalizes the interface on the screen (photo to the upper right) and Prof. Leiserson reviews the setup for the match.

Don Dailey's program to play Khet used a variant of alpha-beta search, an algorithm commonly used for two player games. The program was written to communicate and play with the other programs. Dailey, known as one of the world's top chess programmers, said, "Khet is deeper than chess, in my view – more fun."

TA Yod Watanaprakornkul, who designed the graphical interface providing a visual view of the game moves (instead of lines of text) for both the kickoff demo and the tournament, described the set-up for running the tournament: "The player software, the center of attention in the class and tournament includes both Don Dailey's code and the sudents' code. The challenge for the students is to improve the player to make it run faster and search more efficiently—searching millions of board positions in a second."



The referee software takes care of giving commands to each player as well as time control and move validation, producing data about the state of the games, which is ultimately communicated to the tournament participants and spectators using Yod's graphical interface.

The Nov. 15 demonstration game pitting Michael Larson with Don Dailey's player proved ideal for elevating the 6.172 students to face the challenging programming required for the tournament a month later. (Larson was very good spirited about being trounced by Dailey's program).

Yod and Ruben gave exhilarated reports of the tournament final rounds. "The finish was incredibly intense. Though the tournament went for 7 rounds, two teams tied for first. Neither had ever lost a game, only drew. We played 4 games at the same time for a tiebreaker, with 3 draws. The last game looked to be a loss for one team, but they came back to win with just a few minutes left on the clock!" (See the game interface: http://courses.csail.mit.edu/6.172/khet/2011/)

It turns out that the winning team used the strategy of evaluating as many positions as possible (as opposed to ignoring some bad ones). EECS senior Nathan Rittenhouse, one of the 3 member winning team, was clearly pleased with 6.172 as a whole, particularly with the challenges of the final project. "I enjoy being able to see the results of theoretical speedups materialize in a faster running program. To the engineer in me, the greater empiricism of this practice is quite satisfying."

....EECS classes are pure magic!

TA Ruben Perez (left) follows Mike Larson's Khet demo moves then placing the move generated through Don Dailey's Khet program as the 6.172 students look on.

As a first time Khet player, team member and, as yet undeclared MIT Sophomore, Liz Fong-Jones noted about the process: "As we performed improvements, we were able to see the rate of boards evaluated per second increase, and eventually go from only looking two or three moves ahead in ten seconds to looking six or seven moves ahead." When asked what she planned to do following 6.172, Liz promptly replied, "I'm now a full-fledged Course 6 undergraduate student starting in February and am tremendously excited!"

Professors Amarasinghe and Leiserson created 6.172 four years ago as the realities of over 3 decades of Moore's Law and Dennard Scaling had ultimately allowed the entire field of software engineering—including its instruction—to ignore the basics true for all engineering, i.e., performance and efficiency.

As a hands-on, project-based introduction to building scalable and high-perfomance software systems, 6.172 includes topics such as performance analysis, algorithmic techniques for high performance, instruction-level optimizations, cache and memory hierarchy optimization, parallel programming, and building scalable distributed systems. For each project, students are given a functional and inefficient program and asked to improve its performance. After rigorous grading of the first "beta" submission, the students have a chance to get their program code reviewed by a group of experienced local engineers who are volunteering their time to help them. Students then have the opportunity to improve their code and resubmit for the final grade. Read more about 6.172:

https://stellar.mit.edu/S/course/6/fa11/6.172/index.html

MIT transformed into the Magical Institute of Technology

by MIT graduate students Mitali Thakor (SHASS), Victor Wang (EECS) and Randi Cabezas (EECS)

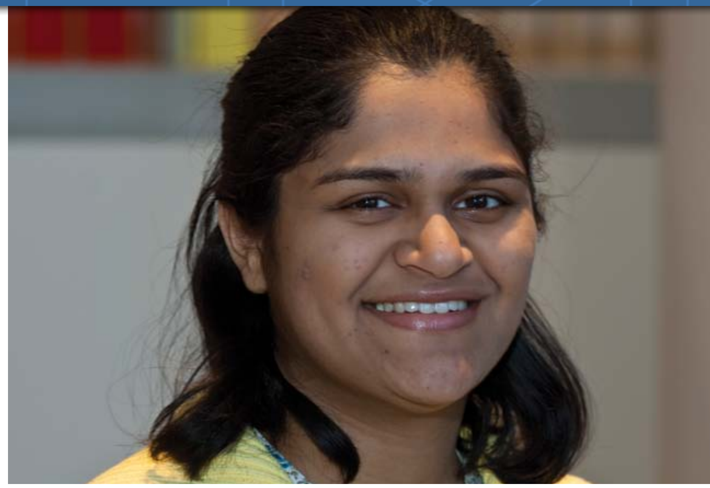
From Feb. 11th-12th, Emmy-nominated magician Larry Wilson came to campus and led three workshops on "Magically Inspired Teaching" (MIT for short!), followed by a magic show to a packed audience at Kresge Auditorium. These events were sponsored by the Graduate Student Council together with Professor Alan Oppenheim, Ford Professor of Engineering. They were part of a broader effort to promote excellence in mentoring and teaching across the Institute.

Saturday featured three small workshops by Larry along the theme of "Magically Inspired Teaching." The workshops focused on taking risks and inspiring and motivating an audience, whether in the classroom or on stage. Participants were encouraged to free themselves from the perils of perception and the ever-shrinking comfort zone. The workshops were designed to provide faculty, graduate students, and other aspiring teachers with valuable techniques to command their audiences' attention.

On Sunday in Kresge Auditorium, upwards of one thousand students, faculty, friends, and family members lined up for Larry's "One-Man Show." A cohort of our very own student magicians performed illusions while an eager audience entered Kresge and waited for the show to start. Larry's performance was amazing. It fully embodied the principles discussed in the workshops, and the proof was a mesmerized audience's undivided attention throughout the hour-long show.

Magic Madness Team (photo courtesy of Tom Baran) Left-Right
Randi Cabezas, Marie Giron, Alex Levin, Cristina Camayd, Richard Weng, Magician Larry Wilson, Prof. Oppenheim, Victor Wang, Mitali Thakor, Ahmed Helal, Daniel O'Malley, Sean Gold, Austin Hess, Emmanuel Carrodeguas

Meet some of our amazing UROP students



Ashwini Gokhale

The title of my UROP is "Formal Reasoning About Reputations in E-Commerce". I work under the direct supervision of Dr. Frans Oliehoek, and I am part of Prof. Leslie Kaelbling's research group.

I model the problem of e-commerce—where an online shopper is a single decision-maker influenced by multiple factors—as a POMDP (partially observable Markov decision process). Research on social influences in e-commerce decision-making reveals that purchasing decisions are often strongly influenced by people who the consumer knows and trusts. Moreover, many online shoppers tend to wait for the opinions of early adopters before making a purchase decision, to reduce the risk of buying a new product. In effect, the 'reputation' of a business is a significant factor in e-commerce decision-making.

The goal of this project is to evaluate the extent of the effect of the 'reputation' of an e-business on the optimum decision-making process of an online shopper, utilizing the POMDP model. The 'reputation' of an e-business is established by factors like online reviews and customer satisfaction, and encoded in the form of advisors who answer the buyer's questions regarding the quality of a seller. A paper based on this project is under peer-review.

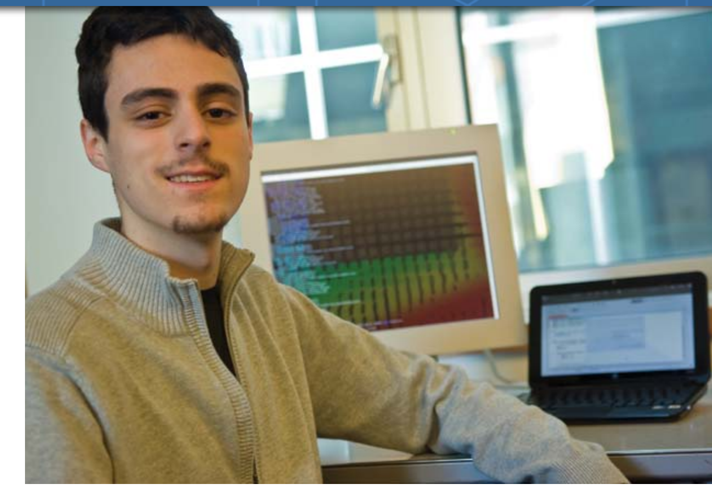
I always knew I wanted to be an Electrical Engineering and Computer Science major—in fact, this is one of the reasons I chose to go to MIT. After taking introductory classes like 6.01 and 6.02, I realized how much breadth there is in EECS. It's important to be aware of the multitude of subfields in EECS, but I think it is also nice to have a deeper understanding of a few subfields.

Kristjan Eerik Kaseniit

The title of my UROP project is "Synthetic Biology Platform Engineering and Modeling." I'm working with Professor Timothy Lu (Synthetic Biology Group) and graduate students Samuel Perli and Fahim Farzadfard. The purpose of the project was to build a platform in the form of a website to provide quantitative data on the characteristics of biological parts and systems proposed, designed and used in the Synthetic Biology Group lab.

During the summer while I was working for this project, Prof. Lu asked me to help on another project, which involves reducing unwanted DNA-protein interactions by designing and analyzing small DNA sequences within genomes of useful model organisms. Specifically, I looked at how many times short DNA sequences (9-18 nucleotides) appear in these genomes. I was looking for sequences that were relatively infrequent and then matched this list up with known zinc-finger binding sites. Zinc-fingers are a class of proteins that bind DNA in a sequence-specific manner. The greater purpose of this search was to introduce into genomes DNA sites that did not occur in the genome already. This way we could be sure of where the zinc-finger can bind. This project was eventually peer-reviewed and published.

I got interested in synthetic biology when, as a freshman, I went to see a talk by Randy Rettberg, who came from a pure CS background, later adding on biology and playing a major part in establishing a new field of study. The things he described in his talk really appealed to me. Coming to MIT (the only school to which I applied from my native Estonia), I wanted to work on a platform to design molecules. Synthetic biology sounds even more awesome, versatile, and most importantly, tangible. When I discovered the flexibility of the new Course 6-7 degree program, I was set.

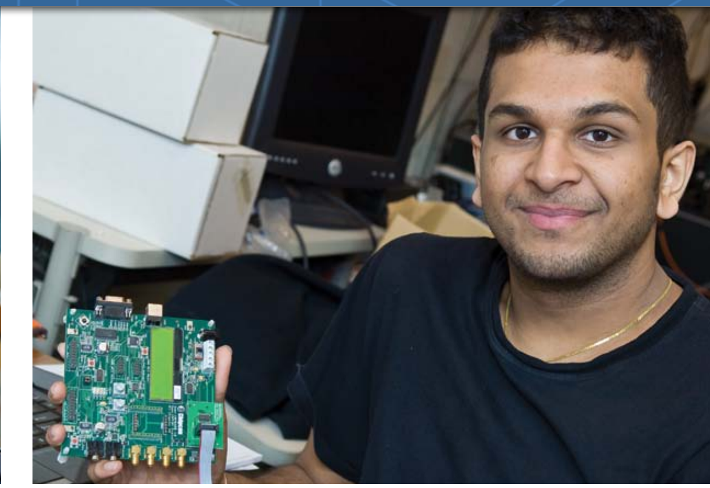


Dylan Sherry

I've been working with Una-May O'Reilly and her Evolutionary Design and Optimization group at CSAIL on an integrated system for the massive parallelization of evolutionary computation. My interest in research has grown through three earlier UROP experiences: one at the Laboratory for Electromagnetics and Electronic Systems, LEES, in the Research Laboratory of Electronics, RLE, and two with groups in the Media Lab. I was introduced to evolutionary computation as a student in Professor Winston's course, 6.034. I found the power and flexibility of the computation to be impressive and encouraging, and joining the group was a natural next step.

Most of my work with the group has been focused on the FlexGP project, which seeks to enable flexible and dynamically factorisable evolutionary computation on a massive scale. One of the first steps in the project was to create a prototype system to learn more about the technologies involved and their limitations. I worked with the group over the summer to design and construct the prototype, which eventually sustained operations across several hundred cloud-backed virtual machines. The prototype focused on genetic programming, a subclass of evolutionary algorithms that is particularly effective when applied to symbolic regression and classification.

The ultimate goals of the project have significant implications. On a practical level, evolutionary computation is a proven approach for solving many classes of problems, and any system with the ability to properly access massive computational resources could find better solutions. With regards to theory, massive computation represents a mainly unexplored domain, and could introduce as-yet unobserved dynamics.



Krishna Settaluri

I initially began in Professor Ram's group by aiding a graduate student in designing a PC Board for a voltage-to-current converter. After completing this, I began focusing on energy harvesting, partly because of its pertinence to today's issues. In particular, I found that using thermoelectric generators (TEGs) for energy harvesting purposes was a viable means for powering circuits, especially for small-scale applications like medical monitoring for patients. When I began this project, I was completely new to TEGs and TEG-based systems. I found the material interesting and started learning more about it.

My main focus during the last 2 years of my undergraduate career dealt with TEG-based systems. Specifically, I wanted to answer the question of how to properly and comfortably use TEGs for body-powered applications. Early in the project, we realized that following existing designs for coupling TEGs with heat-sinks was incorrect for wearable applications. Our approach differed from these designs in that 2D heat-spreading was used for cooling rather than the typical 3D heat-spreading. We were able to comfortably design a body-based power extraction system with a total thickness of under 5mm whereas existing designs extended to above a couple of centimeters.

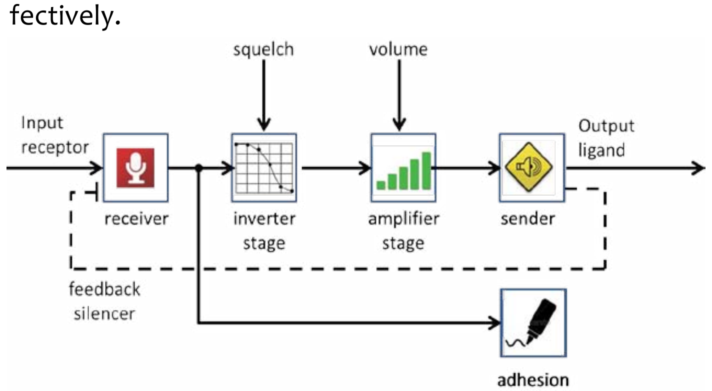
The greatest source of satisfaction, inspiration, and drive for me came from the realization that this project was a direct byproduct of my effort. It was also my first serious exposure to research. I enjoyed being a part of Prof. Ram's group and will be continuing with him for my Master's research. Also, I broadened the scope of my thesis to focus on low power circuit design and am working on this with Professor Chandrakasan as well.

iGEM, International Genetically Engineered Machines, gears up for 2012

The EECS Department is pleased to support student groups including those featured in this newsletter: iGEM, Maslab, SEVT and USAGE

Since 2003 when it was started at MIT during the Independent Activities Period, IAP, the International Genetically Engineered Machines (iGEM) has grown to be an international event including teams from the Americas, Europe and Asia. Over the course of several months, student teams design novel biological systems from a standard kit of biological parts. Three regional "jamborees" then lead up to the world championship, which is held in early November at MIT. 160 teams of mostly undergraduate students from across the globe compete to build biological systems that operate in living cells. MIT placed fourth overall and first in the health and medicine track, one of ten tracks in the 2011 competition. This was the first time that MIT placed in the grand finals. The overall prize was ultimately awarded to a team from the University of Washington. (See: http://20011.igem.org/)

The 2011 MIT team chose a project that was high risk – and high reward. The coordinators for this team (who were interviewed for this article), including EECS Professor Ron Weiss, Jonathan Babb and Deepak Mishra, used synthetic biology and genetic engineering to create genetic circuits that control intercellular communication and perform logic processing in mammalian cells towards the ultimate goal of obtaining tissues-by-design. Because mammalian work is rare at iGEM, the MIT team had to construct and test a large number of mammalian DNA parts—now contributed to the iGEM parts registry for future research. The team successfully demonstrated that all parts of the system worked, but were held back for the regionals by the challenge of communicating effectively.



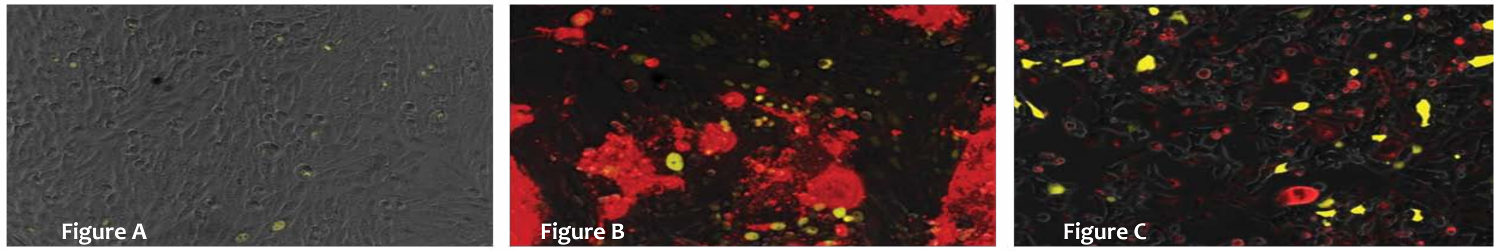
Overall circuit design to achieve autonomous cellular patterning: an electrical analog of the final genetic circuit presented by the 2011 MIT iGEM team, consisting of signaling, differential adhesion, and internal signal processing elements.

Babb notes: "The iGEM competition is about building a new system with a purpose that originates in the minds of the students but that ultimately must be conveyed to a general audience of both their peers and faculty judges. By finals, the 2011 team had greatly improved at communicating the advanced scientific concepts of their project, addressing the concerns and feedback of the judges from the regionals, and going on to develop a strong presentation that showed all the parts of their system working together."

"Tackling the mammalian cell culture process was not the only complexity," Babb continued. "After success at the more intricate process of introducing DNA into mammalian cells (called transfection), the team also needed a high yield (percent of cells successfully engineered) before patterns could be formed. For the competition, the team needed to get results fast, using a technique known as 'transient transfection' – avoiding the slower process of stable integration, which can take up to one month per experiment. Another challenge the team faced was cell-cell communication, which involves being able to express proteins at the surface membrane, regulate protein expression in the nucleus, and being able to send signals both between and within cells in a finely tuned manner. And, the team's system included complex logic taking place inside mammalian cells—something on the cusp of what is possible in mammalian synthetic biology."

Why take such a difficult path? The team coordinators reason that the project motivation is fundamental to advances in tissue engineering – how to program biology itself to form, pattern and grow new tissues. The ultimate success could revolutionize fields such as regenerative medicine—with the potential to eliminate the need to harvest organs for transplants. Experimental results will also lead to scientific understanding about how patterning guides new tissue formation. The approach could complement existing scaffold-based tissue engineering, or even replace it altogether.

As the spring term begins, the 2012 team starts to ramp up towards selecting their project goals and building a team. The IAP course, organized and run by the 2012 team coordinators (and former 2011 IGEMers) Paul Muir (junior in BE) and Andrew Yang (senior, MechE) provided a mechanism for enticing potential team members. This class was also greatly aided by Carolyn Stahl from MIT's Environment, Health and Safety Office as she trained all the students and made extra lab benches available over IAP.



Fluorescence microscopy overlay images of transfected mammalian cells at 10x objective magnification. Sender construct consists of Delta signaling protein fused with mCherry (red) fluorescent protein. Receiver Construct consists of engineered Notch receiver as well as eYFP reporter. Figure A (left) shows a negative control mixture of unstransfected CHO (Chinese Hamster Ovary) Cells and CHO's with receiver construct. There is some low background expression of eYFP reporter. Figure B (center) shows HEK2 93 cells with sender construct mixed with receiver CHO's. There is substantial Delta-mCherry expression from senders as well as eYFP from receivers. Figure C (right) shows a mixture of sending and receiving CHO's which again show high expression of both Delta-mCherry and eYFP reporter. This demonstrates our capability to introduce our signaling module into multiple cell types and achieve successful cell-to-cell signaling.

At the same time, Babb and Mishra have set the bar high with overall goals for the new team including formulating the problem earlier for a faster start, allowing for the option to build on the mammalian systems from 2011 (should the 2012 team choose to do so), raising more funding and linking research outcomes to future career paths for students, finding a more permanent lab space to allow for year-round work on iGEM-related projects and follow ups and (of course) bring home the grand prize, and the aluminum BioBrick (which looks like a giant lego) from the Seattle winners of the 2011 competition!

Although the MIT iGEM team is able to tap into expertise across the Institute—from chemical engineering, to biological engineering, biology, computer science, and electrical engineering—the actual project each year is designed by the students through a series of brainstorming sessions in the spring semester leading up to the competition. Generally, the core Weiss lab team recruits faculty advisors and graduate students to help in the lab across a diverse set of disciplines. The students also find that any lab on campus is willing to help them with a specific technique or provide access to specialized lab resources to help MIT's team succeed. For example, last year the team reached out to the Belcher lab to use an AFM microscope and to the King lab for help with a specific protocol they were having trouble with. This year, they received training from MIT's new NSF Center for Emergent Behaviors of Integrated Cellular Systems Center, EBICS, specifically in mammalian tissue culture, and from BE Professor Linda Griffith and members of her lab.

Mishra and Babb are enthusiastic about the advances from each iGEM event. Babb noted: "The variety of projects at iGEM is phenomenal. Unlike a research conference, where only successful (and often more conservative) approaches are discussed, student teams take great risks and propose extremely novel ideas in an attempt to win the competition should they succeed. Projects range across a number of tracks in the competition, including: Food/Energy, Foundational Advance, Health/Medicine, Environment, Manufacturing, Information Processing, Software Tools, and New Application for ideas that don't fit into any of the predefined tracks. The open-ended nature of the competition, with no predefined criteria for winning, is unique even among competitions. Many teams also pay careful attention to ethical and human practices considerations and outreach for the field. Last year we made a video on intellectual property and gene patent; this year we focused on education about synthetic biology at both the high school and undergraduate levels."

Many past iGEM projects in the Weiss lab have led to successful research, including: RNAi-based cancer therapy, bacterial-based microbial 'sense and destroy' antibiotic therapy, cell-based therapies involving programmed differentiation of stem cells to generate insulin producing pancreatic beta cells, genetic toggle switch in neurons, and pattern-detection for microbiorobots. From this year's work, the 2011 team is particularly interested in how small changes in the logic program internal to each cell can lead to radically different tissue patterning. They are also excited about new variants of cell-cell communication and the team's increasing ability to programmati-

Please note!
Although IAP 2012 is past, the MIT 2012 team has recently been selected and is now looking for graduate students and postdocs interested in joining us as instructors. Individuals interested in a unique and rewarding mentor experience should email Prof. Ron Weiss (rweiss@mit.edu).

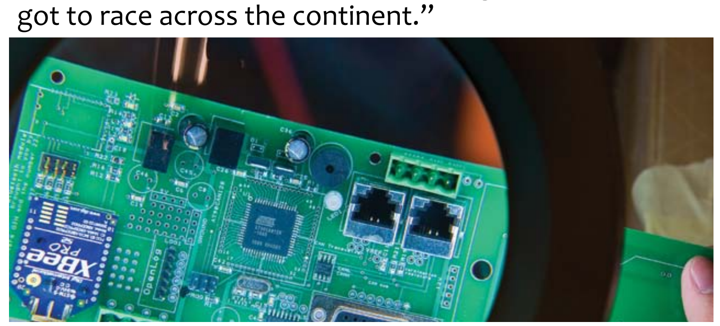
Solar Electric Vehicle Team 2011-12

The Solar Electric Vehicle Team (SEVT), an MIT student organization around since the early 1990s and working under the auspices of the Edgerton Center (and supported by the EECS Department) taps into many technical areas in both engineering and science. Team membership consequently represents a broad spectrum of MIT students providing intense educational and engineering experience. With a goal of promoting alternatively powered vehicles, SEVT members participate in seminars, lectures, museum displays, conferences dedicated to alternative energy, and numerous Earth Day and ecological fairs. And they also enter international solar electric vehicle competitions.

The latest international competition, the World Solar Challenge (WSC), held every two years, took place in mid October 2011, in a race of 36 teams (representing 21 different countries) over a 1,864 mile course in Australia, from Darwin south to Adelaide. EECS students Kelly Ran ('12) and Kai Cao ('11, MEng '12) were heavily involved in the preparations and execution of this and the 2009 challenges. They were assisted by several EECS graduate students Alexander Hayman ('08, MEng '10), Alex MeVay ('02, MEng '02), and Robert Pilawa ('05, MEng '07, PhD '12).

As SEVT member since 2008, member of the SEVT Electrical team for the WSC 2011 and just elected as the Electrical Lead in 2012, Kelly describes her recent experience: "I've helped to wire up Chopper del Sol, solder/encapsulate solar cells, assemble our battery pack, deal with WSC documents and deliverables, etc. Before and during the race, we've had to pack up the car and support cases (with tools, spare components, and anything else we'd need), prepare the car for racing (by testing systems, and in our case, doing a lot of last-minute fabrication), and fix anything that breaks during the race. We pulled a lot of late nights in Australia."

In fact, the team experienced a number of setbacks which were addressed with ingenuity and engineering finesse. Kai, a member of the SEVT team since 2009, relates the decisions process: "When I got to Darwin, the car didn't have a battery pack due to shipping errors. We needed a battery pack within 12 hours or we couldn't race. I had to make a very quick decision on choosing the alternatives... several teams offering us help with both hardware and software. We had to choose between several different spare battery packs and ended up choosing one that wasn't assembled—building a battery pack with our own battery management system overnight. Even though it took more time to build, we could use most of the existing hardware/software that we wrote ourselves, thus improving the reliability of the system. The battery pack ended up performing very well, and we got to race across the continent."



This is a close-up of a previous revision of the "main board" of the car. This PCB functions as the brain of the vehicle.

As a member of the MIT SEVT since her freshmen year, Kelly has had 'driving' experience (photo above) with both the Eleanor in WSC 2009 and the recent Chopper del Sol in WSC 2011. She explains that every team member who knows how to drive and can 'fit inside the car' will be a solar car driver." She adds: "This requires being able to take orders well, to drive for a few hours at a time inside an extremely cramped, hot, humid, stuffy space with limited visibility, to describe problems while driving and perhaps diagnose them, and to keep your cool when things break inside the car while driving."

At the 2011 WSC in Australia, each day of the race ran from 8 am to 5 pm including charging the solar car battery from the rising sun (at 5:30am) and preparing for the race. SEVT members monitored the Chopper del Sol with three vehicles. After seven days of racing, MIT's SEVT made it to the finish line, finishing 15th in the overall competition.

Kelly Ran and Kai Cao at the SEVT N51 shop

Although the team had to swallow the loss from the top tier of the WSC 2011, they continue to work toward upcoming goals, including the American Solar Challenge. This race, held every other year, will run in July 2012 from Rochester NY to St. Paul MN. In the meantime, members also take part in the business/outreach section of SEVT, allowing them to communicate with companies to solicit donations of batteries and other in-kind and cash contributions and to participate in outreach events such as the SEVT shop tour for K-12 students. And hope springs again for the Chopper del Sol to finish in a top spot in the upcoming July race.

That the SEVT experience is both challenging and demanding only increases its appeal to MIT students—undergrad and grad, male and female. Kelly shares: "My fellow team members have definitely influenced my life. These people are my good friends and have a lot of good life experiences and advice to share. It's very inspiring to see what kinds of cool things my teammates are up to, and they have certainly helped to form my perspective at MIT."

http://solar-cars.scripts.mit.edu

Maslab 2012

The full 2012 Maslab group including staff (in blue T's) and contestant teams

Maslab, the Mobile Autonomous Systems Laboratory started its eleventh year at the beginning of the Independent Activities Period, IAP, with a week of lectures followed by three more intense weeks of teams building and testing their unique robots. Well before IAP, Maslab staff members, who run the contest on a volunteer basis, start the preparations in the fall term with the help and guidance of EECS staff and faculty including Professors Leslie Kaelbling, Steve Leeb and Russ Tedrake.

As one of the more challenging robot competitions at MIT, Maslab is also one of the few robotics contests in the country to use a vision-based robotics problem. To complete the competition course, the robots must race to collect red balls and launch them over a yellow wall—without any human intervention. The goal for each team, other than winning an X box and a trophy, is balanced by Maslab's emphasis on creative robots, clever ideas and solid engineering. Maslab (6.186) participants also earn 6 units of P/F credit and 6 Engineering Design Points.

Maslab entrants form teams generally of 2-4 members and work mostly through the night hours using a kit of high quality components—made possible through Maslab's sponsors Oracle, Boeing, Two Sigma, Barracuda Networks and the EECS Department. Participating student teams attend three lectures that cover mechanical design, sensors, computer vision, control theory, and mapping. The Maslab staff equips the lab with a variety of building materials, sensors and tools to ensure that each team can put together a creative and functional robot that will be able to participate in the challenging competition. This popular event, attracting an enthusiastic and loyal crowd, marks the end of IAP and the beginning of the Spring Term!

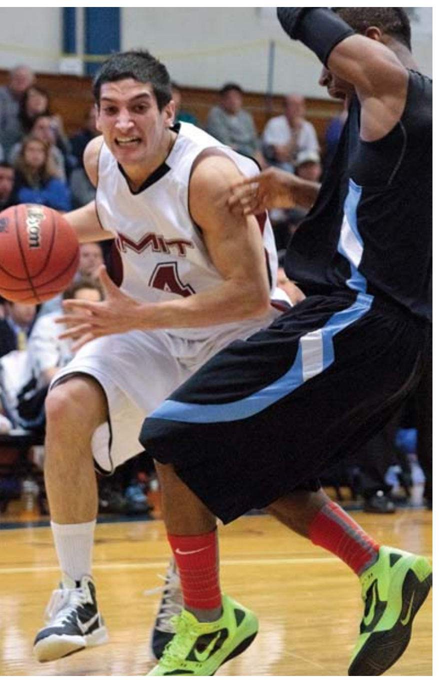
http://maslab.mit.edu/2012/site/maslab.php

On the Courts

EECS's Big Three in the Final Four

As this newsletter was about to go to print, MIT was making news headlines–for its NCAA standing. The MIT men's basketball team, the Engineers, was advancing to the NCAA Division III Final Four–a first in the 112-year history of the program! Three EECS undergraduates played a big role in this feat. Seniors Noel Hollingsworth and Jamie Karraker and Junior Mitchell Kates carried the team with some of the most noted plays.

See the MIT News Office website for more coverage.
http://web.mit.edu/newsoffice/



Pictured upper left, Mitchell Kates, right Jamie Karraker.

The MIT Engineers 2012: Center front row (above the 'NCAA' circle) from left to right are the 'EECS Big Three' Jamie Karraker, Mitchell Kates and Noel Hollingsworth. (Photos: Tom Gearty, c/o MIT News Office)

USAGE 2011-12

As part of the strategic and operational planning for the EECS Department set out by Dept. Head Chandrakasan this fall, 14 Task Force groups and one standing committee were formed. Although a few task forces included several students, the standing committee is made up entirely of undergraduate students and appropriately called USAGE — short for Undergraduate Student Advisory Group in EECS. The goal in forming USAGE is to understand the effectiveness (or not) of current programs through ongoing dialogue directly with the students. In forming this new resource in the department, Chandrakasan notes: "It is great to get feedback from our students on ideas for new initiatives before we actually implement them."

The group was selected after an open call was made to all undergraduate and MEng students asking for volunteers for various working task force groups including the undergraduate experience committee, the website committee, and others. A lot of students volunteered and all who expressed interest in helping to shape the department's future were included.

USAGE will be a standing committee in the years to come, as a year-long commitment of the student members. Students will attend a monthly meeting with the department heads and special guests will be invited. They will also be asked to help with special projects.

To date, USAGE students have already given valuable input in evaluating various proposed undergraduate initiatives — critical as decisions are made on which initiatives should be enacted. Chandrakasan, who attends each meeting with the students, notes, "They have influenced my thinking about undergraduate research, student poster sessions and core EECS courses."

EECS Staff: experienced & ready to help you

Anne Hunter

EECS Undergraduate Administrator

"I am just amazed I have had the privilege of working with so many top people in technology at what is the top university in technology in the world. This opportunity came to me without a set sort of 'Oh, I think I will grow up and be an educational administrator and work with the top students in that field in the world.' And, it's really important, I think, when you deal with the students to remember how smart and hardworking they all are. They are capable of doing amazing wonderful things and should be treated with respect and care -- they deserve it."

Anne Hunter surrounded by her EECS undergraduate tour guides, Spring 2012: seated from left: Dylan Sherry (6-2, '12), Kevin Fischer (6-1, '12), standing from left: Louis Lania (6-2, '14), Irena Huang (6-1, '11), Anne Hunter, and Elaina Chai (6-1, '12).

Anne Hunter got to know MIT as a Wellesley College student—taking MIT courses in the 70s—and then as a young administrator building her skills in what came naturally, using her great curiosity to get to know students, faculty and learn how MIT works.

Anne progressed in her career at MIT for a brief time in Aero/Astro, moving on to a position in Civil Engineering, where she handled the grad applications, sometimes talking with potential students. At 25 she got a job running the undergraduate programs in Course 21 in the Humanities Dept. She ran this for about four years working with fifty students at a time, getting to know them all while she developed ways of handling over 20 majors programs in HASS. She built supporting materials laying the groundwork for her famous checklists that all EECS undergrads use.

During that time Anne took some computer classes as her interest in computer science grew. It was a natural move for her when she transferred to the EECS Department, to work with the Executive Officer, Fred Hennie, and an opportunity to get to know EECS faculty members. When the job in the undergraduate office opened up in 1982, Anne was extremely pleased to take it.

Working as the sole administrator under Professor Leonard Gould in the office was 'absolutely crazy.' Yet, she says that it was wonderful that he assumed that she could do everything. "From the time I came into that job I was taking care of all of the majors," she says.

At that time the EECS Department was at its high water mark, with about 1200 undergraduates. She admits, "I thought it would take me months to know all these students in any kind of name-face way. Only after a couple of months did I realize this was not going to be possible. I had to figure out a different way to do my job rather than getting to know each of them. It all had to be done out of a serious database."

On the other hand, Anne recognized over twenty years ago that things were changing at MIT. More administrators were hired to develop a smoother interface for the students and the running of the programs so that faculty were freed up for teaching and research. She notes that "her role at its essence is not about record keeping or database management—that the heart of it is to be there caring about the students – to be a person in the department that students can go to and be heard."

As she built her listening and support skills for the large numbers of EECS students who came to her, Anne realized that she was not alone as an academic administrator in handling this increasing responsibility. Her suggestion that academic administrators meet for support and advice was implemented at MIT. She also participated in re-engineering in the mid 90s to re-engineer student services – including the Student Life and Learning Committee and the Student Services Center, and, through her membership on the mental health task force, work toward enhancing that service was implemented.

Another big change that Anne notes "has been MIT's ongoing commitment to women and minorities that started in the late 60s. I think there was a real commitment,

EECS Staff: experienced & ready to help you

Anne Hunter, continued

I'd say in the 70s or early 80s, to this being a place where women would be made to feel part of the community and made to feel comfortable and on an equal footing. It's been fun to watch that grow and increase."

In terms of administering newly evolving curricula in the undergraduate program, Anne found that the recent changes (in 2006) were not as significant as when the MEng and 6-2 programs were added in the 90s. She notes, "At the time it was the only hybrid undergrad-grad program. The structures at the Institute did not really accommodate that." She adds: "It took a couple of years to get the MEng program running smoothly. It was EXTREMELY popular. And I still have a meeting every semester to explain the transition from ug to grad status. Otherwise, I would have to do it individually for each of the 200+ students who are admitted each year."

Anne is very pleased with the fact that as a liaison with the MIT Admissions Office for Freshmen and Transfer admissions, the tours for prospective students (and families) which she organized ten years ago are even noted on the main Admissions website. She beams, saying, "We are considered a best practices department for this." She trains a cadre of five to six tour guides for tours at peak times of the year. In fact, the tours happen all year long. Anne meets first with the group, giving a quick overview. The student guide takes the group to see the 6.01 lab, the labs upstairs in bldg 38, and then on to the Stata Center. When she talks with prospective students, Anne is typically asked deadline, requirements and procedural questions. The complexity of the undergraduate program (and the flexibility of choice for EECS students) prevents her from boiling the curriculum down to a small pamphlet.

Over the course of the academic year, Anne keeps in touch with all EECS undergrads by email—sending out a 'Deadlines' email, for example, to answer the heavy flow of 'How can I graduate?' questions and substitution and deadlines questions. In fact, Anne notes that she spends up to four hours a day just answering email, which she finds far more satisfactory than the phone. She also notes: "I couldn't do this job without staff members Linda Sullivan and Vera Sayzew, who are absolutely great with students. There is no 'I 've got to do it all myself' in that sense, because they can catch a distressed student and deal." Anne also says that one of the great things about her job is the 'bosses' that she has learned from—the successive EECS Undergraduate Officers: Gould, Art Smith, Chris Terman and now Denny Freeman.

Despite the large numbers of students who flow in and out of her office, Anne enjoys the chance to get to know students individually—sometimes finding that she has to 'rescue' a student with misunderstandings about requirements. She also notes that the support she gets from the faculty has made her handling such difficult cases possible.

Anne is also gratified to watch students grow over their three or four year MIT experience. "They are having a myriad of varied experiences, a lot of relationships with each other and faculty and industry people that gives them a better sense of how life and the world works and their role in it." In fact, Anne notes that many years back, EECS students generally felt the Department was 'out to get them' – something that over the years has turned around. "Hal Abelson has a great line," she says, "…We [the faculty] want to be warm, compassionate, caring and hard as hell!" – to which she adds, "there is no reason we can't be that way—academically, and still be compassionate people who will do everything possible for each student—short of doing problem sets or taking quizzes."

Anne really works at establishing community among Course VI students. She notes, "Students know each other, but they tend to be clumped into social living groups. I always encourage them to build relationships within Course VI. But the sense of student community within the department could be stronger. I try to build it with the email 'Jobs List' so students talk to each other and I am always happy to see our students forming bonds with fellow Course VI'ers. It's good for them, for our faculty and staff and for the whole department."

As this newsletter was going to press, the MIT School of Engineering (SoE) announced that Anne Hunter is one of three administrators selected to receive the Ellen J. Mandigo Award at the upcoming SoE Infinite Mile Awards event on April 11. The Mandigo Award for outstanding service was established in 2009 and made possible by a bequest from Ellen Mandigo, a member of the MIT community from 1942 until her retirement in 1991. The award, also presented to EECS Administrative Officer Agnes Chow in 2010, is given to staff in recognition of intelligence, skill, hard work, and dedication to MIT over an extended period of time.

Lucille O'Hehir

"The first time that I worked in EE (now EECS) I was young and my whole outlook on work and life was completely different than it is now. My very best friend from junior high school worked in the department as well and we were always getting into all kinds of mischief. The department itself was much smaller. I can't believe how EECS has grown over the years. Everything was done on typewriters and multiple forms that got sent to just about everywhere — everything now is high tech."

On completing evening studies at Bay State Academy in 1969, Lucille had planned to work for TWA, based in New York City, but decided to stay in the Boston area, joining one of her sisters who worked at MIT at the time. Her other sister later worked part-time for EE. Lucille worked in accounting in the EE Headquarters – eventually transferring to Food Services where she worked in several positions through the 1970's and 80's and 90's.

Lucille left MIT briefly in 1972 and upon returning worked for a while in EPSEL which is now LEES/RLE and transferred back to Food Service. She returned to EECS in 1999, where she has worked in the headquarters since then as an administrative assistant. Currently she works closely with EECS Administrative Officer, Agnes Chow. Her primary responsibility is processing 450 to 500 Research Assistant appointments three times a year. She also maintains and updates the database for student and support staff, maintains the informational listings for the department, edits the on-line directory information for staff and employees, processes the support staff payroll, reviews and reconciles the monthly DACCA's for the support staff and research assistants, coordinates all parking needs of faculty and staff, acts as liaison with the temporary help agencies, and she good-naturedly calls herself the 'EECS kitchen maid' for her attention to the headquarters kitchen.

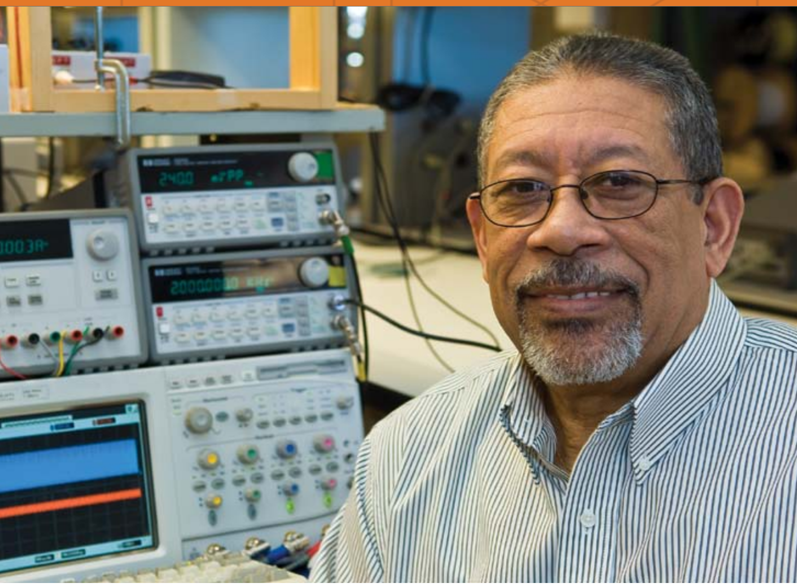
Self-admittedly obsessive about her work, Lucille is the one who puts those around her at ease with her ready humor and insightful conversations with all who stop to talk with her. She enjoys her job very much, saying she tries to do the very best she can. The recognition and awards Lucille has received over the years attest to her skill and dedication. She received the LIDS 'Spot Award' in 2001, the Infinite Mile Award in 2004 and the Caloggero Award in 2007. Lucille says about these awards, "[they] were very humbling for me, but getting recognition for the work you do is a really great feeling."

In EECS headquarters, Lucille puts her energy toward getting to know each person – an effort that pays off all around. She says: "Some faculty and staff I know just by name mostly from email correspondence. We have a very diverse group of faculty and staff and I believe you have to try (if you can) to get to know each person and seek out their personality traits."

Having been at the Institute for many years Lucille feels fortunate to have interacted with so many wonderful and interesting people. While she worked in Food Services where she was Catering Manager and eventually Project Manager, she remembers several events including working with Martha Stewart on several formal presentations (in Martha's early days), catering a meal for then Vice President George H. W. Bush, and learning where Swaziland was as she assisted for an event for the King of Swaziland.

She also recalls meeting and getting to know Doc Edgerton. "At that time EE Headquarters was in building 4," Lucille recalls, "and if you ran into Doc in the hallway he always had something to show you in his lab or he would hand you one of his postcards. He was a wonderful and very personable man."

Lucille's attitude sums up her success and value: "You have to have a good sense of humor if you work in headquarters – from our Department Head Anantha Chandrakasan and down the chain, the camaraderie that we have in the office is what makes it an enjoyable place to work."



Lourenço R. Pires

Technical Instructor, MIT EECS

Lourenço R. Pires has been at MIT since 1982 and is very proud of his work as Technical Instructor in the Electrical Engineering and Computer Science Department 'fifth floor labs' in building 38. Besides the longevity of his position, what is notable is his enjoyment for the work he performs – particularly as a master designer of laboratory demos – for a multitude of students in many EECS classes.

Lourenço, the oldest of ten children, learned how to both manage groups of younger ones and to take on responsibilities, particularly after his father died in 1972. Lourenço earned an Associate Degree in telecommunication from Northeastern in 1978, and a Bachelor Degree in electrical engineering cum laude from Wentworth Institute of Technology in 1987. He worked as a test technician in noise reduction at DBX, Inc., for several years, and when DBX was relocated to California in 1978, Lourenço became a Test Engineer for Teradyne for two and a half years. In 1982, when the MIT Plasma Fusion Center opened, Lourenço was interviewed by then PFC head, Richard Post, and was hired on the spot—marking the start of his long and fruitful association with MIT. Lourenço had previously gained a ham radio license so one of his projects at the PFC involved putting together a high-powered transmitter.

When an opening for Project Technician became available in EECS in 1989, Lourenço successfully interviewed with Charles Patten and Don Troxel. Recalling this opening and his interview, Lourenço notes to this day, "It is a great privilege to work here."

Lourenço knew the Unix system and was immediately helpful in the labs where, he remembers, "computers broke down all the time." As the EECS Department grew and the curriculum evolved, he was happy to work on many classes that required his expertise to both fix all associated equipment and work with EECS faculty in setting up demos for the classes.

Lourenço has worked with and enjoyed this opportunity to learn from and know many EECS faculty members. He worked with Hal Abelson and Gerry Sussman for 6.003, with Alan Grodzinsky on 6.013 and with Herman Haus and Mark Zahn also for 6.013, with Paul Gray and Campbell Searle for 6.002 (from 1995-1998) in which bipolar transistors were used, and with Jim Roberge whose teaching was also based on similar transistors, until the conversion in 1998 to MOSFET. Lourenço worked with Dr. Bruce Wedlock who educated him on everything for 6.071, Intro to Electronics, a class which is no longer taught. Filled with memories of his work under each faculty member, Lourenço also notes that he learned so much from Prof. Zahn, as well as Profs. Jeff Lang, Paul Gray, Lou Braida, David Perreault and Anant Agarwal, who he says besides being brilliant was very funny. They—Agarwal and Lourenço—had worked on 6.002 which required a lot of input from and technical set up by Lourenço. He has also loved working with Prof. Jesús del Alamo, whose teaching he describes as very clear and memorable.

Lourenço's favorite part of his job are the live demos—not just preparing them after working with the particular faculty member who has requested it—but in *performing* the demo. It is an art that gives him the chance (and challenge) of carrying off the demo so that students are sparked to ask questions and interact. He especially enjoys the way new students are really taken with the demos, often asking him a lot of questions. It is also very satisfying, he notes, that students come to him for help because he is there in the fifth floor lab most of the time.

"One of my big times for demos was the MIT 150th," Lourenço recalls. For the MIT 150th Open House, Lourenço wowed the crowds, young and old, with three demos—including the inverted pendulum, the levitating ball and the levitating pancake. He explains that the pancake is really a fried egg that is cooked in a pan on top of a very large levitation coil that creates enough heat to fry it.

Lourenço says with pride that his demos have been recorded for OCW and as a result, he is invited to give demos all over the world.

Cynthia Skier

Director of the Women's Technology Program (WTP) and the Industrial Connection Program (ICP)

—Bringing out the inner engineer in bright high school girls

"My association with MIT began as an MIT Freshman in 1970. I was convinced I was going to major in Chemistry because my best teacher in high school taught chemistry and I was always good in math and science."

Cynthia Skier is far from Chemistry at this stage in her life, but she continues to enjoy her professional career at MIT pursuing her ever fresh interest and love for both math and science mixed with her passion for enabling students to find their 'inner engineer'.

On graduating from MIT with a degree in Humanities and Science, Cynthia pulled in a wide array of experiences including working as an admin in a summer program that was designed to help high school teachers gain a better understanding of industry. Her involvement in Project WITS (Work in Technology and Science) was already a good indication of her interest and attraction to outreach. Her passion for enabling students – in this case through their teachers – to benefit from greater exposure to career opportunities was sparked. A position in management consulting at Bain & Company also built her exposure to career choices, in this case her own.

In 1980, Cynthia came back to MIT and earned a Master of Science in Management Science degree at the Sloan School in a one-year accelerated program that predates the current MBA program. Though replanting herself in management might have been an obvious choice, she decided instead to join her husband Ken Skier ('74) in a startup in 1982—a new software company (SkiSoft) that began as a software licensing company and eventually included packaged software that was sold in stores. They opted to stay a two-person company, and managed the business for 20 years while raising their two children. Cynthia stayed connected to MIT as an Alumni Association volunteer and through AMITA, founded by Elizabeth Swallow Richards as an alternative association for women alumnae. Cynthia was AMITA president from 1996-98 and was active in a high school visiting program where alumnae from MIT visited high schools to spread the word about careers in engineering and science.

By 2002, Cynthia was eager to be a full-time part of MIT once again. She applied for a position in EECS as director of the Industrial Connection Program (ICP) and coordinator of EECS alumni relations. She was delighted to also learn from then Dept. Head John Guttag and Administrative Officer Elizabeth Cooper that the department had just run a pilot session for the Women's Technology Program and needed a director since its founder, an EECS graduate student, was leaving. Cynthia was asked to additionally be the WTP director as part of her EECS position.

This summer will mark Cynthia's tenth year as Director of the Women's Technology Program, which will be in its eleventh summer. She is particularly excited to look back at the growing base of WTP graduates (now totaling 386 in the EECS side of the program) who have maintained ties with her as they start college or move into careers traceable to their first exposure to engineering and computer science and the tremendous opportunities that are available.

She notes, "The mission of the WTP is to point high school girls who are already very talented in math and science towards engineering and computer science. What I really like is that I get to influence students who are in their last year of high school and about to embark on their college careers. WTP exposes them to some of the possible directions and helps them broaden their ideas of what they might do." The program, which expanded in 2006 to include an additional 20-student curriculum track in Mechanical Engineering supervised by Dr. Barbara Hughey, has become a comprehensive and

Cynthia Skier, continued

well organized process – including well tested curricula, a cadre of events to support the month long residential experience and a network of instructors drawn from female students in the EECS Department and elsewhere at MIT.

Over her ten years as director, Cynthia has nurtured WTP-EECS for not just the fortunate forty high school juniors who are accepted each year—but for current MIT women students who teach math, computer science, or electrical engineering and also live in the dorm with the high school students. "By interacting with the MIT women," Cynthia notes, "the WTP high school girls have a chance to explore, and to understand why these women come to MIT, in what they are majoring, and what kinds of UROPs they did. So they get a real sense of what someone who is just a couple of years older is doing—they can try it on for size."

The MIT grad students who teach the WTP classes have the opportunity to design the curriculum—not just work as someone else's TA. With three undergrads working with them, these instructors become the ones who supervise their TAs and make decisions. The real challenge is to cover the amount of material in the short three weeks available. In the fourth week Prof. Steven Leeb teaches a Motor Building Challenge and competition in the Pappalardo Lab, where teams of two WTP students design and build DC motors. A popular addition to the WTP-EECS curriculum is a tour of the Fab Lab sponsored by the Microsystems Technology Lab (MTL). "They love it," Cynthia beams. "They put on 'bunny suits' and get to see how the lab works and watch wafers appear, ultimately receiving a wafer on which their group photo is imprinted."

Cynthia notes about the WTP experience, "Although the WTP students excel at academic achievement, they have typically not had much opportunity to work in teams or to experiment with creative problem-solving. WTP helps them build confidence by diagnosing and analyzing problems on their own. They also learn to collaborate, which is the way engineers work."

Beyond the tangible visits and correspondence Cynthia receives from former WTP students and parents, and MIT women who worked for the program, the metrics prove how valuable WTP is. "I track where people go to college. First year there were 27 high school students. In the next year—my first in 2003, we grew it to 40 and in 2006 we added MechE with another 20 girls each year. At this point over 40% have come to MIT, and more than 60% at all colleges go into engineering or computer science (another 22% are in science or math)."

Cynthia is always seeking ways to keep WTP viable. The tuition fees paid by students cover less than half the costs of running the entire program and scholarships are offered to needy students. WTP is primarily supported by the EECS Department and the School of Engineering, but much of its budget comes from outside corporate and individual sponsors. Cynthia notes that gifts of all sizes are welcome to maintain and build the program (http://wtp.mit.edu).

As director of the Industrial Connection Program (ICP) Cynthia holds Tech talks during Fall and Spring terms for individual companies and also runs a small career fair just for company members. ICP started at the end of '99-2000 by then associate EECS department head L. Rafael Reif. Over 300 EECS students come for the 2-3 hour fair. "No matter what industry," Cynthia notes, "Course VI students are in high demand. The students benefit from these events because they learn about the companies and job opportunities."

ICP benefits are tailored to the individual needs of the company. Cynthia works with the company reps by phone and email—in addition to career fairs, and tech talks, to help them navigate MIT and target their recruiting messages to the EECS students. She notes that ICP company membership has fluctuated from 22 to 10 with the optimal just under 20 to give value to each participating company. Course VI is a bit unusual due to the five year MEng program, Cynthia notes. "When companies are looking at seniors in other schools, they are immediately available for full-time employment, but Course VI MEng students as seniors still have one more year and are looking for internships instead of full time jobs."

Over the years Cynthia has been recognized for her contributions to EECS including the MIT School of Engineering Infinite Mile Award for Excellence in 2004 and the Departmental Special Recognition Award For Outstanding Service to EECS in 2007. She is also appreciative of the chance to enjoy things now that she did when she was an MIT student—without having to do the problem sets! "I love being here at MIT –there are always new things to learn and amazing people to work with."

Pawan Deshpande

MIT '06, MEng '07

"Someone who understands technology can educate marketers on how to best leverage that technology."
—Pawan Deshpande, founder and CEO of HiveFire, Inc.

Since he was in the fourth grade, Pawan Deshpande has been fascinated with computing, programming and online content. (He used to amuse himself programming with QBASIC). "One of my favorite xkcd comics that really speaks to me," Pawan notes, "is entitled 11th grade (http://xkcd.com/519/) which implies that one weekend messing with Perl is more valuable to your career than 400 hours of homework and 900 hours of classes." In high school he says academics were interesting, but his out of school programming on his own time became the real motivator. The prospect of studying computer science full-time at MIT—rather than as an alternative to homework after school—always excited him. At MIT, Pawan Deshpande completed his SB in computer science in 2006 and the MEng (Course 6P) in 2007.

Pawan says there are three types of EECS experiences that have left a lasting impression on him: classes, internships, and the M.Eng. program.

"Among many classes that I enjoyed, four of my most memorable ones during my undergraduate were 6.004, 6.170, 6.033, and 6.050J. Computation Structures (6.004) enabled me to appreciate how MOSFET's can be built up to a functioning computer. Software Engineering lab (6.170) introduced me to the discipline and rigor of software engineering in teams rather than simply programming as a individual contributor. Computer Systems Engineering (6.033) revealed to me the complexities of engineering a 'system' which differs greatly from theory of computer science. Lastly, Information and Entropy (6.050J) shaped how I think of the world -- as everything being information -- which has had an indirect impact on my graduate work in natural language processing and even the work at my company today."

As an undergraduate, Pawan participated in four internships -- at Kubi Software, IMLogic, Microsoft, and Google. He especially enjoyed his time at IMLogic (through the IAP Externship Program), where he and a fellow MIT student built a product to monitor and block peer-to-peer file sharing traffic from scratch in a period of three weeks. Their product was subsequently used by over 2,000 companies. At Microsoft (through UPOP) and Google, Pawan was able to experience the engineering culture at larger companies with very talented engineering teams. At Google, he was exposed to natural language processing while working on machine transliteration—an experience that influenced him to deepen his research in this area when he entered the MEng progam.

The pinnacle of Pawan's studies came as he worked under Prof. Regina Barzilay in the MEng program, which he describes as "perhaps the most enjoyable, influential and intense experience at MIT." Unlike problem sets, or short-lived internships, for the first time, Pawan was able to deeply immerse himself in a single research problem for months at a time in collaboration with his labmates. His work culminated in the MEng thesis, "Decoding Algorithms for Complex Natural Language Tasks", which won the 2007 Dimitris N. Chorafas Foundation Prize and 2007 Charles and Jennifer Johnson Award for Outstanding Master of Engineering Thesis in Computer Science.

Directly after finishing his MEng in 2007, Pawan decided to start his own company, HiveFire, with his freshman year roommate Kevin Chevalier (also an EECS graduate, 6-3 '06, MEng '07). Their product, Curata, allows marketers to quickly find, organize and share content on specific issues or topics in order to establish thought leadership, own industry conversations, and drive qualified web traf-

Pawan Deshpande, continued

fic. Much of the inspiration for this product was based on Pawan's MEng work—and the desire to make similar technology easily accessible to a non-technical user base (ie., marketers).

The name Curata was derived from curation, which is for what their product is used. "In true EECS style," Pawan notes, "the name HiveFire was pseudo-randomly generated by a python script."

When asked what are the less obvious things he learned from his EECS experience, Pawan says: "There are two courses in particular that have been useful, and, impacted my post-MIT life at a start-up in ways I did not expect at the time. User Interface Design (6.831) demonstrated the value of usability in software, which is often overlooked by engineers as just shrink-wrap. Also, I remember ridiculing 6.UAT with friends because it was not a technical class, but it has been immensely valuable looking back given that there are more days that I now spend in a word processor, making slides or speaking at a conference than I do in code.

Outside of coursework, my MEng experience under Prof. Regina Barzilay has impacted me in many ways that I did not expect. Analytically thinking through a deeply technical problem, distilling down a complex set of concepts into a paper, and presenting and justifying my research in conferences have all continued to influence my problem solving sensibilities for technical and business issues alike."

Although Pawan acknowledges the benefits of his father's guidance—Desh Deshpande is co-founder of Sycamore Networks, creator and enabler of MIT's Deshpande Center for Technological Innovation and an influential technology entrepreneur and visionary—Pawan also credits several MIT experiences. He got work in a startup during IAP through the Alumni Association Externship program. And, he gained a better understanding of the economics of entrepreneurship through "The Business of Software" (15.358). "Even more significant, was the chance to interact with students and recent alumni with entrepreneurial ambitions on a daily basis," he notes. "At some point, I realized that if they can start a company, then I probably can too."

Although he did not create the term 'content curation,' Pawan has been on the cutting edge of online marketing practices, particularly business to business (b2b), as he builds Curata and HiveFire. He notes, "Based on my work from my MEng in the field of Natural Language Processing, I have always been interested in content and what can be done with it. Online content is particularly of interest because there continues to be more and more content online every day with no end in sight."

"When I started HiveFire, I was not aware of the term 'content curation' but it perfectly describes what our product Curata does. Content curation is the process where someone finds, organizes and shares content on a specific topic or issue online. Curata helps curators by automating parts of this process. The beauty of applying algorithms and artificial intelligence to help a content curator is that the algorithms do not have to be right all the time. Instead, the algorithms can make a best guess and a curator can take it from there.

"Traditionally the role of marketing has been to better position a company or their product or service to potential customers. Marketing has been traditionally tasked with selling themselves. These days effective marketers proactively engage through content. Marketers now produce 'engaging' and interesting content such as blogs, videos, podcasts, eBooks, interactive games that attracts potential customers to their brands rather than force-feeding them with advertising. The challenge though is that many marketers are not well suited to play the role of a full-time content publisher. Content curation enables such marketers to easily produce timely, relevant and engaging content on a specific topic by curating third party content."

Pawan explains that Curata, launched in 2010, is the only product currently offered by HiveFire, but notes that the process of finding, organizing and sharing content is not exclusive to marketers. He suggests, for example, the case of library and information services professionals also requiring similar technology. "To that end," Pawan says, "I envision HiveFire building our current area of expertise to address similar challenges faced in other markets."

http://www.contentcurationmarketing.com/

Ted Tewksbury

MIT '83, SM '87 and PhD '92

Dr. Ted Tewksbury is President and CEO of Integrated Device Technology (www.IDT.com), the world leader in silicon timing solutions. He earned his BS in Architecture in 1983 and his SM and PhD degrees in electrical engineering from MIT in 1987 and 1992, respectively. After starting his career as a design engineer at Analog Devices, Tewksbury held positions as Sr. Engineering Manager at IBM Microelectronics, Managing Director at Maxim Integrated Products and President and Chief Operating Officer of AMI Semiconductor. Today, as CEO, Dr. Tewksbury is leading a dramatic turnaround of the 31-year old IDT from a digital component vendor to a leading provider of analog-intensive mixed-signal solutions for cloud computing, 4G communications infrastructure and mobility. Dr. Tewksbury serves as a Director on the Boards of Integrated Device Technology (IDTI), Entropic Communications (ENTR) and the Global Semiconductor Alliance (GSA).

Some people take a straight road to their destination. Mine was a nonlinear journey of exploration.

Growing up, I was driven by two competing passions. One side of me was creative and loved designing and building things. The other side was analytical and loved math and physics. I dreamed of going to MIT because it was the best technical university in the world.

I started at MIT as a physics major but found that it didn't provide an adequate outlet for my creative side. Half way through my sophomore year, I took a year off to "find myself", driving a cab in Boston to earn money for school. I returned to MIT in the architecture department, which I loved because it reconciled my creative and engineering passions. After completing my BS, I was admitted to the MArch program on scholarship, but the hard sciences continued to beckon, and I indulged my curiosity by taking classes in physics, electrical engineering, biology, law, economics, business and other subjects. It was the ultimate 'renaissance' education.

One day, I wandered into an analog circuit design course (6.301) being taught by the incomparable Jim Roberge. It changed my life. Analog circuit design was the ultimate combination of physics and creative design. I switched my career direction and took the entire EECS undergrad curriculum in the next two years.

The second defining moment occurred when I met Professor Harry Lee in EECS. Harry took a chance on a wayward architecture student and made me an RA in the Microsystems Technology Labs (MTL). This led to my admission to the department of EECS, followed by an MSEE and PhD specializing in solid-state physics and analog circuit design.

In addition to providing a deep technical foundation, EECS influenced my career in myriad ways. Harry inspired a lifelong interest in data converters; the breadth of disciplines to which I was exposed, spanning device physics, circuit design, software and systems, enabled my cross-functional career mobility; the open and free flow of ideas within MTL served as a model for the collaborative corporate cultures I would later build.

With my PhD from MIT in hand, I went to work for Analog Devices as a design engineer, where I learned how to parlay academic knowledge into manufacturable products. Early on, I realized the power of enlightened management -- by creating the conditions under which other engineers could excel, I could amplify the entire organization's creativity and productivity. I also learned the

Ted Tewksbury, continued

power of leading change. As manager of ADI's joint development program with IBM in the '90's, I became a vocal proponent of SiGe BiCMOS. This got me noticed by Dr. Bernie Meyerson, IBM Fellow and inventor of the technology, who later hired me as Manager of IBM's SiGe products group.

At IBM Microelectronics, I learned how to manage engineering on a large scale -- building and leading the team that developed the industry's first commercial SiGe RF components and data converters. This attracted the attention of Jack Gifford, the founder and former CEO of Maxim, who recruited me as Managing Director, my first opportunity running businesses as well as engineering. I founded Maxim's high-speed data converter and high-performance RF business units and eventually ran eleven business units, introducing well over a hundred new products in six years. From Jack, I learned the art of product definition and disciplined metrics-driven financial and operational execution.

By this time, I had developed a reputation in the industry as a serial 'intrapreneur,' building high-performance teams and new businesses within established companies. When the Board of AMI Semiconductor needed a President and Chief Operating Officer to revitalize the company, I jumped at the chance to expand my skills by running manufacturing and operations. After a successful turnaround and sale of AMI, I was recruited to Integrated Device Technology for my first CEO position.

I never set out to be a CEO. I just wanted to be a great engineer and create innovative products. Along the way, I discovered that I could do this more effectively through increasing management roles. At every stage of my career, my singular goal was to be the best in the world at whatever I was doing, but I seized opportunities to stretch my skills in new directions, including management, finance, sales, manufacturing, operations, investor relations, mergers and acquisitions. They don't teach all of these in school, but MIT teaches you how to think and learn effectively in new situations. Completing a PhD is invaluable because it instills the confidence to delve into the unknown, learn what's important, solve new problems and deliver results. My career progressed rapidly because I earned a reputation for execution, I surrounded myself with the best people, I worked for strong mentors and I developed an extensive industry network.

In retrospect, my multidisciplinary journey through MIT prepared me well to be a CEO. The ability to make connections between seemingly unrelated fields and ideas is the key to innovation. As Steve Jobs frequently said "creativity is connecting things" — or as my MIT architecture professor, Maurice Smith, used to put it, we need to 'think associatively.'

Today's technology and business leaders must be technical, multidisciplinary and adaptable. MIT is only the beginning but, whether you take the direct route or the circuitous path as I did, it provides the tools to go the distance.

Todd Coleman

MIT SM '02, PhD '05

As a professor in bioengineering at UCSD, my research is multi-disciplinary at its core. I attribute the ability to make connections between biology and engineering to my training in Course VI at MIT under the guidance of Prof. Muriel Médard, as well as my postdoctoral training in neuroscience at MIT under the guidance of Prof. Emery Brown. Many of the topics I learned or TA'd while at MIT, and I think that the fundamental perspective that an MIT Course VI training exemplifies enables a researcher to comfortably move from one societally relevant research topic to another.

My research group, the Neural Interaction Laboratory at UCSD, is developing multi-functional, flexible bioelectronics that can be applied with a temporary tattoo, sense the body's physiological signals, and wirelessly transmit them. The applications of this capability range from transforming the delivery of medicine to sports performance monitoring to immersive gaming experiences. What I find fascinating about this area is its transdisciplinary nature, where the design of one device must incorporate knowledge from electro-neurophysiology, medical instrumentation, mechanics, statistical signal processing, circuits, antenna design, and communications theory.

Many of these subjects I learned while at MIT. I was strongly influenced to evolve my research in this arena because of my experiences with MIT friends doing combined MD/PhDs or PhDs in fields that had a strong biomedical component. MIT's close connection to hospitals in Boston, along with MIT's strong traditional emphasis on understanding fundamentals, creates a 'unique petri dish' to create inter-disciplinary scientists.

Another research endeavor of my group involves developing a quantitative approach to understand or control, the interaction between biotic and abiotic systems. A couple of examples of this that we are pursuing include:

- Understanding the dynamical relationship between many recorded neural processes in a brain: By treating a single brain as a stochastic system of interacting parts, and observing many neural signals simultaneously, we attempt to understand these dynamics and how they vary with brain function. Along with neuroscience, ideas from control theory, feedback information theory, and machine learning – all of which I learned in course VI – integrate holistically to paint this picture.

  One consequence of our insights – and our systems engineering approach – is the demonstration of a robust wave-like phenomenon taking place in the spiking of neurons in the motor cortex that underlies the basis of motor coordination. This could have implications in treating humans with movement disorders.

- Engineering efficient brain-machine interfaces: Here, we construct brain-machine interfaces, which are systems that elicit direct communication pathways between a brain and an external device, and engineer them to be as efficient as possible. Due to my training in Course VI both in systems engineering, control theory, and statistics, I was able to identify a key issue that was not being resolved in the neuroscience community – the appropriate use of feedback in such systems.

  By formulating such systems within the context of Course VI concepts, our research group has been able to engineer applications that not only allow someone to spell text with thought, but also to precisely specify a smooth path in two dimensions (an extension of which, in collaboration with aerospace engineers, involved remote neural tele-operation of an aircraft).

Todd Coleman

  Future applications of this paradigm include accelerating the search, gaming, and visualization process by using neural signals along with behavior.

The punchline from this is that my training in course VI was invaluable for me to embark on these exciting research applications. I am truly indebted to MIT and especially my PhD advisor Muriel Médard and postdoctoral advisor Emery Brown.

Not only were they instrumental in instilling in me the MIT virtues of 'how to think' — but also their strong encouragement to learn as much as I can – about as many different areas as possible — because I never know when these topics will help me in the future. Studying under each of them – both of whom are 'class-act' upstanding individuals – strongly influenced my decision to pursue a career in academia.

EECS Alumni are making an impact in academia

Wendi Heinzelman

MIT SM '97, PhD '00

Wendi Heinzelman, Dean of Graduate Studies for Arts, Sciences and Engineering, at the University of Rochester in NY, began her career as an Assistant Professor in the Electrical and Computer Engineering Department (with a secondary appointment in the Computer Science Department) at the University of Rochester in Spring 2001 because she wanted to have impact. "I went into an academic research career in order to have impact—through my research, through my teaching, and through my mentoring of graduate students."

Wendi describes herself as 'a legacy at MIT' as both her father and uncle went to MIT in the '60s, often speaking fondly of their time at the 'Tute. She was particularly attracted by the fact that her research interests – electrical engineering and computer science – were both under one umbrella at MIT, and by MIT's reputation as a world-class research institute. When she visited during her senior year in college, her mind was made up on meeting her soon-to-be advisor Prof. Anantha Chandrakasan, and, in her words, "finding EECS to be a vibrant, exciting place to learn and do research."

Beginning at MIT meant transitions: new school, new research focus, new friends, new city, Wendi relates. She credits her immediate fit with the guidance she received from her "amazing advisor" who taught her how to do interesting, relevant, cutting-edge research—in addition to building lasting friendships that are still vibrant 15 years hence.

Wendi began her master's thesis focusing on image processing, developing approaches for more efficient video coding transmission over wireless channels. At that time, she notes, Anantha had started a project called µAMPS, which focused on the design of a new type of wireless device called a sensor node. These devices, which were novel for their ultra low power operation while providing sensing, processing and communication capabilities, were starting to create a splash in the research community, as they could be autonomously networked together to provide large amounts of data about the environment.

She remembers Anantha telling her about this exciting new area that held potential for novel solutions to many open research questions, and how this would be a great area for her to do her PhD thesis research. "At the same time," she recalls, "Anantha cautioned me that it was a little futuristic, and, while a great opportunity if I wanted to go into academia, might not be the best research topic if I was seeking a career in industry." As it turned out, she was already very interested in an academic career, so she jumped at this opportunity—launching her career and research into protocols, algorithms, architectures and systems for wireless sensor networks.

Another defining moment in her graduate career came when a new faculty member, Dr. Hari Balakrishnan, was hired in EECS. "I took Hari's class on networking," Wendi says, "and, in addition to being a really interesting and highly practical class, this class greatly benefitted my research. Hari became a co-advisor on my thesis, providing me the unique opportunity to have someone with a systems and hardware perspective (Anantha) as well as someone with a networking perspective (Hari) to help guide me in my research and shape my career goals."

Receiving her Master's degree in 1997 and PhD in 2000, Wendi notes, "MIT enabled me to grow in many ways and meet many brilliant people." She has since reconnected with many of her MIT colleagues at conferences, at NSF review panels, and even via social networking sites—valuable professionally and personally. Wendi also notes that EECS afforded her many unique and valuable opportunities. "Taking or TA'ing courses from those whose work was seminal to the field, such as when I TA'd DSP for Al Oppenheim and Greg Wornell or when I took a course on digital communications with Dave Forney, showed me that good teaching and good research really do go hand in hand."

Wendi says that although she hadn't planned on entering academic administration, when the opportunity arose to take on the position of Dean of Graduate Studies in Arts, Sciences and Engineering (AS&E) at the University of Rochester, she thought about how she could put her skills towards helping not just her own graduate students but all those in AS&E to achieve their academic goals and launch their careers. As Dean for 3.5 years now, she notes how rewarding it has been for her to work with Master's and PhD students in disciplines across the humanities, social sciences, natural sciences and engineering. She notes: "My training in EECS at MIT prepared me well for setting policies and developing programs that aim to support the excellence of our graduate students, for working with a diverse group of people to achieve goals, and for providing a balanced view of situations." Her participation in the Women in EECS group at MIT as well as her work with her advisors showed her the importance of strong mentoring toward success in graduate school and in starting a career. "These are lessons I use to this day as I create and execute a range of professional development opportunities for our graduate students, on everything from how to succeed in academia to how to be a mentor and how to be mentored to seeing and making the most of opportunities in diversity."

In all, Wendi expresses her gratitude to MIT, and to EECS in particular, for the multiple opportunities made available — her exposure to world-class teaching and research and to the mentorship from "two of the best advisors anyone could ask for in Anantha Chandrakasan and Hari Balakrishnan." She continues to use the ideas she learned at MIT when teaching her own classes on DSP, Wireless Communication and Wireless Sensor Networks, when she advises her own undergraduate, Master's and PhD students, and when she does research on communications, networking, and computing. "I hope I can have even a fraction of the impact on my students that all of the folks I interacted with in EECS at MIT had on me!"

Sachin Katti

MIT PhD '09

Sachin Katti is currently an Assistant Professor of Electrical Engineering and Computer Science at Stanford University. He received his PhD in EECS from MIT in 2009. His research focuses on designing and building next generation high capacity wireless networks using techniques from information and coding theory. His dissertation won the 2008 ACM Doctoral Dissertation Award - Honorable Mention, the George Sprowls Award for Best Doctoral Dissertation in EECS at MIT. His work on network coding was also awarded an MIT Deshpande Center Innovation Grant, and won the 2009 William Bennett Prize for Best Paper in IEEE/ACM Transactions on Networking. He has also won the Best Demonstration Award at Mobicom 2010, Best Paper Award in ACM Homenets 2011, as well as Hoover, Packard and Terman Faculty Fellowships.

I arrived at MIT in 2003, fresh off a boat as one would say, from India. I had just finished my undergrad in EE at IIT Bombay, an extremely selective institution itself. But MIT blew me away with its intensity; the energy level of the place and the enthusiasm of the people there to engage

EECS Alumni are making an impact in academia

Sachin Katti, continued

intellectually were amazing. The first few months of fall 2003 were perhaps the most intellectually intimidating—as well as rewarding time I have ever experienced. (Imagine taking an algorithms class from an MIT Professor, Erik Demaine, who is younger than you!) The environment naturally encouraged you to explore research areas and to push yourself. It wasn't an easygoing atmosphere; you were constantly challenged to defend your ideas. Moreover, I was part of the Systems group in CSAIL, a research group with impressive lineage dating back to the time when the original DARPA networks and TCP/IP protocols that presage the Internet were invented. People, and especially my advisor Dina Katabi, forced together hitherto disconnected disciplines to solve the challenging problems networks face.

The years I spent at MIT have fundamentally shaped my research taste—to 'look for connections.' My thesis research built an interdisciplinary approach to engineer modern wireless networks, by leveraging approaches in information theory such as network coding and applying it to design wireless mesh networks. These two areas were quite separate historically, having been shaped by an unwritten contract born decades ago. Electrical engineers were expected to deal with messy analog signals, process them and deliver bits to the higher layers, where computer scientists could take the bits and figure out how to network them. The contract had worked quite well for a long time, and had facilitated the explosive growth of the Internet infrastructure. However, it was a poor fit for wireless networks. Shoehorning wired abstractions onto wireless networks had resulted in severe performance problems. My research questioned these long-held assumptions, and showed how an interdisciplinary approach that combines ideas from communication theory, coding theory and networking, can provide dramatic improvements in network performance.

I started down this research path itself quite serendipitously, and the story speaks to the amazing nature of research connections you can make at MIT from random conversations. My advisor (Dina Katabi) and I were attending a talk one day by Prof. Ralf Koetter who was visiting LIDS from UIUC. The talk was on network coding, a topic we had heard was gaining some traction in the information theory community, but we had no inkling it could be applied to practical network design. During the talk we realized that network coding could be applied to simplify many hard problems in designing wireless mesh networks on which Robert Morris was then actively working. From that initial connection, the research agenda grew into making network coding a fundamental building block for wireless mesh networks.

MIT was a great place to do such research, from being able to talk with Dina Katabi, Robert Morris and Hari Balakrishnan about practical problems, to Muriel Médard on theoretical network coding ideas, there was an ideal blend of mentors that helped me take on this interdisciplinary topic. The experience also informed my decision to pursue an academic career. The freedom that academia offers to take on risky research agendas and have the time and resources to bring them to reality and make an impact is very rewarding. My advisor, Dina Katabi, and Hari Balakrishnan, were major influences and role models in making this decision, they taught by example how to balance great research, mentoring and teaching to have impact on the world in general.

After graduating from MIT, I spent a year at Berkeley with Scott Shenker and then started a faculty job at Stanford. As expected, there was a culture change, but in a good way. The closeness of the valley and the energy it brings to the Stanford campus, as well as the close working relationship you can have with cutting edge teams in industry have shaped my research. My recent research has married the fundamental approach that I learned at MIT with the opportunities at Stanford to have substantial impact on industry. My major research focus is on architecting next generation wireless networks; bringing together ideas from information theory, circuit design and software systems to engineer high capacity wireless networks. I have also recently co-founded a company to commercialize some of my recent research on radio design.

Yehia Massoud

MIT PhD '99

Yehia Massoud is the Wallace Bunn Endowed Chair of the Electrical and Computer Engineering Department and the Director of the Center for Integrated Systems at the University of Alabama at Birmingham, (UAB).

Before joining MIT, I had always managed to excel at every level with minimal last minute effort. It was at MIT where my limits were really challenged. I learned that intelligence can only take a person so far but if combined with strong commitment and consistent work, it can lead to profound success. It was my PhD thesis advisor, Professor Jacob White, who taught me the importance of perseverance and staying the course regardless of the difficulties and the obstacles along the way. In the midst of my PhD, I went through a tough six-month period, during which I was basically working day and night, with negligible progress, trying to solve a persistent problem in my numerical integral formulation that limited the formulation's generality and applicability. During this period, Jacob regularly encouraged me to keep working at the problem and looking at it from different angles and perspectives. Jacob's relentless commitment and patience enabled me to overcome the biggest obstacle in my PhD dissertation and led to the generation of an accurate and efficient generalized formulation that was highly regarded by the research community.

Yehia Massoud

At MIT, I was very fortunate to have had research interactions, discussions and classes from great EECS professors such as Stephen Senturia, Steven Leeb, Dimitri Antoniadis, Anantha Chandrakasan, Srinivas Devadas, Munther Dahleh, and Jesús del Alamo. These professors put great emphasis on developing deep understanding of basics along with unwavering dedication to rigorous knowledge of advanced topics. This helped ignite an unending desire for attaining intuitive understanding as well as maintaining analytical rigor in my research. MIT EECS professors also have very high expectations of their students. I particularly remember my PhD qualification exam, where I was asked to solve some problems on the board. One of these problems was given by Prof. Markus Zahn. At the end of the allotted ten minutes, I noticed that Markus was visibly pleased. This came as a surprise to me since I did not reach a final solution. Markus then explained that the problem was an open problem and that he wanted to see how I would proceed in solving such a problem. He then told me he was pleased to see me reach the state of the art in solving this problem in those ten minutes. What struck me at that moment was how high the expectations were for EECS graduate students—to give an open problem in a qualifier exam. I decided then that I ought to have the same high expectation of myself and to never settle for less.

One of my most defining career moments was when I started my academic career as an assistant professor at Rice University in 2003. I needed to devise a plan for what I would do and how I would do it. I looked around and found that many junior professors in academia follow what they perceive as the safe tenure path, where they continue to grind their PhD topic until tenure. I viewed this common "safe" path as a trap that discourages breadth and broad mindedness as well as encouraging risk avoidance and complacency—leading to careers that are often highlighted by incremental research and insignificant contributions. I challenged myself to make my own path and to pursue quality research in the areas that I felt were important and valuable, regardless of my comfort level in these areas. I wanted to make a difference and have an impact.

Within two to three years of making this commitment, my group grew rapidly and we were able to make several well received contributions in multiple areas while developing a wide breadth and a clear research vision. Naturally, Rice liked my progress—so much that they promoted me to associate professor during my fourth year (three years faster than the standard Rice cycle). Four years later, while I was in the process of getting promoted to full professor, I was recruited by UAB to help rebuild its Electrical and Computer Engineering program into one of the top interdisciplinary research programs in the Southeast. I felt I could make a significant difference as department head so I accepted the challenge. Thanks to MIT EECS for teaching me that if you believe in yourself, and have the strong will, unflappable commitment and perseverance, success will follow.

Sridevi Sarma

MIT PhD '06

When Sridevi (Sri) Sarma, '06, introduces herself, she might say, "I got my PhD at MIT in control theory." She might add, "I studied in the Laboratory for Information and Decision Systems (LIDS) with Prof. Munther Dahleh, and now I apply what I learned to the brain." This, the 'brain' part, is when you want to get to know her.

"Turning your career to the interface of neuroscience with control theory is not the typical route for EECS graduates," Sri Sarma continues. Indeed, she leads a research lab that studies neurological disorders and deep brain stimulation therapy at Johns Hopkins University in the department of Biomedical Engineering. She is also a professor and mentor to students. Her description of what she gained in her graduate training and experiences in EECS at MIT are as insightful as her discussions of her work are compelling. She shares a bit of both.

Sri's path to brain-implant controller design started during the time she was doing her doctoral studies in LIDS. While her graduate studies were focused on control theory, she was taking courses in neuroscience on the side. "We had to do a minor in something, but I really wasn't looking to do anything interdisciplinary," she explains.

A class project led her to do a three-day case study on her aunt who had early-onset Parkinson's disease—giving her a completely different perspective of what it's like to live with this disease. Sri saw an opening to put her training to use in finding a better way to help people with neurological disorders. "I was motivated to better understand what's happening in the brain, to use my training in systems modeling and control to better understand the brain, and how to design better therapy."

At the Institute for Computational Medicine at Johns Hopkins University, one of Sri's research areas involves optimizing deep brain stimulation (DBS) for Parkinson's disease and Epilepsy patients. DBS is a procedure during which an electrode is surgically implanted in the brain. The electrode is connected to a wire, which sits under the skin and terminates at a neurostimulator (Figure 1). The neurostimulator contains a battery operated current source that injects current to the tip of the electrode. The current impulses can be targeted in such a way that they are able to alter the electrical activity in the diseased brain to alleviate some of the motor symptoms in Parkinson's and to suppress seizures in Epilepsy patients.

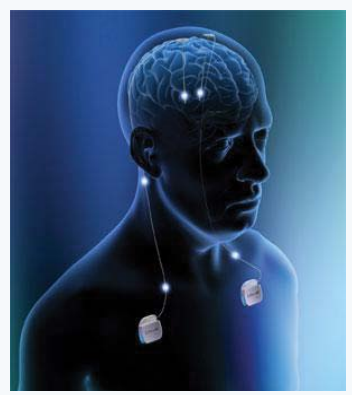


Figure 1

Most doctors who work with DBS do their best to adjust the instrumentation, but it's essentially a shot in the dark. "After a Parkinson's patient recovers from surgery, the doctor can literally tweak the parameters of the stimulators," she said, adding that while the pulse train of current that goes into the electrodes is constant, the intensity of the pulse can be tweaked. Typically doctors ask patients to walk around the room and perform certain tasks while the pulse's parameters are changed. This process is laborious, expensive and lengthy – taking potentially up to a year to optimize the treatment.

Sri's goal is to create a more intelligent system for both placing and controlling the electrodes. In current practice, once the parameters are correct, she says, the same high-power signal runs 24 hours a day, 7 days a week – until the batteries run out three to five years later. At this point another surgery and another round of tweaks are required. Plus, the electrical impulses can trigger other circuits in the brain, making patients impulsive, anxious and/or depressed.

Sri thinks it's possible to re-imagine the whole system. The normal brain operates in a low-power environment. "Why not a low-power alternative for DBS?" she reasons, adding that the electrical signal can be designed to work smarter. "We want to implant an intelligent chip that continuously measures neural activity, and responds with appropriate stimulation with the goal of getting the patient's brain to look more like a healthy brain."

She is now analyzing data from both primates and humans to build models of what exactly DBS is doing. The systems approach and computational framework she brought from LIDS can be both exciting and challenging to neuroscience colleagues who have a set way of doing things. She has found that designing experiments in current neuroscience practice can lead to data overload—whereas the desired outcome is to understand the dynamics of neural systems. In this case a systems engineer is most appropriate. It is hard for neuroscientists to understand and/or appreciate what a systems engineer is trying to accomplish and vice versa.

"LIDS gave me the systems perspective – the methodology and tools to apply to this field. I have not run across many with my training looking at these problems," she said. Specifically, Sri has much to say about working with her PhD advisor, Munther Dahleh.

"I met Prof. Dahleh when I took his Introduction to Linear Systems (6.241) course my first semester at MIT. After some 15 courses in EECS, I graduated with the recollection that this was the most difficult class that I had ever taken in my life. Despite this, I still remember Dahleh being the most dynamic and effective teacher I have had. This is why I decided to join his lab for my PhD."

Now 'in the shoes' of her master teacher and mentor, Sri defines just how keenly she has drawn on her work under Prof. Dahleh. "He taught me that clarity is key. You must be clear in your logic in how to go from one step to another when teaching new material. Every step must be justified and placed in the broad context and clearly motivated. You must be sensitive to the variability in students' abilities and adjust to each individual to the extent possible."

Sri continues, "As a mentor, Dahleh has this amazing foresight in your work. With a grand vision from the outset that we students don't see because we are focused on minute detail, Dahleh embarks with us on our journey—following our lead yet allowing us to get stuck so that we learn *why* a certain path leads to a dead end. Dahleh manages to stay with us until we realize that the finish line is ever so close to his grand vision—now clear to each of us as well. By his example, we learn how to communicate our work both orally and in written form to others in the community. Dahleh taught me that nothing changes when communicating with the neuroscience community except vocabulary and context. The thought process and logic remain the same—a point that is making me successful in my research. I stick to my control systems perspective and training and just place it in new contexts. This leads to very different and novel ways to learn about the brain. In short, Dahleh is incredible and remains a wonderful mentor and one of the most important people in my life."

Having spent three years as a postdoc with Emery Brown in the Brain and Cognitive Science department, learning about neuroscience following her minor in that field while completing her PhD in control theory, Sridevi is now in a good position to build an effective new cadre of researchers who bridge the training and thinking gaps toward major advances in neuroscience research.

We would like to acknowledge the article "A Novel Approach to Controlling the Brain" by Katherine Stoel Gammon in LIDS-All magazine about Sridevi Sarma. http://lidsmag.lids.mit.edu/page4.htm

Mark Somerville

MIT PhD '98

Mark Somerville is Professor of Electrical Engineering and Physics at Olin College, where he also serves as Associate Dean for Faculty Affairs and Research. He has been a member of the faculty at Olin since 2001 (before the College had any students!), and has played a significant role in the creation of the curriculum and the development of Olin's strategy. He completed his PhD at MIT in EECS under the supervision of Prof. Jesús del Alamo in 1998.

My decision to come to MIT, and to work with Jesús, were very much about the people: I remember visiting as a prospective graduate student, and being blown away by the energy and inventiveness of the individuals that I met. I had certainly interacted with plenty of smart people before visiting MIT; I don't think I had seen quite so much initiative and passion as I found during that weekend. This impression was very much borne out by my experience at MIT – the people I worked with (and particularly Jesús) were both intense and intensely committed to their work and their colleagues. I will never forget the way Jesús would rub his hands together in excite-

EECS Alumni are making an impact in academia

Mark Somerville

ment over new experimental results – and I must admit, I find myself doing the same thing with my own students almost twenty years later.

As a graduate student, I had the chance to work with some brilliant undergrads – both UROPs in our lab, and through my role as a Graduate Resident Tutor at East Campus. I particularly remember one undergrad who taught himself a number of advanced statistical techniques, and then (largely on his own) applied them in very powerful ways to our experimental results. Seeing undergraduates learning on their own, and contributing in substantive ways to our research group, changed my perspectives about what college students are capable of given appropriate opportunities, support, and trust. This perspective has strongly influenced my own educational philosophy – and I (as well as a number of other ex-MIT folks at Olin) have worked to make this an integral part of what Olin is about.

My experiences as a mentor to undergraduates were supplemented by equally important classroom experiences. I was very fortunate to work closely with Terry Orlando to do a major revision and development project for 6.730 (Physics for Solid State Applications). Just as the UROP program provides undergraduates with real opportunities to stretch themselves, Terry gave me the space to explore teaching in a substantive way: I got to design some of the core materials for the course and to put together and deliver some of the lectures. I loved the challenge of scaffolding an educational experience for students, and the reward of seeing them master challenging concepts. This opportunity to explore teaching led to my decision to pursue a career in education, and also, I think, played a pretty critical role in helping me get my first academic job.

For me, these themes – intensity and commitment, the virtue of trusting students to go further than the 'ought to' be able to, and the rewards of working with students and seeing them develop as thinkers, as doers, and most of all as people – have formed the foundation for my work in helping to build Olin College from a hubristic idea to a place that is influencing the conversation about how engineering education should change, and that is sending graduates to top companies and schools (including, of course, MIT). And while Olin is not, and does not aspire to be, MIT, Olin's DNA carries more than a few markers from the Institute.

David Wentzlaff

MIT PhD '11

David Wentzlaff joined Princeton University in September 2011 as an Assistant Professor in Electrical Engineering. At Princeton, the research group he started is investigating how to create efficient manycore and multicore computer chips optimized for data center and cloud computers. His research group is also investigating how to make computing systems and electronics more sustainable by designing electronics which are easier to recycle, have a longer useful lifetime, and can ultimately biodegrade, thereby reducing the amount of e-waste produced by the computing community.

I took an exciting path through graduate school which included co-founding Tilera Corporation in 2004. At Tilera, I was the Lead Architect where I designed the chip architecture of Tilera's first two flagship 64-core multicore microprocessors. In starting a new company, I relied on both the technical aspects of my MIT EECS education as well as the great entrepreneurship network at MIT. Tilera has grown into a successful mid-size company and I've been granted 15 patents at Tilera.

While at MIT, I had a great opportunity to get involved with teaching both formally and informally. As a TA in

David Wentzlaff, continued

EECS for 6.004, I had the opportunity to lead recitation sections and help students in the lab—an experience that has sharpened my effectiveness as a professor and eased my transition to teaching. In addition to formally TAing, I mentored numerous MEng and UROP students—also useful for my current advising. I also had the chance to informally teach during IAP by instructing 6.186 and by marrying my love of the outdoors with teaching by running the MIT Outing Club's (MITOC) Winter School.

My research work during my MIT career started by jumping into the Raw Processor project in 2000. As a junior graduate student I had the opportunity to design one of the first on-chip networks for the 16-core multicore processor. Later, I used the Raw microprocessor in my research as I studied the limits of emulating code from different computer architectures in parallel on the Raw Processor. My PhD work built on this early multicore architecture by exploring operating systems that can leverage future 1,000-plus core multicore processors. As a member of CSAIL, I had a great experience collaborating with other students on the Factored Operating System (fos) project. Without the support of all of the other students in my group, fos and my PhD work would have been much less developed and exciting.

I never expected to end up at MIT. During my last year of undergraduate at UIUC, I was trying to start a company which built what were effectively blade computer servers. My backup plan of going to MIT EECS was one of the best decisions I ever made. The Dot-Com bubble burst and I fell into graduate school at the top CS school in the U.S. I chose to go to MIT after visit day weekend. I just loved the environment, loved the faculty, and loved the students. After all of my years in graduate school, my first impressions did not waiver, the community at MIT and EECS is what makes it such a great place.

One of the great things I love about MIT is that people are willing to dream. While working on the MIT Raw microprocessor, we were creating a processor which could best computer chips made by companies with design teams twenty times our size. Most university projects wouldn't have dared to propose designs as radical as ours, let alone build them. The rag-tag group of Raw designers provided one of the best team experiences that anyone could have. We were able to work together to create something great and we even hung out socially and professionally.

Now, away from MIT EECS, I still keep in touch with all of these contacts. Because such a large percentage of MIT

David Wentzlaff

EECS graduates go on to be professors or are in high profile jobs, people from CSAIL who I only knew socially have become great colleagues now that I am in academia.

Vanessa Wood

MIT PhD '11

When I first visited EECS at MIT in March 2005 during the preview days for admitted students, I immediately knew where I'd be heading to graduate school in the fall. The professors, students, and staff were all incredibly enthusiastic about MIT and their research, and I wanted to be part of this vibrant scientific community. I hoped to work at the intersection of materials science and engineering so I was keen to interview with Prof. Vladimir Bulović to see if he had an opening in his group. Unfortunately, his schedule during the visit days was entirely booked. However, he agreed to meet with me at 7:30 Saturday morning before his other appointments and gave me a fascinating tour of his lab. I remember thinking that I hoped I could one day be a professor and radiate such enthusiasm about my research.

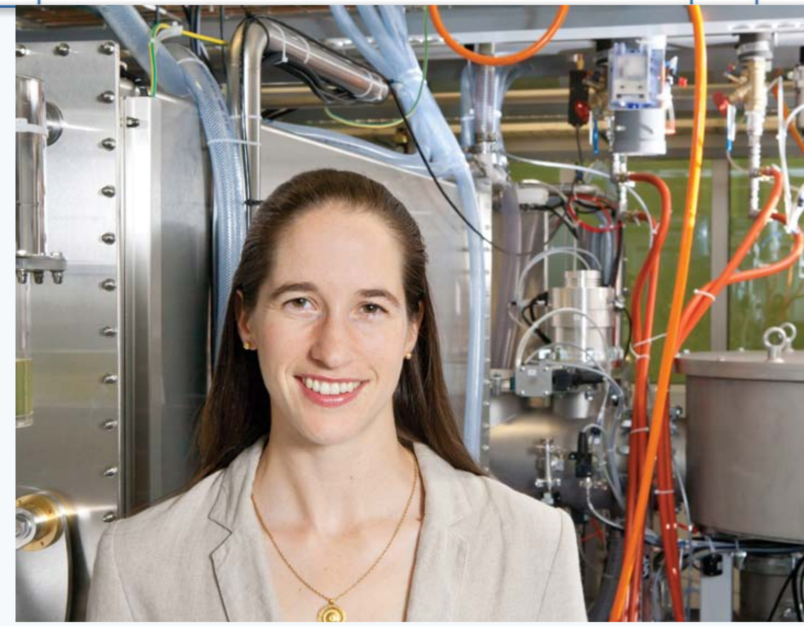
Vanessa Wood, continued

As I look back on my years at MIT, I remember feeling part of a team, the thrill of discovery, and the enjoyment that comes from everyone around you finding science to be 'fun'.

From the outside, MIT has a reputation of competition; however, as a student in EECS, I found the opposite to be true. Whether it was studying for an exam with fellow students or replacing tubing for a water-cooling system in lab, there was always willingness to share knowledge and lend a hand. A group of five of us, who met in classes during our first year, but worked in different research areas, continued to meet weekly throughout our PhDs. Before any of us gave a conference presentation, RQE, or thesis defense, our little group would meet, listen to the presenter, and give feedback on everything from allocation to power point color schemes to ways of explaining a measurement setup more clearly. The spirit of collaboration also ran strong in the lab. In fact, one of my labmates and I organized ourselves into 12 hour shifts so that experiments could run 24 hours a day. We would monitor and tweak each other's experiments if needed. We never saw this as a question of hours or credit – the only bonus was helping each other and learning more in the process.

The thrill of discovery around MIT was palpable and contagious – someone was always excited about his or her latest achievement and their enthusiasm made me want to head directly to lab. Whether it was my officemate using a Lego Technic kit from his time as an EECS undergrad in 6.270 to quickly build a precision rotational stage for an optical measurement, or another labmate using a creme brulee torch to prepare single crystal gold, the "let's get it done" creativity of my colleagues was an inspiration. After hearing me present a part of my PhD research at a conference, inquiring where the idea had come from, and hearing my explanation that involved a tale of some 'failed' chemistry, an epic thirty hour lab session to fabricate the device, and scouring around the basement of Building 13 for some electronics from the 1960s that had been advertised on the Reuse listserve, a professor in my field told me "That's the craziest thing I've ever heard!" I took this as a compliment. However it underscored for me how out-of the-box thinking—a part of daily life at MIT—was not necessarily the norm in the world outside.

Around EECS, it was clear from the quality of the teaching and commitment to students in the program that professors were genuinely having 'fun' with science and wanted others to as well. In my first year, I was fortunate



Vanessa Wood

to take two classes from the late Prof. Jin Au Kong, who kept the attention of a packed Stata hall with histories of the greats in electricity and magnetism such as Maxwell, Green, Ampere interspersed in his lectures. And I still refer to my notes from quantum mechanics (Prof. Hagelstein) and solid state physics (Prof. Ram), when deciding how to present a topic.

Many programs organized by the department were also a terrific benefit to my career. The TA requirement, which I fulfilled with 6.012 taught by Prof. Antoniadis, gave me my first taste for handling and planning a large lecture—invaluable insights as I faced my lecture hall full of students this past year. The student organized MTL Annual Research Conference was a fantastic opportunity for many of us to become acquainted with professional obligations. When Prof. Palacios began organizing mock interviews (2008) to pair students and postdocs interested in a faculty career with a mentor, I was paired with Prof. Millie Dresselhaus. Not only did she provide a valuable critique of my research proposal talk, but a few months after I had started my faculty position, she also made a detour through Zurich on one of her trips to Europe to check how things were going for me on the tenure track.

Now that I'm a professor, I try to bring the same level of enthusiasm, creativity, and team spirit I experienced at MIT to my teaching and research group. I look to my mentors in EECS, in particular, Vladimir Bulović, Leslie Kolodziejski, and Terry Orlando, who could always be relied on for insights and advice – and hope I can contribute to the development of my students in similar ways.

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Bartley C. Johnson '81, SM '81, PhD '86
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Howard Schneider '79
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Howard J. Siegel '71
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Clark M. Baker '76, '80, SM '80
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Roy D. Yates SM '86, PhD '90
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The 2012 Irwin Mark Jacobs and Joan Klein Jacobs Presidential Fellows from left to right: Katie Bouman, Ali Makhdoumi, Narmada Herath, Vitaly Abdrashitov, Fabián Kozynski, Michael Price, Lixin Shi, Noelle Norris, Peter Iannucci, Joan Jacobs, Irwin Jacobs, Yu-Han Chen, Christina Lee, Fadel Adib, Emily Stark. Not pictured: Qingqing Huang, Kyu Kim, Sue Zheng. [Photos taken by Patricia Sampson/EECS]

Department Head Anantha Chandrakasan hosted the annual Jacobs Presidential Fellows Reception on March 7, 2012 in the Flowers Dining Room in Maseeh Hall. The EECS graduate students who are the 2012 Jacobs Presidential Fellows gathered to meet Irwin (SM '57, ScD '59) and Joan Jacobs and to give them brief presentations of their research.

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Irwin and Joan Jacobs with EECS Department Head Anantha Chandrakasan at the reception held in their honor and providing them the opportunity to meet the latest group of Jacobs Presidential Fellows, March 7, 2012.

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MITx launches 6.002x, Circuits and Electronics over 120,000 registered!

MITx, a new online-learning initiative launched by MIT and announced in December, began its first course 6.002x (Circuits and Electronics) on March 5, 2012. More than 120,000 people signed up for the experimental prototype course since registration opened in February. The class is taught by Anant Agarwal (photo right), Gerald Sussman, Chris Terman, and Piotr Mitros. 6.002x is an on-line adaption of 6.002, MIT's first undergraduate analog design course. The class will run, free of charge, for students worldwide from March 5, 2012 through June 8, 2012. Students will be given the opportunity to demonstrate their mastery of the material and earn a certificate from *MITx*. Anant Agarwal will direct the new unit to advance MITx as announced March 16, 2012 by Provost L. Rafael Reif. mitx.mit.edu/