Computer Science and Artificial Intelligence Laboratory

The Computer Science and Artificial Intelligence Laboratory (CSAIL) takes a computational approach to finding solutions to many of the most challenging problems of our lives, our work, and our world. We employ a long-term lens to engineer innovative solutions in an effort to unlock the secrets of human intelligence, extend the functional capabilities of machines, and explore human/machine interactions.

With approximately 50 research groups working on hundreds of diverse projects, CSAIL researchers focus on finding innovative ways to make systems and machines operate faster, better, safer, easier, and more efficiently for the benefit of humanity. Our projects fall into three areas of inquiry:

- Artificial intelligence—We seek to understand and develop both living and artificial systems capable of intelligent reasoning, perception, and behavior.
- Systems—We seek to discover new principles, models, metrics, and tools of both hardware- and software-based computer systems.
- Theory—We seek to understand the mathematics of computation and its wide-ranging, real-world consequences.

CSAIL has a long history of technological innovations that have affected how people interact and do business. Current research explores cloud computing, mobile computing, the next generation of computing devices, and the application of sensor technology to traffic congestion, medical monitoring, and climate and environmental observations. Robotic locomotion and the human-robotic interface are being investigated, as well as advanced software-based medical instrumentation and medical informatics systems to aid clinical decision making. Advancements in biological research are also under way, including developments in the field of computational biology and the application of machine learning to the interpretation of complete genomes and understanding gene regulation.

CSAIL research is sponsored by a large number of diverse sources, from US government contracts to the private sector. US government sponsors include the Air Force Research Laboratory and the Air Force Office of Scientific Research, the Army Research Office, the Defense Advanced Research Project Agency (DARPA), the Department of Defense Research and Engineering, the US Department of Education, the Department of Energy, the Intelligence Advanced Research Projects Activity, the National Institutes of Health, the National Science Foundation, and the Navy (including the Office of Naval Research and Naval Air Systems Command). US and international industrial sponsors include Boeing, Comcast, DuPont, Ford, Foxconn, General Electric, IBM, Intel Corporation, Lockheed Martin Advanced Technology Laboratories, Microelectronics Advanced Research Corporation, Nippon Telegraph and Telephone Corporation, Nokia, Northrop Grumman Corporation, Pfizer, Quanta Computer, and Shell. Other organizations sponsoring research include Aarhus University, Delta Electronics Foundation, DSO National Laboratories, the Epoch Foundation, Industrial Technology Research Institute, Nanyang Technical University, and the Singapore-MIT Alliance.

Research Projects

Within CSAIL we have many single- and multi-investigator projects, as well as a number of virtual centers and large-scale projects. The large-scale projects and collaborations include the following:

T-Party

The T-Party project is a 10-year, $45.5M research collaboration with Quanta Computer, Inc. The project has just completed its sixth year and is currently funding four major research areas:

Cloud computing technologies: new, scalable operating systems for clusters of multicore computers (professor Anant Agarwal); investigation into scalability limitations of standard operating systems on multicore platforms (professor Frans Kaashoek); scalable data stores supporting high-traffic websites (professor Robert Morris); security frameworks that limit data dissemination and allow recovery from attacks (professor Nickolai Zeldovich); new database architectures that increase concurrency of cloud-based implementations (professor Samuel Madden); trusted storage built using untrusted commodity cloud storage (professor Srinivas Devadas).

Human-computer interfaces for interactions between mobile devices and the cloud: continued evolution of a framework for natural language understanding and dialogs (Dr. Stephenie Seneff); an embeddable web-based interface for multimodal interactions including speech and gesture (Dr. James Glass); creating easy-to-use interfaces using web automation (professor Robert Miller).

Telepresence: novel data structures that allow efficient client manipulation of large server-side data streams (professor Stephen Ward); applying machine learning techniques to medical telemetry to aid in the appropriate diagnosis of chronic diseases and medical telepresence incorporating multiple video, audio, and telemetry channels between ambulance and hospital (professor John Guttag).

Computational photography: many unique and effective algorithms to manipulate digital images (professor Frédo Durand); algorithms to extract information content or important features from images (professor William Freeman).

Basic Research in Interactive Computing

In January 2008, CSAIL started a three-year collaboration with Foxconn for basic research encompassing several areas of computer science, including networking, human-computer interactions, computer graphics and vision, and theory. Our research is predicated on the belief that computers and information devices are fast becoming interactive; they interact with other computers, with their environments, and, above all, with humans. Each form of interaction adds a new dimension to the challenge of modeling and understanding the behavior of computer systems and to the task of building and using these systems.

The first phase of this collaboration concluded in December 2010. In January 2011, we started phase two of our collaboration, this time supporting four projects and six principal investigators:

- Advanced hand-tracking and gesture-based interaction (professor Randal Davis)
- Factor analysis–based speech and language analysis (Dr. James Glass)
- Activity modeling and recognition: "using phones as sensors" (professor Daniela Rus)
- 3D Capture and display for mobile devices (professors Frédo Durand, William T. Freeman, and Antonio Torralba)

A total of seven Foxconn engineers in two shifts have visited CSAIL during this academic year to facilitate technology transfer and to receive training for advanced research and development in computer science. In addition, video presentations for the seven projects were delivered to Foxconn in Taiwan in December 2010 to summarize the research results.

Research in Cyber Security

In September 2009, CSAIL established a five-year research collaboration with Northrop Grumman Information Technology, Inc., (NGIT) in the research area of cyber security. In so doing, MIT also joined Carnegie Mellon University and Purdue University as part of the NGIT Cyber Security Consortium.

This project has just completed its second year. During the second year, four projects and six principal investigators were supported by Northrop Grumman:

- Secure and Dependable Systems by Design (professor Daniel Jackson)
- Secure Audit Trails (professor Barbara Liskov)
- Trusted cloud storage with reconfigurable hardware (professors Srinivas Devadas and Nickolai Zeldovich)
- Recovering system integrity using selective re-execution (professors Frans Kaashoek, Nickolai Zeldovich, and Robert Morris)

This project is progressing well, and specific proposals for funding for the third year are now being considered.

The MIT Angstrom Project: Universal Technologies for Exascale Computing

The CSAIL-led Angstrom team was one of four teams selected by the Defense Advanced Research Project Agency for funding under the Ubiquitous High-Performance Computing program. The team is charged with the task of rethinking computing and creating a fundamentally new computing architecture to meet the challenges of computing in the 2020 timeframe. The CSAIL team is the only university-led team of the four, consisting predominantly of university researchers, the majority of whom are MIT faculty. Angstrom is a strongly interdisciplinary program involving faculty from MIT's CSAIL, Microsystems Technology Laboratories, Research Laboratory of Electronics, and Material

Processing Center; industry partners Freescale Semiconductor, Mercury Federal Systems, and Lockheed ATL; and faculty from the University of Maryland Department of Electrical and Computer Engineering. Project Angstrom's goal is to create the fundamental technologies necessary for future extreme-scale computers. Extreme-scale computers face several major challenges, the most difficult four being the energy-efficiency challenge, the scalability challenge, the programmability challenge, and the dependability challenge. To address these challenges, Angstrom is re-examining every layer of system design and interfaces, including circuits, hardware architecture, operating systems, runtime software systems, compilers, programming languages, and applications.

Project Angstrom's vision for addressing the four major challenges of extreme-scale computing is based on two key foundations: creating a revolutionary SElf-awarE Computational model, called SEEC, and creating a fully distributed factored architecture for both hardware and software.

Self-Aware Computational Model

SEEC is a goal-oriented computational model that radically increases developer productivity by abstracting traditional procedural programming into goals (e.g., "achieve the best possible chess move within 10 s burning less than 20 W") that are targeted in our self-aware, factored system. SEEC attempts to enable systems that are orders of magnitude more energy efficient and dependable by explicitly incorporating energy and resiliency goals into the hardware, operating system, compiler, and languages. A major goal of this research is to create and to evaluate algorithms and interfaces for SEEC using methods based on machine learning and control theory.

Distributed Factored Architecture

Our factored approach targets energy-efficient multicores scalable to thousands of cores. For example, distributed power converters will scale because they eliminate centralized control bottlenecks and allow fine-grain voltage control, and they facilitate SEEC, which demands individual control of the voltage, clock, and body bias of each core. Similarly, our factored software targets levels of resiliency and scalability that meet the demands of billions of threads. For example, our SElf-aware Factored Operating System (SEFOS) will factor OS functions into services (e.g., scheduling service or fault-tolerance service) that are each implemented by a dynamic fleet of cooperating servers. Accordingly, our second major goal is to invent fully distributed architectural mechanisms and factored software approaches.

SEEC and factoring are the two overarching themes of Project Angstrom. These two concepts are instantiated in several novel mechanisms in the Angstrom project and will provide solutions for the four major extreme-scale challenges.

Explorations in Cyber International Relations

The Explorations in Cyber International Relations (ECIR) project is a collaboration among CSAIL, the Political Science Department and the Sloan School at MIT, and the Kennedy School of Government at Harvard University. It is one of the projects funded under the Department of Defense (DoD) Minerva Research Initiative. The project is motivated by

the hypothesis that the emergence of cyberspace as a phenomenon calls for new theories of international relations (IR). The current field of IR emerged in the era of nuclear deterrence and focuses on the role of key state actors. It emphasizes concepts of balance of power and a 20th-century world order dominated by a few major players. In contrast, cyberspace (or the internet, more specifically) is constructed by private-sector players, with little state involvement, and empowers a wide range of actors, from large and small states to individuals. At the same time, with fears of cyberwar and tensions between states such as the US and China over how the internet should be regulated, it is no longer reasonable for governments to ignore the influence and importance of the internet.

The collaboration between CSAIL and the Political Science Department has the objective of developing a framework or model that incorporates both traditional elements of IR and a technically sound model of cyberspace. This model will provide a means by which to categorize and distinguish different phenomena in cyberspace, so as to position them within the correct scope of IR analysis and permit the development of relevant theory. Phenomena include moments of conflict, such as cyberattacks in Georgia and Estonia, attempts at global cooperation, such as the Internet Governance Forum, and ongoing international tensions over theft of intellectual property and repression of free speech.

As a part of this project, CSAIL is working on a number of technologies that may contribute to new IR theory and practice. Game theory has been an important IR tool, but game theory is subject to a number of limiting characteristics, including the assumption of a Nash equilibrium, freedom from collusion, excessive complexity, and excessive revelation of information about the players. We are developing a new set of mechanisms that move us "beyond game theory" and remove the necessity of these limits. Interpretation of narrative (including news reports, press releases and government statements, and event assessments) is a daunting task, because a growing body of information is disseminated in cyberspace. We are developing automated tools to attempt to find meaning in written text and to establish the likely evolution of an ongoing cyberevent and the potential for unintended consequences of various reactions. We are also gathering and categorizing cyberevent data and developing a typology of interactions among the important actors that shape cyberspace.

The Ford-MIT Alliance

The Ford-MIT Alliance, an Institute-wide initiative, was established in 1997. In December 2006 it was renewed for its third five-year term at $3 million annually, beginning January 1, 2008, and running through 2012. The Alliance is the Institute's longest running large-scale commitment from industry and represents a significant acknowledgment by the Ford Motor Company of MIT's relevance and impact on its research. Since 1997, the Alliance has funded more than 100 projects of varying duration and budget throughout the School of Engineering, the Sloan School, CSAIL, the MIT Energy Initiative, and interdisciplinary labs and centers across the Institute.

The Ford-MIT Alliance research portfolio has a strong connection to CSAIL's research areas. CSAIL faculty are currently pursuing four areas of research under Ford-MIT Alliance funding:

- Multiple vehicle networking
- Algorithms for improved active safety
- Novel speech interfaces
- Crowd computing

CSAIL is acquiring two Ford vehicles, a 2011 Ford Explorer and a 2012 Ford Focus, to use as test beds for these projects.

World Wide Web Consortium

The World Wide Web Consortium (W3C) was founded at MIT in 1994 by the inventor of the web, Tim Berners-Lee. The W3C is responsible for developing and maintaining the standards that make the web work and for ensuring the long-term growth of the web. Three hundred-sixty member organizations, including most of the world's leading technology companies, are working to enhance the capabilities used within web documents and to transform today's web of linked documents to an expanded web of data and services across a wide range of devices, enabling everyone on the planet to collaborate and share data and information.

Recent Focus

In recent years, a great many factors (people, devices, bandwidth, policy decisions, etc.) have extended the reach of the web in society. A growing number of people consider access to the internet and the web important enough to be considered a fundamental human right. These trends increase pressure on the W3C and other organizations to build robust technology that is capable of addressing diverse societal needs in areas such as privacy, security, accessibility, and multilingual content.

In addition, the rise of video, social networking tools, user-generated content, location-based services, and web access from mobile devices has captured the attention of industry. Leading companies in entertainment, television, gaming, device manufacturing, and other fields have begun to participate in the W3C to ensure that standards for communication, data, and user interface design address their use cases.

The W3C's standards define an Open Web Platform for application development that has the unprecedented potential to enable developers to build rich interactive experiences, powered by vast data stores, that are available on any device. Although the boundaries of the platform continue to evolve, industry leaders speak nearly in unison about how HTML5 will be the cornerstone for this platform. But the full strength of the platform relies on many more technologies that W3C and its partners are creating, including cascading style sheets (CSS), scalable vector graphics (SVG), web open font format (WOFF), the Semantic Web stack, extensible markup language (XML), and a variety of application programming interfaces (APIs). New technologies are on the way (e.g., real-time communications) that will further transform industry and create opportunities for innovation. The platform continues to grow, and the W3C, in turn, is growing to meet the demand.

The demand is also driving W3C to expand its agenda, the number of communities it reaches, and the offerings to those communities. By lowering obstacles to participation, W3C can increase the relevance and quality of its work and bring more innovators to the table for pre-standards and standards track work.

The Open Web Platform

The Open Web Platform for application development is a suite of web technologies that is transforming business practices, creating new business models, and allowing for greater innovation on the web. W3C is designing royalty-free technologies that:

- Provide a rich interface feature set, including style, interaction, and media
- Enrich apps through APIs for device capabilities and user data
- Integrate data and services (mashups, integration of existing databases and services)
- Run on any device (computer, telephone, television, consumer electronics, automobile, etc.) and support interaction through a variety of input and output modes
- Meet network and communications demands (cross-origin resource sharing, real-time communications)
- Satisfy performance and distribution requirements, enable rapid development and deployment, and facilitate maintenance, and
- Address diverse social requirements for privacy, security, multilingual content, and accessibility

Research Highlights

In addition to the large-scale collaborative projects and center research, numerous individual and multi-investigator projects are under way. A sampling of the work is highlighted below.

Printable Robots for Future Manufacturing

Today, the computation, mobility, and manipulation capabilities of robots, mechatronic devices, fixtures, and most other specialized hardware tools (computational and physical) are tightly coupled to the hardware of the system. Since robot architectures are fixed and difficult to extend, the capabilities of each robot are limited by its architecture. Fabricating new robots, add-on robotic modules, fixtures, or specialized tools to extend capabilities is not a real option, because the process of design, fabrication, assembly, and programming is long and cumbersome.

Our goal is to enable quantum leaps in the way engineers go from specifications to design, prototyping, and programming for robots and other tools (e.g., fixtures, appliances, educational devices) that require minimal manual design, assembly, and code development to perform tasks in natural environments. We are developing a compilation system for programmable physical devices as an end-to-end process that provides automatic modeling, specification, design, fabrication, and programming for

creating functional 3D machines. Innovation in the processes for rapidly creating robots and specialized tools will revolutionize the manufacturing industry. The compiler for physical functional objects will enable a new class of machines called printable robots or printable functional objects. Printable robots are functional robots constructed from smart materials that embed joints, actuation, computation, communication, sensing, and interface with other components such as specialized sensors. Printable robots will be designed using an interdisciplinary research program that requires computational innovations in design, fabrication, planning, and programming.

We are developing new manufacturing processes for printable functional objects and associated planning and control algorithms for these robots. In the future, for example, people will use the printable manufacturing technologies at a "Robo-Kinko's" to print not a poster but a robot with a desired function, subject to specified constraints. For example, the desired outcome could be an insect robot with 6 legs capable of carrying a radon sensor for crawling through the narrow spaces of a person's basement to map its radon levels. The user would specify the robot's sensors, the approximate size of the basement, and the duration of the task. The "Robo-Kinko's" manufacturing system for printable functional objects will use the specifications and constraints provided by the user to select and optimize the parameters for the robot, such as size, material, and components (including sensors, actuation, and computation) to create a device capable of meeting the specifications and constraints. The system will compute the mechanical design documents, the component placement maps, the computational substrate and the electronic infrastructure, the low-level primitives for controlling the self-assembly of the device, the behavior primitives, and its high-level programming and user interface. Finally, the system will be fabricated and assembled.

This research is under the direction of professor Daniela Rus.

Computational Modeling of Functional Brain Organization from Functional MRI

Functional MRI (fMRI) provides noninvasive observations of brain activity. We are developing analysis methods to enable rich fMRI experiments for probing brain activity and to robustly integrate information across subjects in a study.

Our motivation comes from visual fMRI studies that present subjects with several categories of visual stimuli. The differences between the signal during stimulation and the baseline point to areas of the brain that are involved in the processing of the stimulus. Unfortunately, this approach faces significant challenges when the experiment involves a multitude of stimuli and if the location of the functional system of interest varies substantially across subjects. Our approach is to consider the space of all possible activation profiles in response to all stimuli in the experiment. We search for stable clusters of activation profiles and characterize functionally homogeneous sets of brain locations associated with these clusters. This is in contrast to the traditional hypothesis-driven techniques that study each experimental condition separately. Rather than rely on an anatomical correspondence across subjects to identify robust activations, we introduce a notion of functional consistency, removing the need to assume any spatial alignment among functional areas in different subjects. When applied to fMRI data from a rich visual experiment, our algorithms robustly localize well known functional areas

previously characterized in many separate studies and identify novel functional areas with a robust profile of response, whose functionality can then be studied in a more focused experiment.

This novel representation of the activation signals opens several directions of research, which we are now pursuing. First, removing the anatomical consistency assumption enables us to explicitly represent and characterize variability in the functional organization of the brain across individuals. In some cases (for example, in the language processing centers in the brain), this variability is on the order of the size of the functional areas. Taking this anatomical variability into account will significantly improve our ability to compare activation patterns across subjects and to construct population-level models of the functional organization of the brain. Second, our approach enables functional localization in patients whose functional organization might be distorted because of pathology, such as a tumor. In addition to better localization of functional systems for surgical planning, our methods offer a new tool for studies of brain plasticity and reorganization.

This work is under the direction of professor Polina Golland, in collaboration with professor Nancy Kanwisher (Department of Brain and Cognitive Sciences) and professor Alexandra Golby (Neurosurgery, Brigham and Women's Hospital, Harvard Medical School).

Advances in Question Answering

The enormous amount of information now available online is a boon to humanity only if we can search for the information we want and get answers we can interpret. Natural language–based question answering is intuitive for humans, but in order to interpret questions correctly and return relevant results, the computer must understand the linguistic structure of the query and the textual structure of the answers. The InfoLab's START system performs natural language analysis, generation, and question answering, and has been on the web since 1993.

Several technical ideas developed by the InfoLab group for the START question-answering system—the ternary expressions representation, the object-property-value data model, and syntactic decomposition—were used in IBM's Watson system, a large-scale question-answering system that recently defeated the all-time human champions on the quiz show *Jeopardy*!

Our ternary expressions representation makes it possible to represent the semantic content of an English sentence as a set of three-term relationships, where each relationship consists of a subject, a relation (such as a verb or preposition), and an object or property. This representation is powerful enough to capture semantic relations obtained from syntactic parse trees. Unlike syntactic parse trees, it is simple enough for fast indexing, matching and retrieval. IBM's Watson system detects syntactic subject-verb-object predicates during question analysis and uses them to query a "triple store" of knowledge. These predicates are another incarnation of the ternary expressions pioneered by START.

Our object-property-value data model makes it possible to view the vast amount of semistructured information available on the web and elsewhere as a uniform database, thus enabling this data to be effectively retrieved in response to natural language questions. Given a database containing semistructured data, simple scripts can be written to extract the value for a property. Depending on how consistent the database format is, these scripts can be produced fully automatically, semiautomatically, or by hand. This model recognizes many disparate ways of phrasing object-property-value questions, such as the use of possessive or adjectival constructions, prepositional phrases, verbs, etc.

Our model of syntactic decomposition makes it possible to decipher complex, multipronged questions by allowing the system to understand that it needs to tackle several subquestions. The system decides, on the basis of the syntactic structure of a question, which subquestions to answer and in what order, and compiles the gathered information into a cohesive response.

The object-property-value data model combined with syntactic decomposition makes it possible to answer complex questions using information fused from many data sources. These techniques added to Watson's large arsenal of language processing technologies and contributed to its success. Our group is continuing with research on further uses of the ternary expressions representation for question answering, for generating explanations of computer actions, and for language analysis for a variety of applications.

This research is under the direction of Dr. Boris Katz.

Cryptographic Challenges in Cloud Computing

The world of cryptography is undergoing a major transition, induced by the transition to "cloud computing," that changes the way people store and use digital data. Data is more often stored remotely (on a cloud server) and accessed by very weak devices (e.g., smart phones) over the internet. The data is not only stored remotely but is also computed on by the cloud services per the user's request, because complex processing on the end user's weak device is infeasible. This allows for great flexibility and availability of computing power, but also raises new questions: How can we be assured of the correctness of remote computation on our data? How can we maintain data privacy while it is manipulated by the cloud? How can we resist the new security threats resulting from storing cryptographic keys and executing cryptographic algorithms remotely in a potentially adversarial setting?

We are developing new cryptographic paradigms and tools that address these challenges. Highlights of the group's achievements in the past year include the development of new public-key encryption schemes that achieve leakage resiliency, remaining secure even when the underlying secret keys can leak in an arbitrary fashion as long as minimal entropy is retained in the secret key; the construction of a compiler that takes any algorithm with secret state and converts it into another algorithm that can be executed in the presence of continual side-channel attacks on each step of the computation; new proof techniques to prove circular security, which is needed when encryption algorithms encode functions of their own secret keys and occurs often while

storing keys remotely; and the exciting construction of the first fully homomorphic encryption scheme that is based on worst-case short-vector problems in arbitrary lattices. Fully homomorphic encryption allows to process encrypted data in an arbitrary way without ever decrypting it.

This research is under the direction of professor Shafi Goldwasser.

Computationally Generated Cardiac Biomarkers for Cardiovascular Risk Stratification

In 2010, approximately 1.25 million new and recurrent coronary attacks occurred in the United States, with an additional 195,000 estimated silent first heart attacks. These events caused nearly one of every six deaths, with over 150,000 of these deaths taking place in patients less than 65 years old. Despite improvements in survival rates, one in four men and one in three women continue to die within a year of a first heart attack. This burden is similar in most of the developed world, and increasingly in the developing world, where it is estimated that 40% of all the deaths by the year 2020 will be attributable to cardiovascular disease.

The burden of coronary heart disease can be reduced, in part, by accurately identifying high-risk patients at early stages following an acute coronary syndrome (ACS) and by matching these patients to treatment and monitoring regimens appropriate for their individual risk. Unfortunately, patients who present with ACS have a wide and highly variable spectrum of risk for future adverse cardiovascular events, and accurately identifying patients at the highest risk for various outcomes remains a persistent and challenging clinical dilemma.

Existing tools to risk-stratify patients for cardiovascular death after ACS are commonly based on echocardiography and clinical risk scores. Unfortunately, these techniques identify only a small group of high-risk patients who comprise a minority of the total deaths in the post-ACS population.

Over the last few years we have developed three computationally generated cardiac biomarkers for risk stratification after ACS: morphologic variability (MV), symbolic mismatch (SM) and heart rate motifs (HRM). We derived these biomarkers from time-series analyses of continuous electrocardiographic data collected from roughly 700 patients, through machine learning and data mining methods designed to measure information that is difficult to visualize directly in these data.

In a recent study on roughly 4,500 different patients, we showed a strong association between all three computationally generated cardiac biomarkers and the endpoint of cardiovascular death over a two-year period. Moreover, the information in these biomarkers is independent of each other marker and of the information provided by existing clinical risk scores, electrocardiographic metrics, and echocardiography. Strikingly, the addition of MV, SM and HRM to left ventricular ejection fraction significantly improves model discrimination, as well as both the precision and recall.

This research is under the direction of professor John Guttag.

Laboratory Sponsored Activities

CSAIL Outreach

Imara

The overall goal of Imara is to find and implement long-term, sustainable solutions to make educational technology and resources available to domestic and international communities. In concert with partners both inside and outside the Institute, we hope our work will enable us to help bridge the digital divide — the perceived gap between those who have access to the latest information technologies and those who do not.

CommuniTech

CommuniTech is a domestic outreach initiative that attempts to heal the digital divide in the local community. The program provides economically disadvantaged adults with the tools they need to gain access to valuable information they can use to better their lives and the lives of their families.

CommuniTech focuses on teaching basic computer technology skills and on providing accessibility to computer hardware. Families Accessing Computer Technology (FACT) is a six-week course taught by MIT student volunteers, designed to teach basic computer skills to underprivileged adults. Clients gain basic computer proficiency, marketability to prospective employers, and a greater connection to the world at large.

Clients who complete the class receive computers from FACT's partner program, the CSAIL Used Computer Factory (UCF). UCF refurbishes donated computers by installing new operating systems and productivity software. UCF also plays a small part in greening MIT by recycling unwanted equipment that might otherwise end up in landfills.

Lacotec Laare, Kenya

The Laare Community Technology Centre (LCTC) in Kenya was founded by Eric Mibuari '06 in 2005 with the assistance of MIT's Public Service Center. The aim of this community center is to increase general computer awareness and literacy in the Laare community by providing cheap, local, and accessible training on the use of computers.

The LCTC particularly targets high school–educated youth, seeking to equip them with basic computing skills that they can apply for personal use, in industry, and in education. So far, the LCTC has offered various levels of training to more than 500 students. The LCTC takes particular note of the economic difficulties of its potential trainees and strives to charge the lowest feasible fees. Recently, it has expanded to include a IT educational initiative that targets elementary school students.

Middle East Education through Technology

CSAIL's support of the Middle East Education through Technology (MEET) program has continued over the past year. MEET is an innovative educational initiative aimed at creating a common professional language between young Israelis and Palestinians.

MEET enables its participants to acquire advanced technological and leadership tools while empowering them to create positive social change within their own communities. Many MIT students volunteer to teach MEET summer courses at the Hebrew University in Jerusalem. CSAIL continues to host http://meet.csail.mit.edu/ and provide technical support to the MEET program.

TEK

Several CSAIL members have been supporting Time Equals Knowledge (TEK). The project empowers low-connectivity communities by providing a full internet experience using email as the transport mechanism.

Although the internet has revolutionized information delivery for most of us, for many communities in the developing world accessing online resources remains an economic and technological challenge. High charges for telephone and internet service provider access can quickly grow unaffordable, and low-bandwidth connections limit the amount of material that can be viewed per session. Because phone lines are limited, it is often difficult to time-share between internet and voice. Furthermore, unreliable network and power infrastructures can sometimes block internet access altogether.

Compared to direct web access, email can be much cheaper, more reliable, and more convenient in developing areas. The TEK Client operates as a proxy on the user's machine, enabling users to browse downloaded pages using a standard web browser. New searches are automatically encoded as emails and sent to the TEK Server, which queries the web and returns the contents of resulting pages by email. TEK is free software distributed under the GNU Lesser General Public License.

OCW Outreach Initiative

Adnan Esmail, a mechanical engineering graduate student, has combined MIT's OpenCourseWare (OCW) initiative with CSAIL's support to bring the Institute's educational resources to the Indian subcontinent. The OCW outreach initiative consists of mirror sites that make the course information available to those in nations with poor bandwidth infrastructure.

The program has been realized in partnership with Aligarh University in Aligarh, India, and Lahore University of Management Sciences, in the capital of Pakistan's Punjab province. It runs on hard drives that have been generously donated by Maxtor for OCW proliferation. This expansion of access gives talented students who do not have the technological resources they need a chance to reach their full educational potential.

Seminar Series

Six speakers gave presentations during the 2010–2011 Dertouzos Distinguished Lecture Series.

Craig Mundie, Microsoft Corporation, "More like Us: Human-Centric Computing"

Kathy Yelick, UC Berkeley, "Exascale Computing: More and Moore?"

Rodney Brooks, Heartland Robotics, "Robots Working with People"

Chuck Thacker, Microsoft Research, "The Future of Computer Architecture Research"

Bill Weihl, Green Energy Czar, Google, "Green IT: Myth, Mirage, or Reality?"

Michael Jordan, UC Berkeley, "Inference of Protein Structure and Function"

Organizational Changes

During the past year Victor Zue continued to serve as director of CSAIL. The director's duties include developing and implementing strategies designed to keep CSAIL growing and evolving, fund raising, determining laboratory policies, and examining promotion cases. Four principal investigators served as associate directors and assisted the director with his duties. They were Frans Kaashoek, Chris Terman, Daniela Rus, and William Freeman (who served as interim associate director during the fall semester while Daniela Rus was on leave). Professor Rus returned to the position of associate director during the spring term.

In December 2010, Victor Zue announced his resignation as director of CSAIL commencing July 1, 2011. Victor Zue served in leadership positions for the past 10 years within CSAIL and its predecessor laboratory, the Laboratory for Computer Science (LCS), which merged with the Artificial Intelligence Laboraory (AI) in 2003. A search committee was formed under the leadership of professor Ronald Rivest and a new director and codirector were named in June 2011. Anant Agarwal will become the director of CSAIL commencing July 1, 2011, and Chris Terman will become the codirector.

CSAIL has an active executive committee, which met twice a month to review and advise the director on policy, processes, and activities within the laboratory. Members of the executive committee included Regina Barzilay, Jack Costanza, Erik Demaine, John Fisher, David Gifford, John Guttag, Nancy Lynch, Rob Miller, Karen Shirer, and Patrick Winston, in additional to the director and associate directors.

John Guttag continued in the role of "space czar," overseeing the space committee and managing the allocation of space within CSAIL. The space committee also implements improvements to the facilities that will increase the quality of the environment for the laboratory's faculty, staff, and students.

Jack Costanza continued as the assistant director for infrastructure, overseeing information technology infrastructure and user support, building operations, and communications. Karen Shirer continued in her role as assistant director for administration, overseeing finance and human resources.

Elizabeth Bruce continued as director of industry partnerships. She oversees the CSAIL Industry Affiliates Program (CSAIL-IAP), a corporate membership program that offers companies the opportunity to access CSAIL's faculty and students through annual conferences, recruiting events, and on-site visits.

Awards and Honors

Our faculty and staff won many awards this year, including the following:

Scott Aaronson: 2010 Career Award for Scientists and Engineers (PECASE), MIT CSAIL

Anant Agarwal: 2010 Jamieson Prize for Excellence in Teaching, MIT EECS; 2010 Best Student Paper Award, International Conference on Autonomic Computing

Arvind: 2011 Best Paper Award, ANCS Symposium

Hari Balakrishnan: 2011 ACM SIGCOMM "Test of Time" Award; 2011 Best Paper Award, ACM/IEEE

Tim Berners-Lee: 2011 UNESCO Niels Bohr Gold Medal Award; 2011 Gorbachev Foundation Mikhail Gorbachev Award; 2011 Bilbao Web Summit DANA Web Awards; 2011 Honorary Doctor of Science, Harvard

Konstantinos Daskalakis: 2010 Sloan Foundation Fellow; 2010 NSF Career Award; 2011 Spira Teaching Award, MIT EECS; 2011 Outstanding Paper Award, SIAM

Erik Demaine: 2010 Mathematical Association of America Polya Lecturer Award; 2011 Mathematical Association of America Polya Lecturer Award; 2011 Smithsonian Pieces in Permanent Collection Award

Jack Dennis: 2011 Best Paper Award, Gauss Center for Supercomputing

Srini Devadas: 2011 Best Paper Award, ACM/IEEE

Frédo Durand: 2011 NVIDIA Best Paper Presentation, ACM

Joel Emer: 2011 Purdue University Outstanding Electrical and Computer Engineer Alumni Award;

2011 Most Influential Paper Award, ACM/SIGARCH–IEEE-CS/TCCA

John Fisher: 2010 Best Paper Award, Neural Information Processing Systems (NIPS)

Shafi Goldwasser: 2010 IEEE Emanuel R. Piore Award

Eric Grimson: 2010 Best Paper Award, Neural Information Processing Systems (NIPS)

Daniel Jackson: 2010 Bose Award for Excellence in Teaching, MIT EECS

Frans Kaashoek: 2011 ACM Infosys Foundation Award; 2011 "Test of Time" Award, ACM SIGCOMM

David Karger: 2011 ACM SIGCOMM "Test of Time" Award

Boris Katz: 2011 IBM Open Collaborative Faculty Award

Manolis Kellis: 2010 NSF United States Presidential Early Career Award for Scientists and Engineers (PECASE)

Jonathan Kelner: 2010 Sloan Foundation, Fellow; 2011 Edgerton Award, MIT; 2011 Best Paper Award, STOC; 2011 Best Paper Award, SIGMETRICS

Barbara Liskov; 2011 Honorary Doctorate, University of Lugano, Lugano, Switzerland;

2011 Honorary Doctorate, Northwestern University, Chicago

Tomas Lozano-Perez; 2010 IEEE Pioneer Award

Nancy Lynch: American Academy of Arts and Sciences, Fellow

Silvio Micali: 2011 Ford Professor of Engineering Award, MIT

Robert Miller: 2010 Best Paper Award, UIST; 2011 Jamieson Teaching Prize, MIT EECS

Robert Morris; 2010 ACM SIGOPS–Mark Weiser Award; 2011 ACM SIGCOMM "Test of Time" Award

Ron Rivest: 2011 RSA Lifetime Achievement Award; 2010 James R. Killian Jr. Faculty Achievement Award, MIT

Jerry Saltzer: 2010 NIST and NSA National Computer Systems Security Award

Madhu Sudan: American Academy of Arts and Sciences, Fellow

Joshua Tenenbaum: 2011 National Academy of Sciences Leonard T. Troland Award

Patrick Henry Winston: 2011 MacVicar Faculty Fellowship Award, MIT

Nickolai Zeldovich: 2011 NSF Career Award

Key Statistics for Academic Year 2011:

Faculty: 86 (14% women)

Research staff: 46 (22% women)

Administration, technical, and support staff: 66 (64% women)

Postdocs: 60 (10% women)

Visitors: 164 (15% women)

Paid Undergraduate Research Opportunities Program Participants: 79 (27% women)

Master of engineering students: 50 (24% women)

Graduate students: 339 (18% women)

Victor Zue
Director
Delta Electronics Professor of Electrical Engineering and Computer Science