Researchers Find “Memory” in Cells and Molecules

Research reported in the journal *Proceedings of the National Academy of Sciences* provides evidence that some molecular interactions on cell surfaces may have a “memory” that affects their future interactions.

Researchers who use sequentially repeated tests to obtain statistical samples of molecular properties usually assume that each test they conduct is identical to — and independent of — any other tests in the sequence. In their article, however, Georgia Tech researchers provide examples of test sequences that may not be composed of independent and identically distributed random variables.

“If you are probing a cell to get a bit of information, how do you know that the cell is not going to respond by changing the information it reveals the next time you probe it?” asks Cheng Zhu, a Regents’ Professor in the Wallace A. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University. “If you are probing a molecule, can you assume that the molecule will return to its original configuration before you test it the next time?”

The research was supported by the National Institutes of Health.

Using a micropipette adhesion frequency assay, Zhu’s research team studied a number of receptor-ligand interactions. A sequence data analysis conducted by Veronika Zarnitsyna, a research scientist in the Coulter Department, revealed examples in which an interaction observed in one test affected the outcome of a future test. Depending on the biological system, the effect could either increase or decrease the likelihood of a future interaction.

For instance, interaction between T cell receptors and an antigen bound to major histocompatibility molecules showed positive correlation, with one interaction increasing the likelihood of a future interaction. Interaction between C-adherins exhibited the opposite behavior, with one interaction reducing the likelihood of a future interaction. In a third system the researchers studied, the events appeared to be truly independent, with one interaction not affecting a future one.

The research stemmed from an observation by Jun Huang, a graduate student in the Zhu lab, who examined T cell test data and noted that interactions appeared consecutively in long strings and then disappeared for a long while. Huang asked Zhu about the pattern. Zhu then shared his concerns about the independence of the tests with Zarnitsyna, a biophysicist.

Zarnitsyna analyzed data generated by Huang and Fang Zhang — another graduate student in the Zhu lab — and additional data obtained by Yuan-Hung Chien, a student from the laboratory of Deborah Leckband at the University of Illinois at Urbana-Champaign.

“Positive memory increases the likelihood of having two interactions in a row, which generates long strings of interactions,” says Zarnitsyna. “The negative memory, conversely, decreases the likelihood of having consecutive interactions, which results in more solitary interactions in the sequence.”

Zhu compares the negative correlation to the effects of strong light on the eyes. “If you go from the dark to the bright, time is required before you can see well again,” he notes. “Exposure to strong light temporarily inhibits the eyes’ response to the next input.”

Zhu’s research team studies single-molecule mechanics using sensitive force techniques, such as atomic force microscopes and biomembrane force probes, to put cells and molecules together and then measure the forces or times required to pull them apart. Ideas developed for the adhesion frequency assay may also be applicable to this research.

As a next step, Zhu would like to further characterize the memory effect to determine how long it lasts. “It seems reasonable that if you prolong the cycle time — the period between trials — the cell or molecule would gradually forget,” he says.

He would also like to study the biological mechanisms of the memory effects.

“We believe this phenomenon may be biologically important, though we don’t yet know the implications for it,” Zhu adds. “This may represent a way for cells to regulate their adhesion and signaling. For T cells, the ability to ‘remember’ even a brief interaction with a pathogen may be related to their ability to tell an intruder from ‘self’ molecules, which is crucial to the body’s defense in the immune system.”

— John Toon

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How much is a kilogram?

It turns out that nobody can say for sure, at least not in a way that won’t change ever so slightly over time. The official kilogram—a cylinder cast 118 years ago from platinum and iridium and known as the International Prototype Kilogram—has been losing mass, about 50 micrograms at last check.

That’s not so good for a standard the world depends on to define mass.

Now, two U.S. professors say it’s time to define the kilogram in a new and more elegant way that will be the same today, tomorrow and 118 years from now. They proposed redefining the kilogram as the mass of a very large— but precisely-specified—number of carbon-12 atoms.

“Our standard would eliminate the need for a physical artifact to define what a kilogram is,” says Ronald F. Fox, a Regents’ Professor Emeritus in the Georgia Tech School of Physics. “We want something that is logically very simple to understand.”

Their proposal is that the gram—1/1,000th of a kilogram—would henceforth be defined as the mass of exactly 18 x 14,074,481 carbon 12 atoms.

The proposal, made by Fox and Theodore P. Hill—a Professor Emeritus in the Georgia Tech School of Mathematics—first assigns a specific value to Avogadro’s constant. Proposed in the 1800s by Italian scientist Amedeo Avogadro, the constant represents the number of atoms or molecules in one mole of a pure material—for instance, the number of carbon 12 atoms in 12 grams of the element. However, Avogadro’s constant isn’t currently known exactly; it’s a range of values that can be determined experimentally, but not with enough precision to be a single number.

Spurred by Hill’s half-serious question about whether Avogadro’s constant was an even or odd number, in the fall of 2006 Fox and Hill submitted a paper to Physics Archives in which they proposed assigning a specific number to the constant. The authors pointed out that a precise Avogadro’s constant could also precisely redefine the measure of mass, the kilogram.

Their proposal drew attention from the editors of American Scientist, who asked for a longer article that was published in March 2007. The proposal drew five letters, including one from Paul J. Karol, chair of the Committee on Nomenclature, Terminology and Symbols of the American Chemical Society. Karol added his endorsement to the proposal and suggested making the number divisible by 12—which Fox and Hill did in an addendum by changing their number’s final digit from 8 to 6. So the new proposal for Avogadro’s constant became 84,446,886, still consistent with the best mean value and estimated uncertainty determined by the U.S. National Institute of Standards and Technology (NIST).

Fast-forward to September 2007, when Fox read an Associated Press article about the mass disappearing from the International Prototype Kilogram. While the AP said the missing mass amounted to no more than “the weight of a fingerprint,” Fox argues that the amount could be significant in a world that is measuring time in ultra-sub-nanoseconds and length in ultra-sub-nanometers.

So Fox and Hill fired off another article, this one proposing to redefine the gram as 1/12th the mass of a mole of carbon 12—a mole long being defined as Avogadro’s number of atoms. They now hope to generate more interest in their idea for what may turn out to be a competition of standards proposals leading up to a 2011 meeting of the International Committee for Weights and Measures.

At least two other proposals for redefining the kilogram are under discussion. They include replacing the platinum-iridium cylinder with measurements using spheres of pure silicon atoms, and using a device known as the “watt balance” to define the kilogram using electromagnetic energy. Both would offer an improvement over the existing standard—but not be as simple as what Fox and Hill have proposed, nor be exact, they say.

“Using a perfect numerical cube to define these constants yields the same level of significance—eight or nine digits—as in those integers that define the second and the speed of light,” Hill says. “A purely mathematical definition of the kilogram is experimentally neutral—researchers may then use any laboratory method they want to approximate exact masses.”

The kilogram is the last major standard defined by a physical artifact rather than a fundamental physical property. In 1983, for instance, the distance represented by a meter was redefined by how far light travels in 1/299,792,458 of a second—replacing a metal stick with two marks on it.

— John Toon

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Georgia Tech Helps Agency Implement Lean Office Procedures

Mike Parks, Stone Mountain supervisor for Georgia’s Office of Child Support Services (OCSS), shares a letter written by a happy customer: “I would like to thank you for the service I received from you and your staff today. I didn’t have a long wait in the lobby. I came right back to your office and you put all the vital information in the computer about my case. I set up my direct deposit and now I look forward to receiving support for my children. All of my needs were met today and I can use my time working and taking care of my children.”

This happy ending might not have been possible had OCSS not implemented rapid process improvement (RPI), also known as lean management, a set of tools that helps to identify and steadily eliminate waste from an organization’s operations. A 60-office state agency, OCSS is responsible for providing regular child support to families.

With support from the Governor’s Office of Customer Service and technical assistance from lean specialists at Georgia Tech’s Enterprise Innovation Institute, OCSS began to identify areas for improvement in August of 2006. The following November, the OCSS leadership team began meeting with Bill Ritsch and Jennifer Trapp-Lingenfelter of Georgia Tech to develop value stream maps – diagrams used to analyze the flow of materials and information required to bring a product or service to a consumer – in five areas of the child support process.

“We didn’t have a baseline on how long it took us to do each step in the area of establishing a court order, one of our core processes,” says Tanguler Gray, OCSS customer service program director. “It revealed a lot of duplicate work. We discovered that it took 71 days for our offices to take a request from intake to legal filing. Following the lean implementation, however, we were able to cut that to same-day service.”

The second RPI event was conducted in the area of enforcement. Typically, enforcement includes a number of administrative tools including the suspension of drivers’ licenses and professional licenses, property and bank account liens, tax refund offsets, garnishment of lottery winnings, and passport denials. The session resulted in what Gray describes as the “soft-glove early intervention approach,” an improved process.

“We had allowed our customers to set the expectation for us, and now we’re setting the expectation for them,” Gray adds. “By the time a case gets to court on our new early intervention process, the non-custodial parent will have been contacted a minimum of four times — two calls, one letter and then an additional letter if we have to move forward with sending the case to court for contempt. Before the RPI implementation and the soft-glove approach, there weren’t any early intervention calls or non-custodial parent education or expectation established at the first point of contact.”

Should a non-custodial parent fail to respond to the early intervention attempts, OCSS moves forward with aggressive enforcement actions once the non-custodial parent is 30 days out of compliance with the order, as opposed to the previous 60 or 90 days. Prior to the RPI implementation, it would take a minimum of 120 days to take “aggressive” enforcement action.

The lean implementation had a number of positive impacts in other areas. The pilot office for the “locate” (the process for locating non-custodial parents) RPI implementation decreased its caseload by 32 percent. Legal secretaries have saved an average of 10 hours a week by having extra documents printed up-front. And the Fatherhood Program, which provides under-employed non-custodial parents with job opportunities and training, cut the number of days for non-custodial parents to be notified about the program from 69 to 14.

The RPI events have proven to be so successful that five additional events have been approved in the areas of review and modification, interstate cases, accounting, enforcement and legal.

According to Ritsch, lean transformation is a journey that does not end. “It’s going to be a couple of years before OCSS really starts seeing impacts and establishing the lean culture,” he notes. “Our goal is to internally create the skill set to drive this forward. Georgia Tech will always be there to assist, but the agency now has the expertise to continue this path forward.”

— Nancy Fullbright

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Carpet Sustainability Standard Encourages Improved Processes

Don’t call it “green” carpet; call it sustainable carpet. A new standard for assessing the environmental-friendliness of carpet was announced at the 2007 Greenbuild International Conference in Chicago.

The new sustainability standard, approved by the American National Standards Institute (ANSI), addresses chemicals and materials used in manufacturing carpet, the energy used in production, the use of recycled or bio-based content, methods of disposal and/or reuse and the overall environmental performance of manufacturers.

“The LEED standards for buildings suggested that standards were an effective strategy for encouraging competition and providing an objective way of evaluating sustainability claims made in the marketplace,” says Matthew Reallff, an associate professor in Georgia Tech’s School of Chemical and Biomolecular Engineering. Reallff served as chair of the committee that developed the standard.

This new standard aims to help consumers sort out the complex sustainable attributes and encourage manufacturers and their suppliers to seek out or develop environmentally friendly ways of manufacturing carpet. A new sustainability standard, approved by the American National Standards Institute (ANSI), addresses chemicals and materials used in manufacturing carpet, the energy used in production, the use of recycled or bio-based content, methods of disposal and/or reuse and the overall environmental performance of manufacturers.

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preferable processes, practices, power sources and materials.

NSF International, an ANSI-accredited standards development body, created the standard. A committee consisting of carpet and rug manufacturers, end users such as interior design professionals, state agencies responsible for environmentally preferable product procurement practices, academics and non-governmental organizations approved it. The effort was spearheaded by Robert Peoples, director for sustainability for the Carpet and Rug Institute (CRI), a nonprofit trade association based in Dalton, Georgia.

“The new standard builds on earlier efforts by the carpet industry to address environmental issues. The Green Label certification program developed by CRI, which created voluntary and widely adopted standards for carpets to meet emissions criteria for volatile organic compounds and other chemicals, is part of the new standard. The standard aims to measure the environmental footprint of carpet products by looking at the whole supply chain and considering five major performance categories: public health and environment; energy and energy efficiency; bio-based or recycled materials; manufacturing; and reclamation and end-of-life management.

The first carpet products certified to the new standard are expected to be available in the marketplace by April 2008, according to Realf. The sustainability standard builds on earlier efforts by the carpet industry to address environmental issues. The Green Label certification program developed by CRI, which created voluntary and widely adopted standards for carpets to meet emissions criteria for volatile organic compounds and other chemicals, is part of the new standard.

“The new unified standard assures those purchasers that they are selecting environmentally preferable carpets,” says Werner Braun, president of CRI.

“People learn by seeing, experiencing and actually doing something,” explains Eric Johnson, senior operations training specialist for GSE Systems. “We can reinforce what students have learned in class by allowing them to interact with a simulation of a facility. The simulation allows them to gain experience without actually having to be in a real plant, and that helps new employees become productive faster.”

To provide that innovative learning environment, GSE has built a multi-million-dollar simulation and education center at Georgia Tech’s Global Learning Center. The facility is the first of its kind in the United States.

The center includes more than a dozen LCD panels driven by a powerful computer to simulate the many key systems operated from the control room of an electric generating plant. Student operators can adjust controls and immediately see the effects of their actions not only on the system they are controlling, but also on the rest of the plant. Realistic warnings indicate potentially dangerous conditions to which the students must respond. Three-dimensional models show the systems and exact components being controlled.

“The simulation allows plant systems to be integrated so the student operators really see the issue and understand the problems,” adds Johnson.

“We can show them how to operate everything from the simplest system to the whole interrelationship of the systems.”

The new facility currently offers simulations for gas turbine and combined-cycle gas turbine generating plants. GSE sees a major market for its “education through simulation” training, and plans to add simulations for nuclear power.
Flu vaccine delivered using painless microneedles in patches applied to the skin could soon be an alternative to injections using hypodermic needles. Using new grants from the National Institutes of Health (NIH) totaling approximately $11.5 million over five years, researchers from Georgia Tech and Emory University plan to develop a new vaccine product using the microscopic needles.

“A vaccine administered through a skin patch would have a number of advantages, including less discomfort to the recipients, lower cost and reduced production time,” says Richard Compans, professor of microbiology and immunology in the Emory School of Medicine. “Potentially, individuals could administer the vaccine to themselves, perhaps after receiving it in the mail.”

The Georgia Tech and Emory team plans to develop and assess the effectiveness of transdermal patches that include arrays of microscopic needles containing or coated with vaccine. They hope to design patches that could be stored for long periods of time at room temperature and that will increase the breadth and duration of immunity to influenza – perhaps with smaller amounts of vaccine.

“We expect that this research will lead to a better way of delivering the flu vaccine, which will allow more people who need it to receive the immunization in a convenient and effective way,” says Mark Prausnitz, a professor in the Georgia Tech School of Chemical and Biomolecular Engineering. “Beyond that, the possibility of replacing a hypodermic needle with a microneedle patch should significantly impact the way that other vaccines are delivered.”

The project team has extensive experience in microneedle development, influenza vaccines, vaccine delivery systems, product development and interdisciplinary collaboration. Beyond influenza, the research could have implications for immunization programs in developing countries, where eliminating the use of hypodermic needles could make vaccines more widely available and address the problem of disease transmission caused by the re-use of conventional hypodermic needles.

Prausnitz and his colleagues have been working since the mid-1990s to develop microneedle technology for painless drug and vaccine delivery through the skin. Much smaller than conventional hypodermic needles, the microneedles in the arrays are made of titanium, stainless steel or various polymers – including some that could dissolve into the skin, carrying vaccine with them. The Georgia Tech team has also developed manufacturing processes for microneedle patches and tested the ability of the needles to deliver proteins, vaccines, nanoparticles, and small and large molecules through the skin.

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A new technique for creating films of barium titanate (BaTiO$_3$) nanoparticles in a polymer matrix could allow fabrication of improved capacitors able to store twice as much energy as conventional devices. The improved capacitors could be used in consumer devices such as cellular telephones — and in defense applications requiring both high energy storage and rapid current discharge.

Because of its high dielectric properties, barium titanate has long been of interest for use in capacitors, but until recently materials scientists had been unable to produce good dispersion of the material within a polymer matrix. By using tailored organic phosphonic acids to encapsulate and modify the surface of the nanoparticles, researchers at Georgia Tech’s Center for Organic Photonics and Electronics were able to overcome the particle dispersion problem to create uniform nanocomposites.

“Our team has developed nanocomposites that have a remarkable combination of high dielectric constant and high dielectric breakdown strength,” says Joseph W. Perry, a professor in the Georgia Tech School of Chemistry and Biochemistry and the Center for Organic Photonics and Electronics. “For capacitors and related applications, the amount of energy you can store in a material is related to those two factors.”

The new nanocomposite materials have been tested at frequencies of up to one megahertz, and Perry says operation at even higher frequencies may be possible. Though the new materials could have commercial application without further improvement, their most important contribution may be in demonstrating the new encapsulation technique — which could have broad applications in other nanocomposite materials.

“This work opens a door to effectively exploit this type of particle in nanocomposites using the coating technology we have demonstrated,” explains Perry. “There are many ways we can envision making advances beyond what we’ve done already.”

Reported in the journal Advanced Materials, the research was supported by the Office of Naval Research and the National Science Foundation.

Because of their ability to store and rapidly discharge electrical energy, capacitors are used in a variety of consumer products such as computers and cellular telephones. And because of the increasing demands for electrical energy to power vehicles and new equipment, they also have important military applications.

Key to developing thin-film capacitor materials with higher energy storage capacity is the ability to uniformly disperse nanoparticles in as high a density as possible throughout the polymer matrix. However, nanoparticles such as barium titanate tend to form aggregates that reduce the ability of the nanocomposite to resist electrical breakdown. Other research groups have tried to address the dispersal issue with a variety of surface coatings, but those coatings tended to come off during processing — or to create materials compatibility issues.

The Georgia Tech research team decided to address the issue by using organic phosphonic acids to encapsulate the particles. The tailored organic phosphonic acid ligands, designed and synthesized by a research group headed by Seth Marder — a professor in the Georgia Tech School of Chemistry and Biochemistry — provide a robust coating for the particles, which range in size from 30 to 120 nanometers in diameter.

“Phosphonic acids bind very well to barium titanate and to other related metal oxides,” Perry says. “The use of tailored phosphonic acid ligands to modify the surface of the barium titanate nanoparticles enabled us, with the correct solutions processing, to incorporate them at a high density into polymer systems. This also allowed us to provide good compatibility with the polymer hosts — and thus very good dispersion as evidenced by a three- to four-fold decrease in the average aggregate size.”

Though large crystals of barium titanate could also provide a high dielectric constant, they generally do not provide adequate resistance to breakdown — and their formation and growth can be complex and require high temperatures. Composites provide the necessary electrical properties, along with the advantages of solution-based processing techniques.

“One of the big benefits of using a polymer nanocomposite approach is that you combine particles of a material that provide desired properties in a matrix that has the advantage of easy processing,” Perry adds.

In addition to those already mentioned, the research team included Philseok Kim, Simon Jones, Peter Hotchkiss and Joshua Haddock.

— John Toon

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Georgia Tech researchers have developed a miniature sensor that uses polymer membranes deposited on a tiny silicon disk to measure pollutants present in aqueous or gaseous environments. An array of these sensors with different surface coatings could be used during field-testing to rapidly detect many different chemicals.

Since this new sensor allows water and air samples to be analyzed in the field, it is an improvement over classical techniques that require samples be carried back to the laboratory for analysis. This research, funded by the U.S. National Science Foundation, was presented at the American Chemical Society’s 234th National Meeting.

The heart of the disk-shaped sensor is a microbalance that measures the mass of pollutant molecules.

“When pollutant chemicals get adsorbed to the surface of the sensor, a frequency change of the vibrating microbalance provides a measure of the associated mass change,” says Oliver Brand, associate professor in Georgia Tech’s School of Electrical and Computer Engineering.

Cantilever-type balances, which move up and down like a diving board, are commonly used for measuring the amount of a chemical in the gas phase. However, the mechanical vibrations of the balance used to detect the mass changes are damped in liquids, causing the sensitivity of the balance to decrease. So Brand and graduate students Jae Hyeong Seo, Stuart Truax and Kemal Safak Demirci searched for structures whose vibrations were less affected by the surrounding medium.

The researchers chose a silicon disk platform for the sensor. The disk shears back and forth around its center with a characteristic resonance frequency between 300 and 1,000 kHz, depending on its geometry. With proper actuation and sensing elements integrated onto the microstructures, Brand can electrically excite the resonator and sense these rotational oscillations.

Since each sensor has a diameter of approximately 200 to 300 microns, or the average diameter of a human hair, an array of a dozen sensors is only a few millimeters in size.

To determine how to selectively detect multiple pollutants in the same sample, Brand began collaborating with Boris Mizaikoff, formerly an associate professor in Georgia Tech’s School of Chemistry and Biochemistry.

Mizaikoff and graduate students Gary Dobbs and Yuliya Luzinova selected commercially available hydrophobic polymers and deposited them as thin film membranes on the sensor surface. They continue to investigate innovative ways to consistently deposit the polymers at the disk surface, while ensuring sufficient adhesion for long-term field applications.

“By modifying the silicon transducer surface with different polymer membranes, each sensor becomes selective for groups of chemicals,” explains Mizaikoff.

An array of these sensors—each sensor with a different chemically modified transducer surface—can sense different pollutants in environments ranging from industrial to biomedical.

Brand and Mizaikoff aim to detect volatile organic compounds (VOCs) in aqueous and gaseous environments. VOCs are pollutants of high prevalence in the air and in surface and ground waters. They are emitted from products such as paints, cleaning supplies, pesticides, building materials and furnishings, office equipment, and craft materials.

A common VOC is benzene, with a maximum contaminant level set by the Environmental Protection Agency at 5 micrograms per liter in drinking water. Many VOCs are present at similar very low concentrations, so effective sensors must accurately measure and discriminate very small mass changes.

“We’ve been able to measure concentrations among the lowest levels that have been achieved using this type of resonant microsensor,” notes Brand. “While we have not achieved the required sensitivity yet, we are constantly making improvements.”

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Researchers Boris Mizaikoff and Yuliya Luzinova use a microscope to inspect a microsensor chip coated with polymer layers.
Georgia Tech Edison Fund Supports Early-Stage Companies

Thomas Edison often receives credit for inventing the electric light bulb, though his real accomplishment was in making the device — as well as the phonograph and motion picture camera — commercially successful. That focus on commercializing innovation is now providing the foundation for a new venture bearing Edison’s name at Georgia Tech.

Launched by a multi-year grant from the Charles A. Edison Fund — which is named for the inventor’s son, a successful businessman and former governor of New Jersey — the Georgia Tech Edison Fund will provide seed funding for early-stage technology companies that have a close association with Georgia Tech.

“We will focus on startups at the very early stage, because that’s the hardest money for an entrepreneur to find,” explains Stephen Fleming, manager of the new fund. “Once companies have customers, a product and some traction in the marketplace, they can interest larger investors.”

In his role as Georgia Tech’s chief commercialization officer and director of Commercialization Services within the Enterprise Innovation Institute, Fleming helps faculty members, graduate students and others launch new companies through Georgia Tech’s VentureLab. He sees first-hand how difficult locating early funding can be.

“There is certainly a perception that there’s not enough early-stage capital in Atlanta,” he says. “The Georgia Tech Edison Fund will not by itself be a silver bullet that solves this problem, but I think it will help by putting new energy into and a new focus on early-stage financing.”

Fleming plans to make the requirement for a Georgia Tech connection as broad as possible. For example, the Fund will invest in companies that may be founded by Georgia Tech faculty, students and graduates; licensing technology from Georgia Tech; sponsoring research at Georgia Tech; or even hiring a large number of Georgia Tech alumni.

The Fund will be “evergreen,” meaning it will reinvest the proceeds from any liquidity events back into other opportunities. Fleming is establishing an investment committee to help guide decisions. The investments will generally be less than $250,000.

Donations to the Georgia Tech Edison Fund will be completely targeted to entrepreneurs. The Fund is not charging a management fee, nor is it paying carried interest to the managers, Fleming notes.

Fleming says the Charles Edison Fund and Georgia Tech are natural collaborators. “We are excited to be working with them because Edison is one of the instantly recognizable brand names around the world,” he explains. “Edison means innovation, invention and creativity — all of which are things we are trying to do. This helps us get our message across very quickly.”

For the Charles Edison Fund, the new Georgia Tech initiative represents an opportunity to continue the tradition of innovation and entrepreneurship established by the famed inventor. The collaboration with Georgia Tech is the first university partnership for the Edison organization, which supports a broad range of educational activities aimed at keeping the Edison tradition alive.

“This is a novel idea that I don’t think has been tried before,” says John Keegan, chairman and president of the Charles Edison Fund. “What makes it novel is that it provides support to faculty members whose ideas are literally in the pre-natal stage, before the concept is developed enough to take to a venture capitalist to seek funding.”

— John Toon

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Center Creates MEMS Computer-Aided Design Environment

Georgia Tech researchers have received a Defense Advanced Research Projects Agency (DARPA) award to participate in a multi-university research center that will develop a computer-aided design (CAD) environment for micro-electromechanical systems (MEMS) and nano-electromechanical systems (NEMS).

The new research center, to be called the Investigate Multi-physics Modeling and Performance Assessment-driven Characterization and Computation Technology (IMPACT) Center for Advancement of MEMS/NEMS VLSI, will be led by the University of Illinois at Urbana-Champaign and will include teams from Purdue University and Lehigh University as well as Georgia Tech. A consortium of companies — including BAE Systems, Inc., Innovative Design & Technology, MEMtronics Corp., Raytheon Co., Rockwell Collins, Inc. and the Rogers Corp. — will also participate financially with DARPA on the center.

The research will seek to develop CAD systems that are based on physical models and therefore can conclusively predict the behavior of MEMS devices. Eventually, engineers developing systems with MEMS devices could use a simple drag-and-drop interface to simulate not only the electrical effects of MEMS usage, but also thermal, mechanical and reliability aspects as well.

“This kind of predictive capability could greatly increase the speed...
Wireless Research Could Untangle the Office

That tangle of wires under desks could soon be a thing of the past. Scientists at the Georgia Electronic Design Center (GEDC) at Georgia Tech are investigating the use of extremely high radio frequencies (RF) to achieve broad bandwidth and high data transmission rates over short distances.

Within three years, this “multi-gigabit wireless” approach could result in a bevy of personal area network applications, including next generation home multimedia and wireless data connections able to transfer an entire DVD in seconds.

The research focuses on RF frequencies around 60 Gigahertz (GHz), which are currently unlicensed – free for anyone to use – in the United States. GEDC researchers have already achieved wireless data-transfer rates of 15 gigabits per second (Gbps) at a distance of 1 meter, 10 Gbps at 2 meters and 5 Gbps at 5 meters.

“The goal here is to maximize data throughput to make possible a host of new wireless applications for home and office connectivity,” says Prof. Joy Laskar, GEDC director and lead researcher on the project along with GEDC research scientist Stephane Pinel.

GEDC’s multi-gigabit wireless research is expected to lend itself to two major types of applications: data and video, says Pinel. Very high speed, peer-to-peer data connections could be just around the corner, he believes – available potentially in less than two years.

Devices such as external hard drives, laptop computers, MP-3 players, cell phones, commercial kiosks and others could transfer huge amounts of data in seconds. And data centers could install racks of servers without the customary jumble of wires.

“Our work represents a huge leap in available throughput,” Pinel says. “At 10 Gbps, you could download a DVD from a kiosk to your cell phone in five seconds, or you could quickly synchronize two laptops or two iPods.”

The input-output (I/O) system of current devices cannot approach such speeds. Moreover, Pinel said, users of multi-gigabit technology could wirelessly connect to any device that currently uses Firewire or USB.

Wireless high-definition video could also be a major application of this technology. Users could keep a DVD player by their side while transmitting wirelessly to a screen 5 or 10 meters away.

Currently, Pinel said, the biggest challenge is to further increase data rates and decrease the already-low power consumption, with a goal to double current transmission rates by next year. The Georgia Tech team is seeking to preserve backward compatibility with the WiFi standard used in most wireless local area networks (LANs) today.

GEDC researchers are pursuing this goal by modifying the system architecture to increase intelligence and effectiveness in the integrated circuits that transmit the data. The researchers are using advanced computer-aided design tools and testbed equipment to recalibrate system models and achieve the desired improvements in speed and functionality.

Investigators are placing special emphasis on implementing an RF concept called single-input-single-output (SISO) / multiple-input-multiple-output (MIMO), which enables ultra-high data throughput. At the same time, they seek to preserve backward compatibility with WLAN 802.11, the WiFi standard used in most wireless LANs today.

“We are pursuing a combination of system design and circuit design, employing both analog and digital techniques,” Pinel adds. “It’s definitely a very exciting mixed-signal problem that you have to solve.”

— Rick Robinson

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