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FEBRUARY 2008 VOLUME 112, NUMBER 2

OLD KING COAL

Impact of coal power at UW-Madison p. 12

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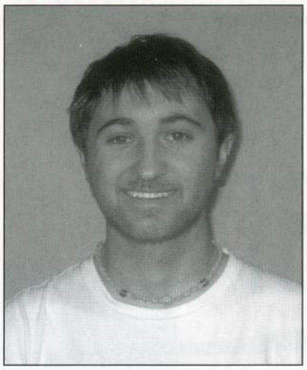

Kevin Jayne
Writing Editor

A man, a plan, a canal: Panama

Last month, I had the chance to escape the frigid Wisconsin weather for a cruise of the Caribbean. In the wake of another grueling finals schedule, my only intentions were to relax and catch some rays. Instead, the trip presented me with the unique opportunity to pass through one of the world's greatest engineering projects—the Panama Canal. I knew post-finals recovery was complete when I found myself curious about its design and history.

Operating since 1914, the canal revolutionized the transport of goods from one side of the world to the other. Though the convenience of a passage through Central America was realized hundreds of years earlier, the Panama Canal has yet to eclipse the century mark. Despite a seemingly simple goal, every previous design and attempt to traverse the narrow strip of land had failed.

The ideal solution was clearly a waterway, so the French took the first crack at carving the landscape down to a sea-level canal. The effort failed miserably, as the French found themselves completely unprepared for a climate ripe with diseases such as malaria and yellow fever. France was forced to abandon the project when 22,000 workers perished in just a few years of labor.

It was at this point a burgeoning international superpower, the United States, threw their hat in the ring. For aiding Panama in its quest for sovereignty from Colombia, the U.S. had earned the right to take over the project in 1904 and awarded control of the canal upon its completion. President Theodore Roosevelt declared success absolutely crucial for the purpose of expanding naval power and control of the valuable land area. The engineer chosen to head the project, John Stevens, had a considerable task on his hands.

So how would Stevens handle the position? Despite pressure to move forward with the canal, Stevens made a controversial decision shortly after work had resumed and shut down the project.

He sent the laborers home, shifting his focus toward sanitizing the area to create a safe work environment. Stevens worked with Dr. William Gorgas, who was the first to surmise that mosquitoes were the root cause of the malaria and yellow fever outbreak. Their efforts were initially met with skepticism, due to the dramatic increase in cost as well as the delay a work stoppage would cause. However, the two stuck by their guns and virtually rid the area of both diseases, a state that's been maintained to this day in the canal zone.

With the area now fit for labor, Stevens confronted skeptics once again as he altered the French design for a level canal to that of a lock system, requiring the removal of far less soil. Cost issues arose again as Stevens worked to persuade Roosevelt, eventually receiving approval. After 10 years of construction, the Panama Canal was finally operable. The design has remained largely unaltered since, undergoing expansions only to keep up with the ever-increasing size of cargo ships.

John Stevens' approach to such a complicated situation naturally got me thinking ahead to my own upcoming engineering career. Despite the burden of a country willing him forward, he demonstrated the mindfulness to take a step back and reassess his options. This is a strategy not reserved for earth's greatest challenges—it should be applied in everyday problem solving as well.

Stevens' decision to halt the project until working conditions were improved was rooted in ethics as well as practicality. The move exemplified what would later come to be the first point of the National Society of Professional Engineer's ethical code: "to hold paramount the safety, health, and welfare of the public."

As we all witnessed in the Minneapolis tragedy this past summer, modern engineering decisions continue to have serious implications for general public welfare. Engineering is a profession in which even the smallest of details requires full consideration (undersized one-half inch gusset plates have recently been determined the critical factor in the 35-W bridge collapse).

Even at the entry-level position, the inherent responsibility that comes hand in hand with a job in engineering cannot be understated. WE

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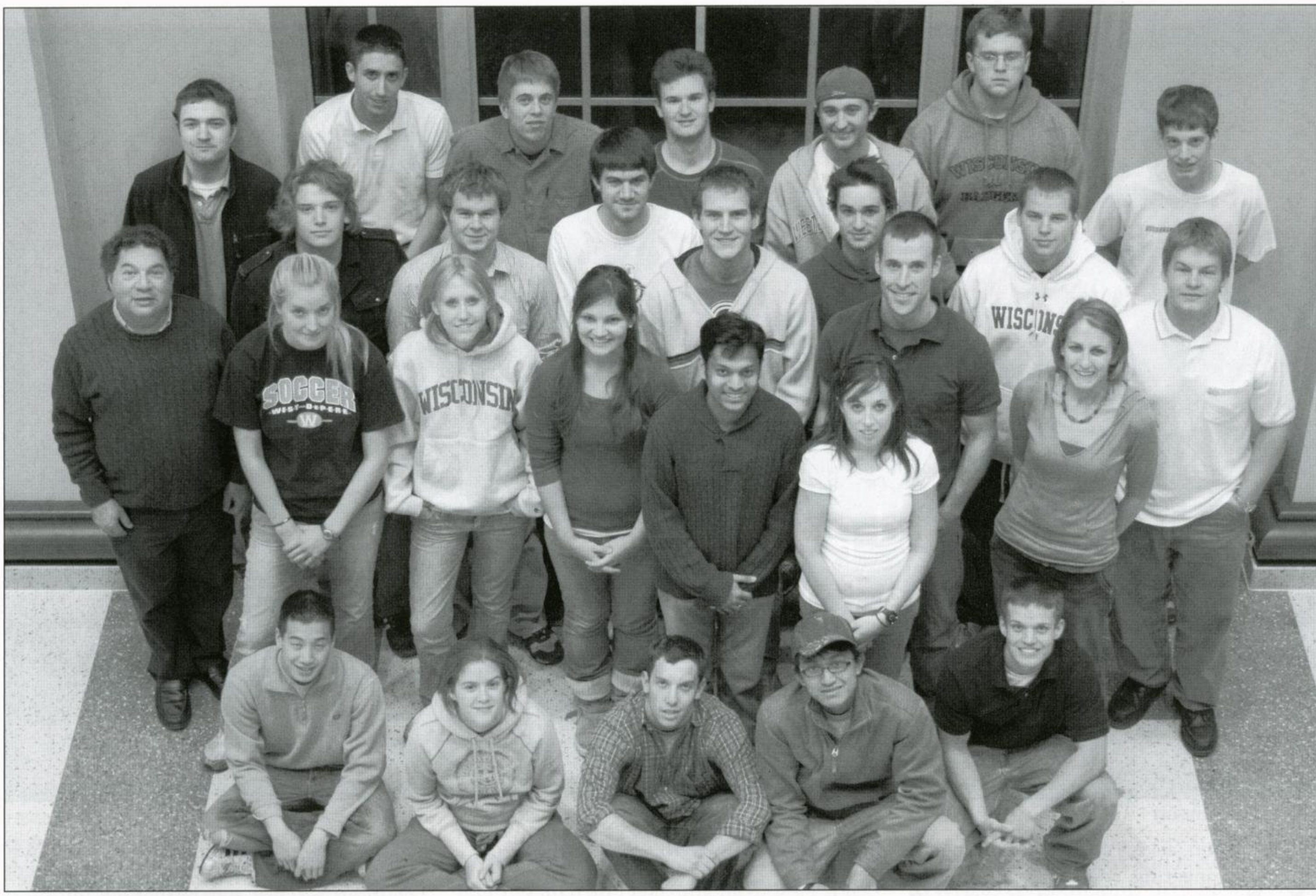

Photo by Jamie Tabaka and Anna Mielke

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The Plastic Professor

World-renowned polymer expert always finds time for his students

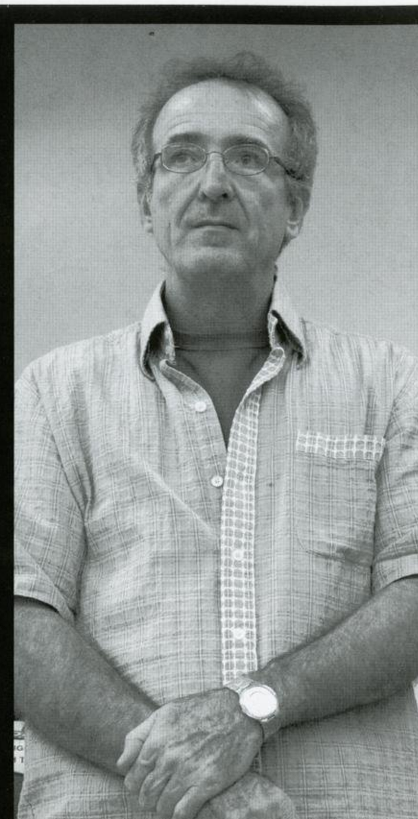


Photo by Matson Contardo

By Ryan Denissen

When asked to list common engineering materials, most students would recall metals such as steel, aluminum and copper. However, more polymers are used in engineering designs than all three of these combined. Professor Tim Osswald of UW-Madison's mechanical engineering department is an expert in polymer engineering and strives to teach students the engineering behind plastics.

When speaking with professor Osswald, the origin of his accent is difficult to determine. Because of his last name, few would guess he was raised in Columbia.

"We come in all colors and flavors and sizes," Osswald says. Professor Osswald came to the United States as an exchange student with a desire to learn English. He attended the South Dakota School of Mines and Technology. After seven years, Osswald graduated with a bachelor's and master's degree in mechanical engineering. He then attended the University of Illinois where he earned a Ph.D. in polymer processing. He decided to further explore his interests in polymers and attended the Institute for Plastics Processing in Aachen, Germany.

After two and a half years of postdoctoral work in Germany, Osswald began looking for an opportunity to work in the United States.

"I wanted to go into teaching and actually Madison was my first choice," he says.

Osswald wanted to come to Madison for both the university and the city. UW-Madison is at the forefront of modern polymer processing and it has built a name for itself.

"In the areas of polymers and rheology, Madison is known as the cradle," Osswald says. Fortunately, UW-Madison was able to offer Osswald a faculty position.

Osswald says that his greatest passion is his family, but this family man shows equal dedication to helping his students. Osswald teaches many of the mechanical engineering polymer sections for the core manufacturing processes classes. He also teaches the upper level polymer classes: Design with Polymers and Modeling and Simulation in Polymer Processing. As an instructor, Osswald loves the opportunity to contribute his knowledge to the student body. In fact, his favorite part of teaching is the personal experiences with students during his office hours when he can contribute directly to a student's understanding. "What I enjoy most about teaching is seeing the satisfaction on a student's face when they get something, when you have the feeling you have taught them something new."

Osswald's students enjoy these individual learning experiences. "He is very approachable, a very nice person and easy to talk to," UW-Madison undergraduate Travis Day says. As a well-known and respected leader in the polymer field, Osswald spends a lot of time traveling to various conferences and meetings. However, even with this busy schedule, he is still able to find time to help his students.

Like many experts in their field, Osswald often does litigation consultation. Osswald is unique, however, because he uses these case studies from industry as learning tools for his students. "That is where I get many of my real life examples for my class" Osswald says. He has even developed a series of five minute podcasts using real examples to discuss engineering ethics. "This is an area that we really don't touch very much in engineering education."

He is continuously finding new ways to prepare his students for their future career in industry. "Osswald is constantly revising his courses to improve their quality and keep them current," teaching assistant Sean Petzold says.

Osswald's enthusiasm for teaching includes a desire to lead the polymer engineering curriculum. He has written seven textbooks, including "Polymer Processing Fundamentals" and "Injection Molding Handbook." Osswald says that one of his passions as an engineering professor "is to write the textbooks and help set the direction for the field." Osswald's commitment has helped to establish UW-Madison as a clear leader in polymer engineering study worldwide.

As a knowledgeable individual interested in molding the polymer engineering field, Osswald is also the English language editor of the Journal of Plastics Technology and an editor for the Americas for the Journal of Polymer Engineering. Though English is not his native language, Osswald's verbal and writing skills outshine many native speakers. He explains that he acquired these skills through "practice" and assistance from his Ph.D. advisor at the University of Illinois.

Professor Osswald is also committed to advancing the polymer engineering field through research. Currently, his main focus is researching the polymers of renewable resources, also called biopolymers. These polymers are better for the environment than traditional polymers because they are typically biodegradable and are produced from renewable and sustainable resources such as corn and soybean.

Another recent project Osswald has started may help save the lives of U.S. soldiers. He is designing non-pneumatic tires for vehicles. Rather than using pressurized air, an inner structure will support these tires.

"One of the applications is for the Humvees so that when their tire gets shot out they are not stranded," Osswald says. Tires designed with an inner structure could prevent "flats" from occurring and help soldiers avoid vulnerable situations.

Osswald has published over 100 papers, making his research well known around the world. "He is very knowledgeable of the fields and is very well respected," Petzold says. Unfortunately, his extensive body of work and world-renowned research once made him a target for plagiarism. In 2005, a faculty member from a foreign university completely plagiarized one of his papers. A colleague of Professor Osswald found the copied paper in an international journal. "They may have thought that it was far enough away that nobody would notice, but today with the web you can search anything," Osswald says. The culprit was quickly dismissed from the university.

With the recent renovation of the Mechanical Engineering Building, the dean's office saw the need for improvements to the polymer research and teaching facilities. Professors Osswald, Turng and Giacomin were involved in the design of the new Polymer Engineering Center. The new center has three main functions: student curriculum development, research and industry relations.

Photo by Matson Contardo

Professor Osswald examines the molecular orientation of a soy-based protein plastic.

"Before we were crammed in various labs in the CAE building," says Day. The new Polymer Engineering Center provides an open area for students and faculty to work, as well as consolidating all of the lab equipment to a single location. "Now we have all of our labs under a single roof … in one room that is 3,500 square feet," Osswald says. This central hub allows polymer researchers to easily ask questions, discuss results and get assistance when needed.

UW-Madison students and faculty are very privileged to have this center. "As far as mechanical engineering departments in the country, this facility is unique," Osswald says. This new facility demonstrates the UW-Madison College of Engineering's commitment to remaining a premier polymer engineering university.

Polymers are a relatively new engineering material and their use continues to grow as new applications and materials are developed. Professor Osswald is working harder than anyone to teach students about the materials and mold the polymer field for the future. WE

Author bio: Ryan Denissen is a senior majoring in mechanical engineering.

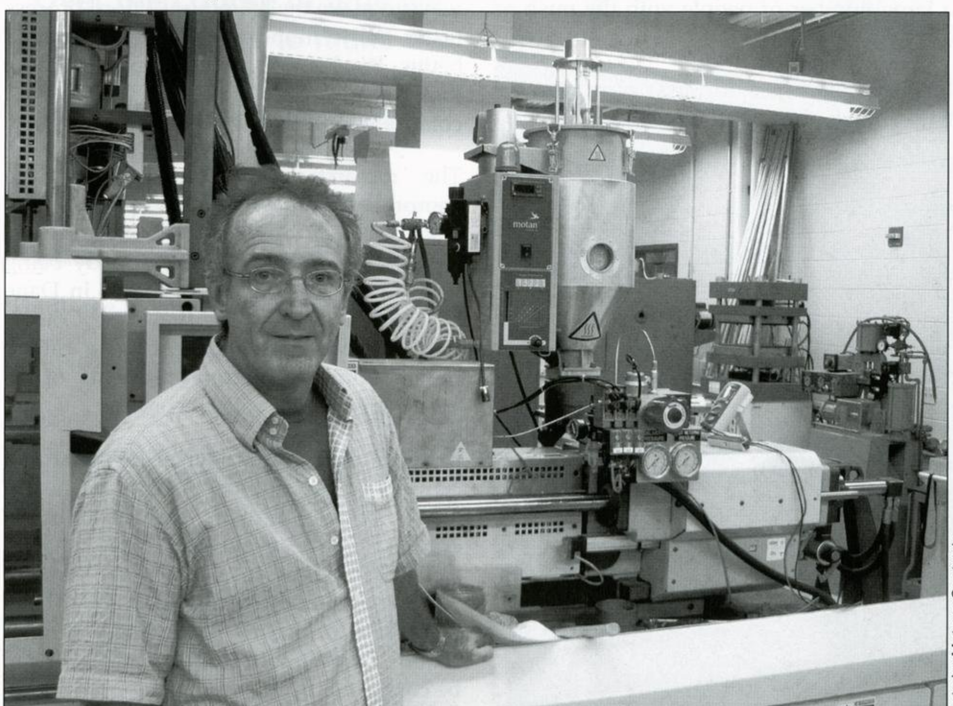


Photo by Matson Contardo

Located in the newly-renovated Mechanical Engineering Building, the Polymer Engineering Center offers better facilities for student curriculum development, research and industry relations.

Campus Emergency Alerts

By Elizabeth Grace

In light of the tragic Virginia Tech shootings last spring, campuses all over the country have evaluated their crisis communication alert systems to ensure that they provide maximum security for their students. In September of 2007, UW-Madison was forced to enact their own emergency procedure system when safety on the west side of campus was threatened. While many students received news of the campus lockdown via e-mail and word of mouth, some students claim they walked home late at night from classes, work and club meetings on a deserted campus unaware of the possible dangers they faced.

In the days following the campus threats, students and staff questioned whether the university took all of the appropriate measures and whether steps could be taken to better alert students. Talk of cell phone notifications such as voicemails and text messages started to surface.

Following the tragedies at Virginia Tech, several startup companies specializing in mass communication alert procedures were established. These companies have the abilities to send voicemails and text messages to cell phones, phone calls to land lines and e-mails to multiple addresses of a large number of people with the push of a button.

UW-Madison has formed a committee to address this issue and develop the best alert system for contacting students. The committee consists of Division of Information Technology (DoIT) staff knowledgeable in data and phone routing technology, John Lucas from the UW-Madison communications department who aids in press releases and the UW Police—including police lieutenant of emergency management, Joe Hornbeck. The committee met over the summer to research and begin to work out processes.

"Over the course of time we have found ways to make the [communication] process faster. We've found ways to make the data better. We learned that the pool of data that we were drawing e-mail from wasn't comprehensive enough," Hornbeck says.

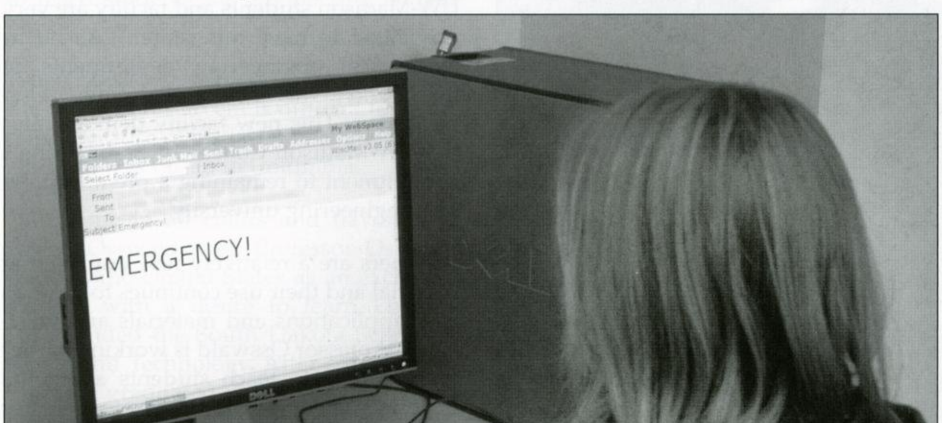


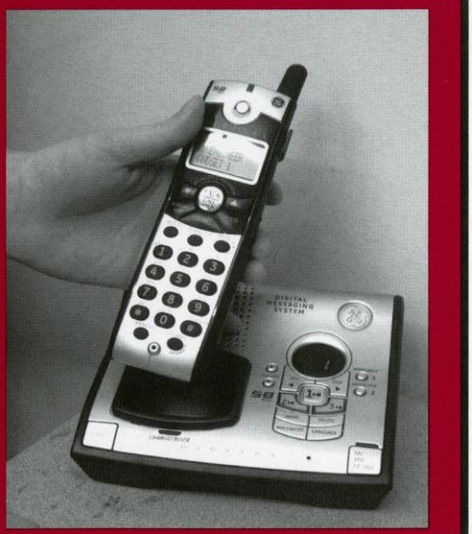
Photo by Anna Mielke

Currently, the only campus-wide emergency alert systems in place at UW-Madison are through e-mail or word of mouth.

The research committee completed a comprehensive review of its options. They began with an operation already in place: Reverse 911. This system is already being utilized by non-student residents in Dane County and it involves the Dane County Communication Center sending a call to phone numbers alerting residents of an emergency with a voice recording.

Between staff and students' personal and campus phone numbers, there are nearly 36,000 phone numbers that need to be enrolled in the program. Approximately 2,500 of these are entered into the Reverse 911 system each week once they have met the formatting and programming requirements. Soon, students and staff can be contacted through the system.

Other options include installing communication devices in classrooms such as battery powered alert systems on a



Photos by Kristina Thomson and Anna Mielke

message screen that are controlled via FM radio waves. In the case of an emergency, radio waves could be sent to these screens, which would then light up and warn students in class. The committee has also looked into installing wireless remote speakers that can be mounted in classrooms, and sirens or PA systems similar to those in high schools. While all of these could aid in alerting students, installation, maintenance and management of the systems would be both costly and time consuming.

"Over the course of time we have found ways to make the [communication] process faster. We've found ways to make the data better."

-Joe Hornbeck

"Until the crisis comes home for them [students] are just not participating," Hornbeck says.

Another option is text messages to students' cell phones. However, campuses that have incorporated text messaging alert systems have experienced many difficulties. While UW-Madison has the capabilities to send these text messages, research on other campuses has shown that students are reluctant to sign up to receive the text message alerts for fear of receiving spam from the universities or due to text messaging expenses. Also, many cell phone companies may block the service assuming that such a mass operation might include spam that their customers would not want to receive.

Another concern is that the mass text messages could lead to thousands of phone calls which would quickly overload cell phone towers.

"If I sent ten or twelve thousand text messages out to tell you there is an active shooter, you're going to get on your phone to call somebody, so you create this big loop within the infrastructure, and we are not entirely convinced that the infrastructure can even handle it," Hornbeck says. "We are not entirely convinced that the system—the infrastructure for distributing text messages—will actually support the volume that we have. There are times on campus, for example football games, when everyone is on their cell phones that the system is considerably bogged down."

In addition to technical concerns with a mass text messaging system, there are questions of how such a plan might be implemented.

"With text messaging, there comes a lot of policy issues. There are free systems out there, but then you get beer ads. Do you really want the number one binge drinking school in the nation to have beer ads on their emergency text messages? We can't really do that," says Hornbeck. UW-Madison has looked into third party vendors, but there does not seem to be any proof that these systems are infallible. The committee feels, however, that if there is a system that can support a campus of our size flawlessly, the next step would be to choose a vendor.

There are several alert options that UW-Madison could invest time and money into. At this time, though, students must depend on e-mail alerts and word of mouth to find out about emergencies on campus. Whatever decision the committee makes, student safety will be their top priority. WE

Author bio: Elizabeth Grace is a senior studying English and technical communications.

Photo by Anna Mielke

The UW-Madison Police Department is one of many offices researching alternative ways to alert students and faculty in the event of a campus crisis. Current methods include sending text messages to cell phones and installing alert systems in classrooms.

Open source means Open doors

What is 'open source' and what does it mean for you?

By Jaynie Sammons

Unless you're a computer engineer or IT-savvy, the term "open source" may not make you think of anything computer-related. But while you've been busily updating your highly-commercialized Windows operating system, a growing community of users has been utilizing open source software and taking advantage of features beyond the realm of what many know to be possible.

The phrase open source refers to the sharing and manipulation of the source of a product, design or even knowledge. Open source is most commonly associated with the collection of files that translates from a readable format to what the general public sees and uses on their end—a program's source code. Since open source code can be manipulated by the general public without repercussion, the user can expand the capabilities of a program beyond what is initially marketed by the company.

Hieu Q. Tran, Ph.D., an associate instrumental technologist in the Chemistry Computer Center, is familiarized with the topic. Tran not only helps to research computing hardware and software for the chemistry department, but also helps to ensure that their interconnected network of computers runs smoothly.

"The benefits to using open source software is that it's free ... nowadays, when you buy commercial software you have to upgrade, or when a new [operating system] comes out you have to replace all your hardware and software, which can get expensive," Tran says. "You can choose what you need and you can, depending on your abilities, modify the software to make it more efficient for your system. And if you have time, you can modify your code and give it back to the community."

One recent development in the world of open source is the free productivity suite OpenOffice.org. The software is designed to be similar to Microsoft Office, but its code is available to developers who are encouraged to develop their own applications within the framework. These additions are often posted for all to use and incorporated into the next release of the suite.

"The benefits to using open source software is that it's free ... nowadays, when you buy commercial software you have to upgrade, or when a new [operating system] comes out you have to replace all your hardware and software, which can get expensive."

-Hieu Q. Tran, Ph.D.

Tran used OpenOffice.org's presentation software (think Microsoft PowerPoint) as an example of the power of open source software. Most students are familiar with PowerPoint's general interface and know what it is capable of creating. But Tran explains that the abilities of the software are vaulted into a whole different level when using open source software.

"Let's say I prepare my PowerPoint lecture on here, and I record my voice and change the slides while running the software. So in the end I would have a movie of what I'm doing on the screen. You could make it into a lecture and post in on the web for students," Tran says.

Tran also described the term "hacking" as a good thing, rather than the notorious definition the media has attached to the term. While a hacker may be someone who gathers illegal information from computers, it is recognized amongst the open source community as someone with a vast knowledge in source code manipulation.

"The real definition that the people in the computer community like to hear is 'hack,' meaning you create some good things, some kind of tips or tweaking. It doesn't always have the [negative] meaning of someone who broke into your computer," Tran says.

Regardless of what you call it, the output of open source developers is impressive. And, as Tran later added, the improvements made through the release of open source code have helped an extended audience—not just those doing the improving—because every update is posted for all to use.

But why would developers donate their time debugging and improving code for the general public? Tran suggests that it may actually be more selfish than it sounds. "People volunteer for that. There are a lot of young, talented people out there who are doing this ... it's like exercising your brain ... and also, it's kind of like a bragging right," Tran says.

Historical Background

The label open source was first coined by Netscape on January 22, 1998 when the company announced it would make its source code accessible to the public. They released the code for their 5.0 version of Netscape Communicator Standard Edition, which included Netscape Navigator. Many questioned Netscape's motives and wondered if this strategic move would hurt them in the long run.

Netscape argued that "harnessing the creative abilities of all Internet developers will be an unprecedented way to advance the features and quality of Netscape Communicator for all customers," and hence developed a commu-

Continued on page 10

Open source means opens doors

(continued from page 8)

nity (Mozilla.org) for developers to share their thoughts on enhancing the product. The code developed by this community was then reviewed by a group within Netscape and re-released. The product was continuously improved, due in great part to the efforts of the open source community. Mozilla.org is now home to the very popular—and open source—Firefox Internet browser.

The Internet is arguably the best example of the value of open source. Users are able to freely gather information from sources they would not normally have access to without the connection the Internet provides. They can post information of their own, knowing that it will be shared with a broad audience. And most importantly to values of the open source culture, users are also able to interact with each other without limitations based on location or economic status.

A Dying Culture

Unfortunately, Tran believes that he open source community has lost some of the momentum that it held when it initially started. He claims this could be due to lack of funding, resulting in increased commercialization. Redhat.com, for example, used to be a hub for open source, hosting Linux, an open source operating system.

"The Linux on this site used to be really good and people used to pay attention to it; you could build scientific software on it, for example. But now it [has become] commercialized so the open source is no longer reliable to run my more serious software," Tran says of Redhat.com.

It's hard to know for certain if the open source culture is dying out, or if commercialization is simply quieting down this once prominent group. But in anticipation of reaping the benefits of these computer masterminds, the general population can only hope that this community regains momentum. WE

Author bio: Jaynie Sammons is a senior in industrial and systems engineering. This is her fourth semester with the magazine.

OLD KING COAL

Technology provides the means to improve the reliability, cost and environmental impact of coal power on UW-Madison's campus.

Photo by Ahmad Asyraf Rosli

By Matt Stauffer

Wisconsin in general, and Madison in particular, has a reputation for being green-minded and environmentally conscious, but controversy surrounding the use of coal has cast a black cloud over the UW-Madison campus which threatens to bring political acid rain down on the university physical plants and other power facilities in Madison.

Coal-fired power plants provide energy for more than half of our nation's electricity demand. Critics of coal often cite this fuel as being excessively dirty and rather inefficient. However, its low cost and abundance results in its wide use. There are three coal-fired power plants on Madison's isthmus: the MG&E power plant on Blount Street, UW-Madison's Charter Street plant and the state-run Capitol Heating and Power facility.

Since 1958, the Charter Street power plant has provided UW-Madison with heating and cooling, performing a crucial role in the daily operations of the university. The Charter Street plant is currently facing a lawsuit from the Sierra Club and other environmental groups over issues surrounding the plant's permit and maintenance practices. The suit contests that the plant did not get new permits for what plant officials state was routine maintenance—including an economizer replacement and tube replacements—which has been performed several times since 1996. If these items are classified as more than "routine maintenance," a new permit is required for the Charter Street plant. This would undoubtedly be accompanied by new emissions standards which the plant would not meet with current technologies. The plant applied for a new permit in 1999, but it still has not been issued. In the past few years, the federal Environmental Protection Agency has relaxed the standards of "maintenance driving new permits," so under current law the maintenance in question is not an issue. However, the Sierra Club argues that, during the time the maintenance was performed, the law required the plant to seek new permits and meet stricter emissions standards. (Case update available at www.news.wisc.edu/14528)

"The existing [Charter Street] plant is 50 years old. The issue is: If we do go ahead and update emission controls on the existing plant, do we want to throw good money after bad equipment … when we can install a CFB [circulating fluidized bed] facility, increase our loads and have an even further reduction of emissions with new best-available technology?" Daniel Dudley, a professional engineer in the campus utilities department, says.

CFB boiler technology is a relatively new method for producing low-cost electricity with coal and other solid fuels at high efficiency and lower emissions than previous boiler designs. In the CFB combustion process, crushed coal is mixed with limestone and fired in a method resembling a boiling liquid, where the fuel is suspended on an upward flow of air. This causes a turbulent mixing of gas and solids, much like a bubbling fluid, which facilitates complete combustion of the fuel and provides more effective heat transfer.

UW-Madison campus power facilities need to meet three main criteria. First and foremost is reliability. Reliability means having a diverse mix of fuels to prevent reliance on just one fuel source that may be curtailed or subject to cost fluctuations. The second issue is cost effectiveness. UW-Madison's fuel and utility bills are paid for by the taxpayers of Wisconsin, so the facility is required by state statute to buy and handle fuel for heating and cooling needs in a cost effective manner. The third issue is environmental concerns. The environmental impact of all UW-Madison facilities, including air emissions and water management, are subject to tight scrutiny.

"Anything we do to our system has to consider the effects of reliability, cost effectiveness and environmental impacts," Alan Fish, UW-Madison associate vice chancellor of facilities planning and management, says. "And frankly, when you look at Charter Street, we clearly can do a lot better in all three areas."

This reliability is even more important on campus than it might be elsewhere.

The physical plant team, along with a major consulting firm, completed a study about a year and a half ago which recommended that UW-Madison move forward with a set of CFB boilers which would allow the facility to continue to burn solid fuels—coal and biomass included—in a more efficient state-of-the-art facility. This facility would allow diversification of fuel supplies, which would effectively increase the reliability and cost effectiveness of the plant through decreasing fuel costs and increasing electricity generation.

A fluidized bed boiler would significantly reduce regulated air emissions compared to the current pulverized coal burning facility on Charter Street. The net carbon output, or carbon footprint, of this proposed facility still needs to be analyzed. Even though carbon is not directly regulated today, it is a driving issue that is important economically and politically.

UW-Madison has provided the state budget committee with a proposal to build a new facility to replace the half-century-old plant on Charter Street, but the proposal was denied in the most recent state budget passed in the fall of 2007. The budget is written every two years. So, assuming that a CFB facility is approved in the 2009 capital budget, UW-Madison could have power provided by a CFB facility as soon as 2012. According to future load projections, our current facilities will run out of capacity sometime in 2014.

"It does take a significant effort to build one of these [CFB facilities] so we would like to try to get this in motion as soon as possible," Dudley says.

The contractor that conducted the proposed study on campus recently completed a successful CFB project in Manitowoc, Wisconsin. Michigan State University, the University of Iowa and the University of Minnesota also have CFB facilities providing power on their campus. All of these facilities are located in America's heartland which have significant agriculture resources. These resources could potentially provide organic matter that a CFB can use for fuel as a supplement to coal.

"We believe the future is going to be some combination of solid fuel," Fish says. UW-Madison recently received a $125 million grant from the Department of Energy to be one of three bioenergy research centers in the country. This project focuses on converting plant matter into fuel for transportation and power generation (see "Beyond Ethanol" in Wisconsin Engineer, November 2007).

"Having a state-of-the-art boiler on campus where we can test a whole variety of fuels as part of our research, on a commercial scale, is going to be another great advantage to keep us on the forefront," Fish says.

One obstacle is that a new facility is expensive. One of the proposed CFB unit's cost is in excess of $110 million. The proposed project includes two CFB units. There are also costs associated with relocation, storage facilities and the need to dismantle the old Charter Street plant. Thus, the final projected cost of this project is in excess of $300 million. If approved, this cost would fall on state taxpayers.

"From the University's standpoint, we want to work with the state to upgrade the 1950's technology on Charter Street," Fish says.

Photo by Ahmad Asyraf Rosli

The 50-year-old coal plant on Charter Street is ready for technological upgrades. Cost efficiency and generation reliability are the main goals for future projects.

Despite the high initial cost of a new plant, there are savings associated with the CFB facility which come from utilizing cheaper fuels and avoiding the need to purchase electricity from private utility companies such as MG&E.

"The study completed a year and a half ago estimated that the first 350,000 pound fluidized bed boiler, assuming both fuel savings and electricity cost, would have a rate of return of about six to eight years," Fish says. This is very attractive considering the expected lifetime of the new facility would be in excess of 50 years.

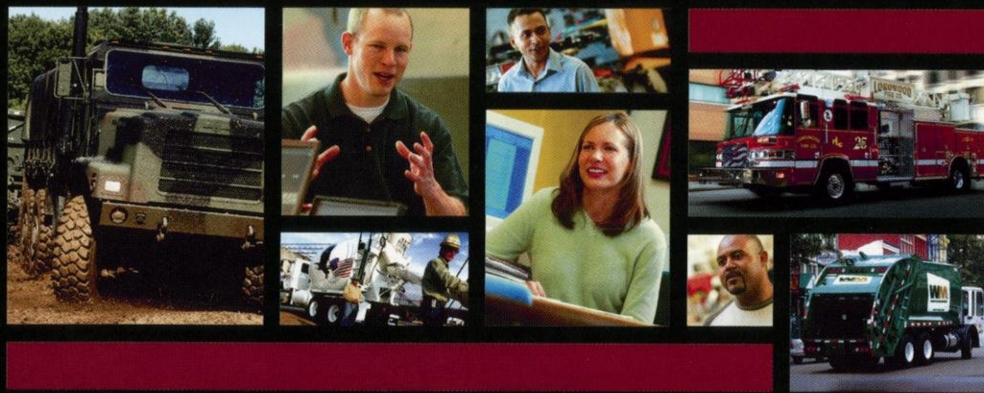
"The beauty of the CFB is that we can burn whatever fuel is available as the most cost effective, and still meet the emissions rate reduction," Dudley says. This equates to significant cost savings when compared to the alternative of phasing out coal plants all together in an effort to meet emission standards.

"If we were to turn the solid fuels switch off today on campus and decide we are going to burn all natural gas or oil, that's a $30 million hit annually to our budget and essentially doubles the fuel costs for this campus," Dudley says.

There are many different parties with conflicting interests who all hold a stake in this project. The University's steam load peaks at about one million pounds per hour, and the annual growth rate, despite conservation efforts, has been steady at about fifty-thousand pounds per hour. The University has a commitment to the taxpayers to meet this demand in a cost-effective manner. Environmental groups will always criticize power plants for their ecological impacts; however, there is no such thing as free energy. From a research standpoint, building an entirely new top-notch power plant would be very exciting and would present new opportunities for energy research at UW-Madison.

"The bottom line is that we are not satisfied with the way the Charter Street plant operates today," Fish says. "We believe that we can be more efficient, we can emit significantly less regulated pollutants and carbon and we believe we can be as reliable or more reliable depending on how we make an investment in the Charter Street plant." WE

Author bio: Matt Stauffer is a fourth year student studying materials science and engineering.



The clear new nuclear

By Zachary Prefontaine

The future of nuclear power has never looked brighter thanks to the efforts of the Global Nuclear Energy Partnership.

The Global Nuclear Energy Partnership (GNEP) was introduced by the U.S. Department of Energy on Feb. 6, 2006. The U.S., China, France, Japan and Russia were the original founders of the organization, and 11 more countries have joined GNEP since this past September.

"What's so exciting about GNEP is it really attempts to address really big issues with nuclear power," Kyle Oliver, a UW-Madison student with a B.S. in nuclear engineering who has his master's research funded by GNEP, says.

GNEP was created to develop and provide sustainable energy without carbon emissions or greenhouse gases and to recycle spent nuclear fuel to help minimize waste and proliferation risks associated with nuclear energy. The group also promotes the spread of nuclear power to developing nations.

GNEP is aggressively pursuing its goals by providing funds to large national laboratories for research and development seeking solutions to the problems associated with nuclear power.

Nuclear power produces no carbon emissions or greenhouse gases, but radioactive waste is produced. In the public's eye, the production of radioactive waste is nuclear energy's biggest downfall. However, as Oliver says, it may actually be one of the biggest advantages nuclear energy has to offer.

"In this mode of generating power, we get to keep the waste. It is in our possession," Oliver says. Coal plants allow their waste (carbon emissions) to rise into the atmosphere, which is going to have enormous consequences for our environment. Nuclear energy allows us to control where the waste goes instead of throwing harmful waste into the atmosphere.

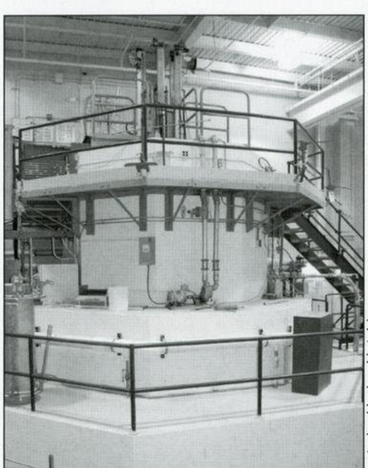


Photo by Harley Hutchins

UW-Madison's nuclear reactor is located in the Mechanical Engineering Building.

GNEP wants to make nuclear power sustainable. To do so, they are developing new ways to recycle spent nuclear fuel in a safe way. The current process used to recycle spent fuel is called Plutonium and Uranium Recovery by Extraction (PUREX). The process takes spent fuel and recycles it into three main parts: pure uranium, plutonium and fission products. The uranium that is recovered is enriched for reuse in nuclear reactors, and the fission products are stored in a geological repository. Many countries, including France and the United Kingdom, currently recycle nuclear fuel with PUREX. However, the U.S. does not because weapons-grade plutonium is produced.

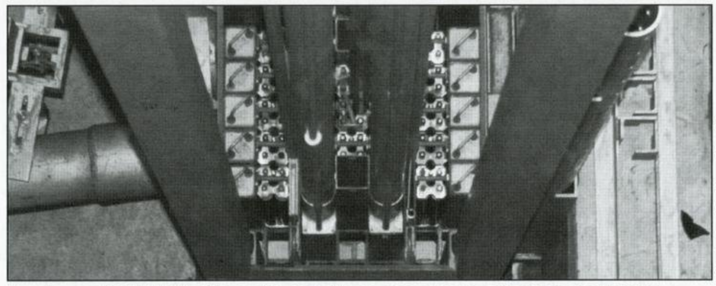


Photo by Harley Hutchins

A view of UW-Madison's nuclear reactor core through the pool of regulating water.

Obviously, it is a big problem to be producing weapons-grade plutonium in today's world, so GNEP has started to develop a new process to recycle spent fuel called Uranium Extraction (UREX+). The UREX+ process does not directly produce weapons-grade plutonium because the plutonium extracted is mixed with neptunium. This greatly reduces proliferation risks because it would be much harder to get the plutonium out of the new compound if it happened to fall into the wrong hands.

GNEP is also trying to spread nuclear energy across the world. As a member of GNEP, the U.S. is making an effort to do their part. The U.S. has formed a program called the Nuclear Power 2010 Program. This program is a joint government and industry effort to find sites for new nuclear reactors and share in their construction. The project has recently issued the first Construction and Operation Licenses to power companies. These power companies will decide by 2010 whether they will go ahead with the construction of a new reactor. The Nuclear Power 2010 Program has promised $500 million of insurance to help cover delays in construction to the first two reactors to be built. The program has also promised $250 million of coverage to the next four after that. This will help encourage power companies to build new reactors, which is an expensive and risky endeavor.

The efforts of GNEP are encouraging and offer hope to finding a sustainable energy free of harmful emissions. However, even though a goal is in sight, much work remains. As always, it is important to remain energy-conscious in our everyday lives as new solutions are sought. Nuclear energy may not be the entire answer, but it is certainly going to play a role. WE

Author bio: Zachary Prefontaine is a third year student studying nuclear engineering. This is his second semester writing for Wisconsin Engineer.

The HEAT

Bacteria in lakes may

By Debjit Roy

Global warming is the greatest planetary emergency we have ever faced. It is estimated that the global surface temperature will warm by an average of 2 to 6 degrees Fahrenheit over the next century. An extensive climate change may alter and threaten the living conditions for much of humankind. In Wisconsin, this could translate to wetter winters and drier summers with longer, hotter and more frequent heat waves.

Several climate research groups around the globe are studying the long-term trends in climate change and its impact on the ecosystem. They are developing processes and taking action in an effort to anticipate and protect the world's future climate. A significant boost for the climate change research community came in 2007 when this research was recognized with a Nobel Peace Prize award.

Most of the research undertaken to understand the factors that lead to climate change has been conducted in the oceans or terrestrial environment. However, a research team at UW-Madison, lead by Trina McMahon, professor of environmental engineering, is part of a multidisciplinary group of UW-Madison and University of Illinois researchers. The group is studying microorganisms—specifically bacteria—that reside in natural lakes with high levels of decaying organic matter. They are searching for clues to climate change in a study funded with a $1.5 million grant from the National Science Foundation.

"People appreciate fish, but not bacteria, in the lakes as bacteria are not visible. But bacteria are unbelievably diverse and have tremendous capability to carry out biochemical reactions," McMahon says.

Bacteria reproduce very quickly, and there are about a million more types of bacteria than there are insects. They are metabolically active organisms and respond very rapidly to any change in climate. They also have a short life span, so the window of time in which researchers can observe changes in their community structure is short. These factors, fueled with the latest tools and techniques, such as DNA sequencing, enable the researchers in limnology, the study of lakes, to answer a plethora of questions about the structure of the bacterial community that might otherwise remain unanswered.

Just like the forest contains several types of trees, the bacterial community contains various types of bacteria species. The initial goal of the research is to understand the functions of the bacterial community and the structure of these communities at different climatic conditions.

Lake ecosystems provide important resources such as food, water and oxygen. The primary function of the bacteria is to recycle the excess carbon present in the lakes. They also recycle chemicals that contain nitrogen and phosphorous, decompose wastes and play an important role in producing minerals that spur the growth of other organisms.

"Bacteria are the workhorses of the lakes," Stuart Jones, a graduate student in McMahon's lab, says.

Due to the difference in climatic conditions such as changes in temperature, light, salinity, chemicals and precipitation, the mixing

Photo by Natasha Benkovich

Professor Trina McMahon and graduate student Stuart Jones belong to a team of researchers investigating the role bacteria plays in climate change.

IS ON:

affect climate change

patterns of lakes vary. For example, Lake Mendota mixes twice a year—once before the lake freezes and once after the ice melts. During different levels of mixing, different structures of the bacterial communities are formed. Hence, the functions of these bacterial communities vary with season.

"Bacteria are the workhorses of the lakes"

-Stuart Jones

The research group has recently concluded a study in the Yuan Yang Lake in Taiwan where typhoons frequently affect the lake.

Before a typhoon hits the lake, the upper portion of the lake is warm and is rich in oxygen, whereas the bottom portion of the lake is cold and lacks oxygen due to the presence of bacterial communities. With typhoon activity, the lake mixes, and new types of bacterial communities form. The most significant insight obtained from the study is that the patterns of the community prior to and after the typhoon are similar. This pattern repeats throughout the typhoon cycle.

At this point, it is clear that the structure of the bacterial community influences its function in recycling carbon into carbon dioxide gas. The climatic changes alter the pattern of the community, which introduces changes in the concentration of carbon dioxide gases in the atmosphere. The changes in the atmospheric carbon dioxide concentration influence the climate. This correlation leads researchers to draw conclusions about how bacterial community structures affect the climate.

However, it is yet to be determined how changing climatic conditions will affect the bacterial community. The bacteria may either stop performing their functions, function faster or function differently, any of which would affect the quality of water and rate of release of greenhouse gases.

One of the biggest challenges of this study is that these bacteria cannot be cultured in research laboratories.

"Bringing bacteria to labs is like growing pandas in zoos. Pandas do not like to reproduce in zoos, and they do not behave the same if their natural habitat is disturbed," McMahon says. That is why fresh bacteria samples need to be collected during climate changes.

The group will also study the bacterial community in northern Wisconsin lakes and identify environmental factors that can change their community structure. Pumps will be used to induce mixing within the lakes. Taking weekly water samples from a northern Wisconsin lake, the researchers will use new DNA sequencing tools to study how these quick-growing microorganisms change in response to their environment. Another goal of the study is to understand the interaction of bacteria with other microbes, such as algae in the lakes. The results from this experiment will be transferable, as the bacterial communities in different lakes perform similar ecosystem processes under similar climatic conditions.

The fundamental idea behind this research is to grasp the basic science behind natural lake ecosystems. "Once we study and understand the system, we may be able to engineer the system better," McMahon says.

How would the ecosystem function if Lake Mendota no longer froze over? All we know is that the mixing pattern and the structure of the bacterial community would be different. But how that would impact the ecosystem processes is a question for further research.

The damages due to global warming are becoming irreversible. "The bacterial communities of lakes can serve as a sentinel—or early warning device—signaling the impact of climate change at all geographic scales," Jones says. This early feedback during climate change can help us act quickly and take preventive measures before climate change moves beyond human control. WE

Author bio: Debjit Roy is a third year Ph.D. student studying industrial systems engineering and is a research assistant with the Center for Quick Response Manufacturing.

Photo by Natasha Benkovich

MP3s No Longer Free

By James Kadunc

You hear a song you like on the radio. You sit down at your computer, find it and download it. In less than five minutes, it's on your MP3 player and ready for you to take to class. These days, the hardest part of getting a song for free is remembering its name. Few people actually see this action as immoral or illegal.

This situation plays out countless times each day and is a textbook case of copyright violation. The Recording Industry Association of America (RIAA) is currently trying to crack down on digital music piracy, mainly through lawsuits against copyright infringers.

The RIAA has recently displayed a tendency to target college students with lawsuits. In the last year, over 1,000 UW-Madison students have received letters from the RIAA accusing them of copyright infringement on university networks. Given that only around 5,000 students live in university housing each year, this is an astonishing number.

The RIAA has not definitively stated why it preys on students in the majority of copyright infringement cases. The David and Goliath lawsuits have garnered the RIAA loads of bad press. The RIAA claims that college students are the most likely to pirate files. While this may or may not be true, it is easy for the RIAA to define who is a college student online.

Internet protocol (IP) address records cannot define much about the users behind them, but colleges have their own range of address space as well as well-defined records of who is using an IP address at any given time. This combination means that, when connected to a campus network, a student's IP address might as well be their name. This means the RIAA, with the help of the university, can compile extremely accurate information on who is downloading what and when.

Generally, upon deciding that a student has violated enough copyrights to make it worth their while, the RIAA will file a lawsuit against the IP address in question. It will then subpoena the owner of the IP address (the university) for the personal information of the person using that particular address at the time the infraction occurred. With that information, the RIAA will generally attempt to settle with the person to the tune of $750 to $2,000 per song. It should be noted, though, that in cases not involving students, fines have ranged up to $250,000.

Photo by Tim Lam

Apple's iPod music players, frequently used on college campuses, are popular storehouses for illicit downloads.

A key in this process is the RIAA's assumption that the owner of the IP address also has information about who is using which IP address and when. In an effort to avoid liability, universities have invested hundreds of thousands of dollars into making sure their systems are readily able to log user information.

UW-Madison's Division of Information Technology (DoIT) originally stated that it would not forward copyright infraction information that it received onto students. The stance it took was that it would not do the RIAA's dirty work in matching IP addresses to students. DoIT felt that the RIAA would not go through with the lawsuit itself; it simply wanted to settle out of court with as many students as possible. Soon, students were being sued by the RIAA, and UW-Madison found it could be held responsible if it chose not to comply.

The RIAA recently released a document outlining its expectations of college campuses in curbing illicit file sharing. The document calls for strict Acceptable Use Policies (AUP) regarding online ethics and campus network use. The RIAA also asked that campuses carry the burden of providing legal alternatives for students, citing the student-oriented Ruckus music service as a viable option. The document went on to recommend that campuses implement a system to block peer-to-peer (P2P) traffic within its network, making the questionable assertion that the sole use of P2P networks is illegal file sharing.

UW-Madison has a strict AUP regarding illicit and malicious use of its network, as well as a separate, equally verbose Copyrighted Materials Policy. DoIT has furthermore taken a hard stance against blocking P2P traffic within the university network. It feels that hindering illegal file sharing is not worth having to block everyone. In keeping with this hands-off approach, UW-Madison also does not promote any music service.

So what can students do to protect themselves? Every student should know DoIT's policies regarding use of the campus network. These documents are fairly long and tedious, but since virtually all students have agreed to them, it's best to know what they entail. If you do choose to run P2P software on the university network, know that the RIAA targets students who share (read: allow for upload) large amounts of files. Naturally, not sharing files hinders the growth of P2P networks, so it may be necessary to decide how much is too much. Obviously, though, the best way to avoid legal trouble is by not breaking the law. WE

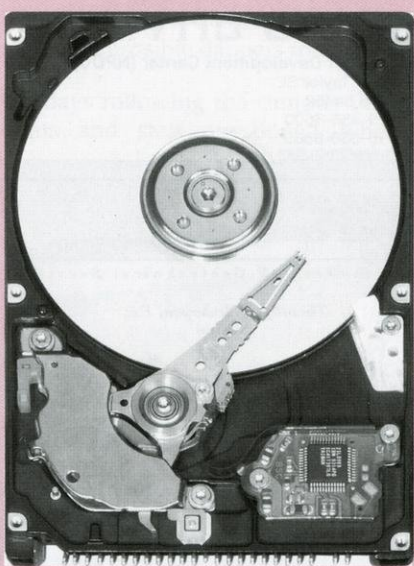
Author bio: James Kadunc is a sophomore majoring in chemical engineering and economics.

ROCK SOLID

By Matt Treske

The world of consumer electronics has continued to evolve faster than a Pikachu rubbed with a Thunder Stone, but advancements to the most static component of the personal computer have been out of the limelight for years. The hard disc drive (HDD) has been a staple of personal computer information storage since the late 1980s and has seen little change in functional, cosmetic or mechanical operation. However, the traditional HDD might be on the same path as the ball mouse when it meets its first major opponent in 15 years of dominance—the solid state drive (SSD).

Solid state drives have already begun to integrate themselves into the daily lives of many consumers. Whether it is a USB pen drive to transport documents or a new iPod Touch to store and play music and video, many college students are already reaping the benefits of this new storage medium.



OLD HDD

Old Hard Disk Drive (HDD) technology used a mechanical magnetic arm and spinning magnetic platters for storage.

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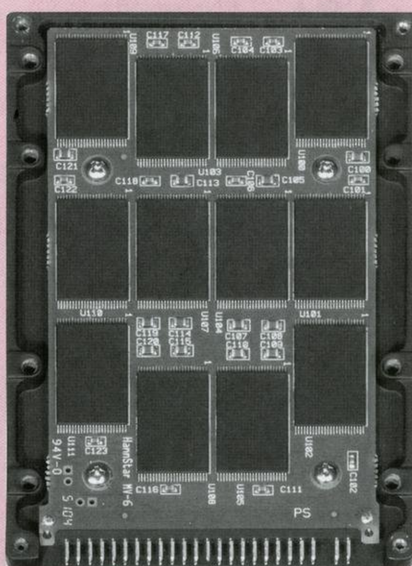


NEW SSD

New Solid State Drives (SSD) have no moving parts and use non-volatile NAND flash chips for storage.

HDDs rely on spinning magnetic platters and a read/write head to store and access information. SSDs operate by utilizing an array of compact flash memory modules to store and access information far more quickly than traditional disc drives. Containing no moving parts, SSDs offer a plethora of unique qualities not shared with their hard disc counterparts.

The advantages of solid state drives begin with their physical durability. Samsung claims that their SSDs can survive impacts of up to 1,000Gs—more than twice the resistance of a typical hard disc drive when not in motion (when an HDD is actually spinning, their maximum impact is much less). They are also operational in extreme climates that range from -20 to 80 degrees Celcius. Additionally, SSDs do not suffer the same type of fatal mechanical errors that so many consumers have become accustomed to when their HDD fails.

The physical attributes of SSDs are highly intriguing to portable electronics users and those sick of replacing dying hard drives, but the most appealing and promising aspect is their sensational speed in seeking stored data.

New solid state storage drives are set to revolutionize data storage.

SSDs are able to locate stored information far more quickly than HDDs because they do not need to search over a broad area of magnetic platter of often fragmented information. Instead, SSDs nearly eliminate seek times and locate information in under half a millisecond. 7200 rpm (typical of many commercial drives today) hard drives usually require 13 to 15 milliseconds for the same task.

Speedy seek times result in demonstrations of high performance in real-world applications such as Microsoft Windows startup times. SSDs do not suffer from "spin-up" delays that traditional HDDs must experience when a computer powers up. According to Samsung, their 32 gigabyte (GB) model has a maximum read time 150 percent faster than that of a traditional HDD and cuts Windows startup times in half.

Laptop owners ought to be the most excited about the introduction of solid state drives. SSDs offer the laptop user an assortment of benefits ranging from improvements in weight and heat to power consumption and noise.

One of the major benefits of the solid state drive is its low weight; an SSD weighs roughly one-third that of a standard 2.5 inch laptop HDD.

Another benefit for SSD laptop consumers is their reduced heat and noise output. An SSD produces much less thermal energy than an HDD and requires less cooling to keep it operational and intact. In addition, it generates absolutely no noise since it does not have any moving parts.

SSDs are also very promising in the realm of battery life. The idle and operating energy consumption of standard laptop hard disc drives is about 0.5 watts and 2.1 watts respectively. Samsung's 32 GB solid state drive requires 0.9 watts under a full load and just 0.05 watts during idling.

But don't toss out your old hard drives just yet! There are several reasons why the HDD is going to remain resilient in the market of consumer electronics.

The most obvious difference between the two drives to the average consumer is the cost. Consumers have become accustomed to decidedly low prices for information storage. The going rate for 1 GB of storage on a 3.5 inch desktop hard disc drive is between $0.20 and $0.40. Currently, the price for 1 GB of storage on a solid state drive is over $10.

Another concern for SSDs is their long-term reliability. Hard disc drives have proven to be a reliable storage medium for over a decade. Their reliability is well-known, whereas SSD reliability has yet to be determined.

Solid state drives show brilliance in seek times, portability and startup speeds. However, hard disc drives continue to show their prominence in transfer rates. Transfer rates are the speeds at which a drive can write or read data to or from the drive itself. Most tests show that 7,200 rpm HDDs boast over a 20 percent advantage in read/write tasks when sustained transfer speeds are emphasized.

Currently, the largest capacity solid state drive available is 128 GB. This is less than half the capacity of the most spacious 250 GB laptop and 1 TB desktop hard disc drives. However, plans for larger models are in the works by several companies in the not-so-distant future.

Advances in flash memory are finally in the spotlight and the dawn of the solid state era may soon be upon us. Questions of price, storage capacity and transfer rates will continue to loom around this exciting medium of storage but will begin to fade as technology grows.

According to iSuppli, a technology market intelligence firm, "By 2010, 60% of notebooks will have flash-enabled storage."

While perhaps a bold claim, SSDs are here to stay. WE

Author bio: Matt Treske is in his fourth semester with Wisconsin Engineer.

Photo by Helmi Hasan

Many consumers rely on external hard drives to expand the storage capacity of their computers.

No-bot like ro-bot

By Victoria Yakovleva

I recently ran into an acquaintance on campus. We got into the usual small talk, consisting of where we're living and how we're liking Madison. Inevitably, the conversation steered into what majors we are pursuing. I told her I am going for an engineering degree. At that, a scrambled look appeared on her face as she asked me, "Engineering? What do you do in engineering?"

When it comes down to it, what engineers do is design. But, when I look through my classes, I find few that involve the design process. This can be a bit discouraging for beginning engineering students such as myself who sit through calculus and chemistry lectures wondering, "So when do we get to build something?"

Thankfully, there are student organizations out there that offer such opportunities. Among them is the Institute of Electrical and Electronics Engineers (IEEE).

In 2003, IEEE student members at UW-Madison came together to design and construct their first robot, named "Oliver," to compete in the Intelligent Ground Vehicle Competition (IGVC). The IGVC is a competition held each year in June, and offers engineering students an opportunity to get involved with the design of an unmanned ground vehicle and compete for cash prizes.

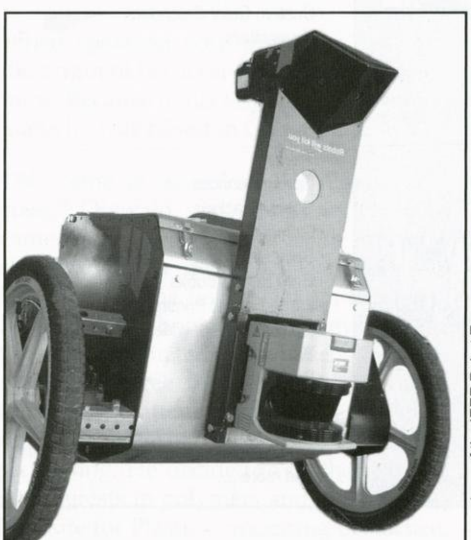


Photo courtesy of the IEEE Robot Team

"ReWIRED" was the team's 2007 entry in the Intelligent Ground Vehicle Competition.

The three award categories are design, navigation and autonomous challenges. The robotic vehicle is qualified only if it is grounded (propelled by means of wheels, tracks, etc.), is within the size limits (within 3 to 7 feet long, 2 to 5 feet wide and no higher than 6 feet) and operates without human guidance (no remote controls).

The design challenge is based on innovative design features in the vehicle's hardware and software. The navigation challenge assesses the vehicle's ability to travel from a starting point to designated destinations while circumventing obstacles such as barrels and fences. The autonomous challenge evaluates the vehicle's ability to navigate around an outdoor obstacle course. The vehicle must stay within the white or yellow painted line boundaries, maintain a maximum five mile per hour speed and avoid obstacles, such as potholes and cones.

Though "Oliver" didn't win anything in 2003, the UW-Madison Robot Team has made significant strides over the years. In fact, in 2006, they placed fourth in the design challenge—an award worth $1,000—for their robot named "WIRED."

"We were pretty proud of it, because everyone else in the top five spent about $20,000 on their robot while we spent $1,500," Jamie Tabaka, this year's team leader, says.

Constructing a prize-worthy robot isn't easy. There is a lot that goes into it. For instance, the design of the body has to hold a laptop, two lead-acid batteries (the same type of batteries used in cars) and power supplies. Power has to be included for the computer, the motors as well as the different sensors, all of which have different power requirements.

"We're always working off of what we've learned in the past," Ken Leedle, this year's mechanical group leader, says.

Last year, for example, they put the batteries at the front. As a result, much of the weight was slightly forward of the front axle.

"When you're going down a ramp [on the course], you have to control the motion very carefully. If you go too fast, the robot just tips over," Dhananjaya Rao, this year's embedded and electrical group leader, says.

Leedle admits that one of the downfalls of last year was that they didn't get to do much testing prior to the competition.

To be qualified for the competition, the group has to turn in their design report at the beginning of May. However, as the team has found out from experience, the majority of the work starts only after this design report is handed in. As Leedle puts it, that's when the "hardcore work sessions" and all-nighters start up.

One of the reasons for the late start is that team leaders spend a good portion of the first semester training newcomers. This doesn't leave much time for work on the robot design.

Constructing a prize-worthy robot isn't easy. There is a lot that goes into it.

"We could probably get things [done] quicker if we didn't spend all sorts of time bringing in new people and training them," Tabaka says.

Many of the other teams in the IGVC competition aren't very team-oriented. Rather, they "have a professor that runs the entire show, who decides what sort of systems they're going to buy … and [then] buys all this really expensive equipment," Tabaka says.

Though it takes a long time to bring new members up to speed, as Zac Witte, this year's software leader says, "… it's worth it. The main purpose is to learn and gain experience."

While new members to the Robot Team learn things like the basics of writing C code, veteran members learn how to improve their design from past years.

This year, the team has decided to use a new scripted interface language to remotely control the robot. This Universal Real-time Be-

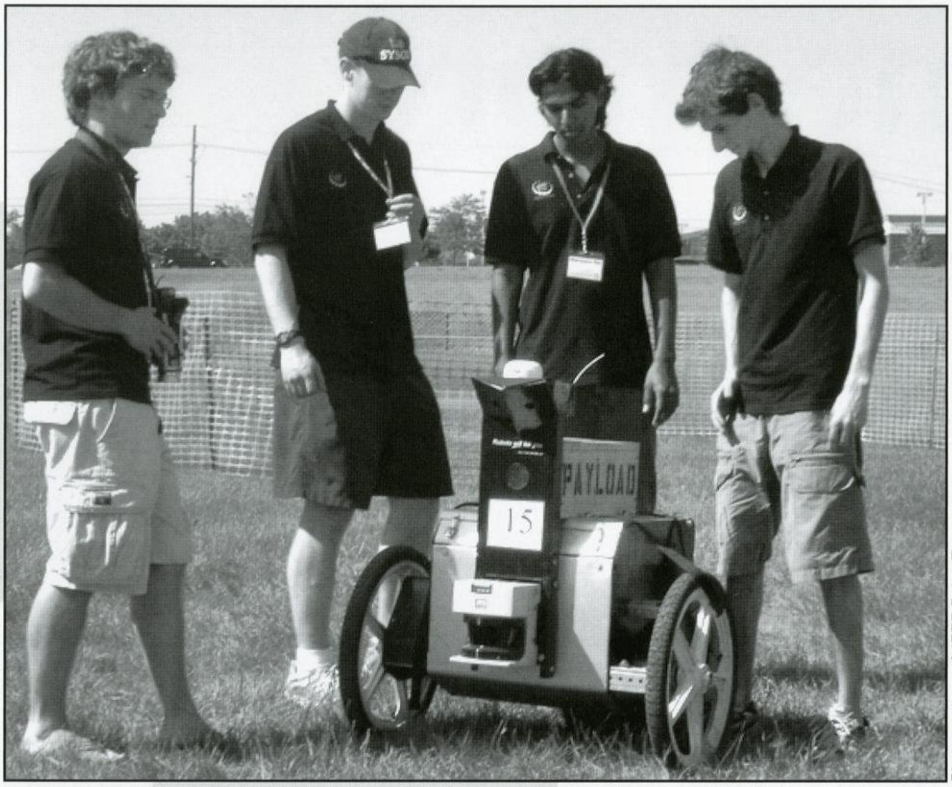


Photo courtesy of IEEE Robot Team

IEEE members, from left, Paul Ambuehl, Ken Leedle, Dhananjaya Rao and Michael Slootsky analyze their robot during the Intelligent Ground Vehicle Competition.

havior Interface (URBI) framework should offer a much simpler and more flexible method for developing a robot that can interact with its surroundings.

Moreover, the team members have come to realize what it takes to impress the judges.

"Most of the judges are in some sort of defense-related profession, so they're attracted to certain things that could be modified for military applications. So we sort of pitch our design in a way that attracts them the most," Tabaka says.

Last year, the team had a laser range finder that shot a laser to see what object was in front of it. Having realized that this wouldn't be good for military applications, this year they're trying to switch to an all-passive robot that uses stereovision—the same concept by which our eyes work.

Stereovision is not only more militarily applicable, but also more intelligent. The new software will allow the robot to not only react to what is directly in front of it, but rather create a map of its entire surroundings in order to figure out the best path to take.

The team has also realized that, as Tabaka says, "the top teams that do well every year enter a couple robots into the competition."

Thus, this year the team intends to enter last year's entry with some slight modifications and also a robot with a completely new design. The benefit of this is that it not only increases their chances of winning, but it also gives them an opportunity to experiment with new features on last year's robot before employing them on the new robot.

The team hopes to have a good chance this year against some of the leading competitors, such as Virginia Tech, who continue to dominate the competition year after year.

Though the team members acknowledge that winning would be great, they're not about to just buy expensive parts in order to win a prize. Each member has a greater reason for being on the team.

Rao, for instance, has been interested in robotics for quite some time. When he saw the Robot Team as a student organization, his interest was instantly sparked.

"I was like, 'Cool, this is something I want to do,' so I started coming to meetings," he says.

Leedle was part of his high school robotics team for three years. When he got to Madison, he was excited to hear there was a robotics team and didn't hesitate to join.

"[You] get a lot of hands-on experience … you won't get in your classes," he says.

"And there's the benefit of having this on your resume," Witte adds.

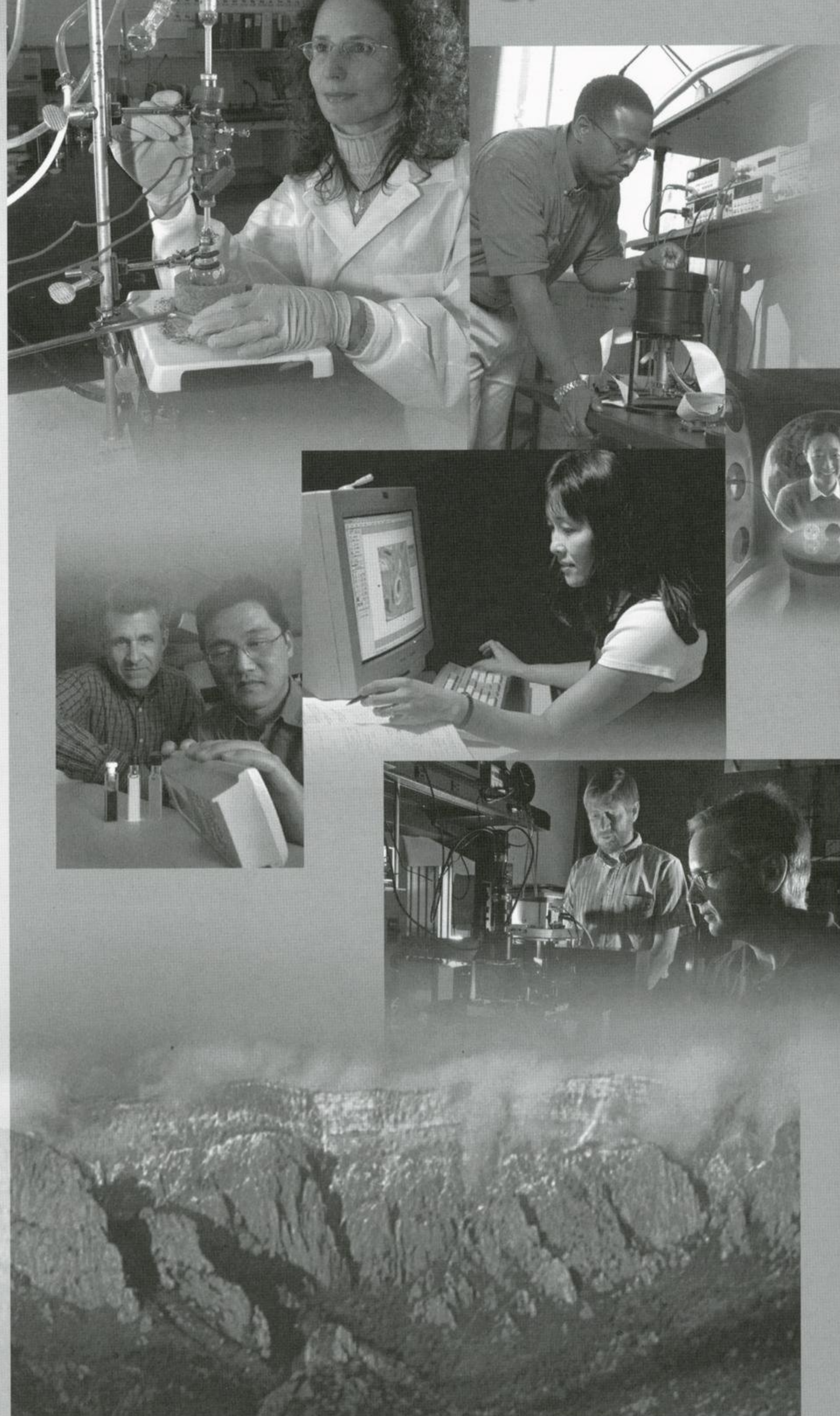
So if you're looking for a taste of engineering design, join a student organization—like the IEEE Robot Team. WE

Author bio: Victoria Yakovleva is a second-year engineering student. This is her fifth article for the magazine.

Just one more

The finest in eclectic humor

By Victoria Yakovleva



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