



**DTC Industrial
Affiliates
Open House
strengthens
collaborations**



Making Connections

What are Minnesota's high-technology strengths? How can an organization such as the Digital Technology Center (DTC) make a difference in boosting Minnesota's high-technology industry?

Around 150 participants explored those questions and learned more about digital technology research, trends, and innovations at the DTC Industrial Affiliates Open House, held May 2. The DTC sponsored the open house to encourage discussion among industry and University researchers, as well as to share DTC research with industry representatives.

"Now that we have been in our new home for more than a year, we wanted to formally update our current sponsors and to welcome involvement by new partners," says Andrew Odlyzko, DTC director. "The open house allowed our faculty members to discuss their work

and allowed industry and faculty to explore opportunities for collaboration."

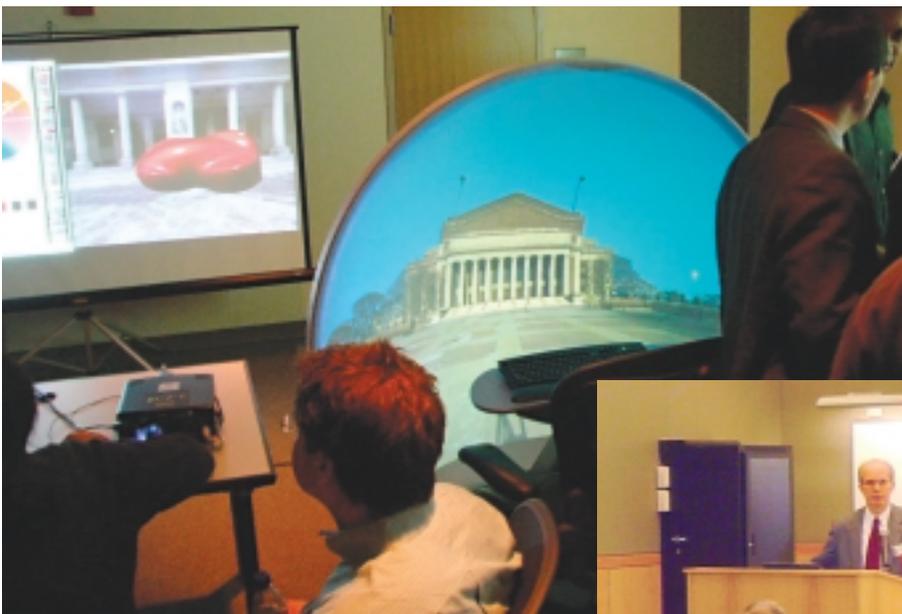
Working with industry is a bedrock principle of the DTC. In fact, the DTC resulted from the identification of digital technology as one of the five key areas that are essential to strengthening the University and advancing the state's economy. Part of its mission involves helping to bolster the leadership position of Minnesota's digital technology industry.

The open house attracted representatives from diverse companies, including Honeywell, Cray, Seagate, Sun Microsystems, Adventium Labs, IBM Corp., MTS, 3M, Sota Tec, MTS, Thomson Legal & Regulatory, Mayo Clinic, and Unisys, among others.

As the keynote speaker, Kate Rubin, president of the Minnesota High Tech Association (MHTA), discussed Minnesota's technology-based economy. MHTA accelerates the growth, success, and sustainability of the state's technology-based economy through public policy, outreach, and education initiatives.

In today's economy, while individual disciplines are important, the lines are blurring and technologies are converging, says Rubin. Considered very good in many individual technology areas, Minnesota is ripe for establishing a framework for sustainable technology based on the intersections of those technology areas, she says.

When technologies converge, experts from various disciplines begin to collaborate with one another, she says. For example, mechanical engineers become contributors to medical research, and information technology experts become contributors to biological research.



“The open house helps us share our research with industry and learn more about industry needs.”

— JIM LICARI

The DTC supports those kinds of interdisciplinary actions, and participants learned more about a number of DTC research projects that involve interdisciplinary approaches with impact that reaches beyond the individual project. The open house featured presentations from DTC faculty (*see below*), poster/demonstration summaries, and discussions with faculty, post-doctoral associates, graduate students, and undergraduate students.

“The open house succeeded in generating discussions among faculty and



industry that continued well beyond the event itself,” says Dr. Jim Licari, assistant director for industrial liaison. “We are excited by those discussions and the possibilities for new partnerships with industry.”

DTC involves industry through its DTC Partnership Program that consists of three levels:

- **Affiliates program**, which includes participation in DTC Advisory Teams, an annual meeting to review DTC research and digital technology trends, e-mail updates, access to member-only web pages, exclusive access with reduced fees to the DTC/Office of Information Technology (OIT) Usability Laboratory, and free or reduced registration fees to Supercomputing Institute workshops and symposia.
- **Consortium Program**, where consortium members work as a team with a group of DTC faculty and researchers to advance the research and application of a specific area of technology. DTC currently has organized two consortiums—the DTC Intelligent Storage Consortium (*see page 7*) and the Digital Design Consortium.
- **Research Program**, which allows companies to work one-on-one in proprietary relationships with DTC faculty.

“The open house helps us share our research with industry and learn more about industry needs,” says Licari. “We look forward to building on the foundations that started or deepened at the open house.”

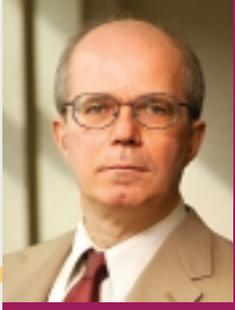
DTC continues to plan additional ways to involve industry, says Odlyzko, including invitations to events such as this one. “We are committed to working together with our industry partners, and we are encouraged by the success of the May open house.”

More information about the DTC Partnership Program is available at <http://www.dtc.umn.edu/industrial.html>.

RESEARCH PRESENTATIONS

The DTC Industrial Affiliates Open House featured the following presentations by faculty members. Interested in learning more? Check out <http://www.dtc.umn.edu/news/industrialaffiliates.html>.

GRID COMPUTING	Jon Weissman
BIOINFORMATICS AND COMPUTATIONAL BIOLOGY	Yiannis Kaznessis
DATA MINING AND DATABASES	George Karypis
GRAPHICS AND VISUALIZATION	Gary Meyer
INTELLIGENT STORAGE ARCHITECTURES	Tom Ruwart, David Du
WIRELESS COMMUNICATIONS	Georgios Giannakis
NETWORKING	Zhi-Li Zhang
DISTRIBUTED ROBOTIC TEAMS	Nikos Papanikolopoulos



FROM THE DIRECTOR

A Place for Ideas, A Place for Collaboration

“ Since the move [to Walter Library], the DTC has succeeded in facilitating new collaborations, in attracting new funding for interdisciplinary projects, and in involving more companies.

Andrew Odlyzko is the DTC director, an ADC Professor in the Department of Mathematics, and Assistant Vice President for Research. He can be reached at odlyzko@umn.edu.

When the Digital Technology Center (DTC) moved into its new home in the remodeled Walter Library just over a year ago, it marked an important milestone. The DTC facility brought together faculty and graduate students from diverse disciplines throughout the University. It also offered industry a place to come and work side-by-side with faculty who are conducting cutting-edge research on the many topics that relate to digital technologies.

Since the move, the DTC has succeeded in facilitating new collaborations, in attracting new funding for interdisciplinary projects, and in involving more companies. It does so with support from throughout the University of Minnesota.

Another change recently involved the DTC—one that will help make its operations run more smoothly without affecting its ability to nurture all kinds of interdisciplinary collaborations. In July, the DTC switched its reporting relationship from the University's Office of the Vice President for Research to the University's Institute of Technology (IT).

The switch simplifies many internal issues, making it easier for the DTC to recruit and hire faculty and administer funding from grants and other sources. The DTC does involve faculty from many departments throughout the campus. However, most of the research in digital technologies is done in IT, so the majority of DTC faculty come from IT departments. IT Dean and Regents Professor H. Ted Davis has supported the DTC from the time it was a mere idea, and he continues as one of the center's strongest advocates.

For the most part, this change will go unnoticed. The DTC will continue to reach out to departments throughout the University and to act as a single point of contact for industry. In this issue, we share with you news about our recent activities with industry and our ongoing collaborations. Many of these activities would not have taken place, if not for the existence of the DTC.

For example, undergraduates from all over the country spent the summer at the DTC and in faculty labs as part of the Summer Undergraduate Bioinformatics Institute (*see story on*

page 4). The proposal resulted in large part from collaborations among DTC faculty and those from the Academic Health Center, the College of Biological Sciences, and the Institute of Technology. The DTC administers the program, which the National Science Foundation (NSF) and the National Institutes of Health funded for four years.

The DTC also supports another large collaborative project that attracted outside funding. The close proximity of a DTC laboratory to one of the University's student computing labs makes possible an innovative project. DTC researchers are turning 60 personal computers into a powerful computing grid that they can tap when machines are not in use by students. The project received funding by the NSF Computer, Information Science, and Engineering Directorate.

This summer, DTC-affiliated faculty received funding from the NSF Information Technology Research (ITR) Program for three new projects:

- The Institute for the Theory of Advanced Materials in Information Technology, led by James R. Chelikowsky, chemical engineering and materials science professor
- Multi-Robot Emergency Response, led by Nikolaos Papanikolopoulos, computer science and engineering professor
- Collaborative Research in Immersive Design Environments, led by Victoria Interrante, computer science and engineering professor

In another new project, faculty in the College of Biological Sciences will make use of DTC expertise and facilities to digitize field data for comparative purposes. The recent UNISYS equipment gift to the DTC and the interdisciplinary nature of DTC provide the necessary ingredients for this type of research.

Although only in its youth, the DTC has attracted diverse faculty and has generated the continuing interest of industry (*see stories on pages 1 and 7*). I invite you to learn more about us, to attend a seminar, or contact us with questions. We are a place not afraid to see where our ideas may go. We are indeed a place for collaboration.

Summer Studies

Undergraduates participate in bioinformatics research at DTC institute

For his summer, junior David Breslauer boarded an airplane and traveled from California to Minnesota in pursuit of an intriguing academic opportunity at the Digital Technology Center.

Taiala Carvalho didn't need to travel far—she already lived in Minnesota and attends the University of Minnesota. She majors in mathematics, but when she learned about the DTC Bioinformatics Summer Institute, she knew that she wanted the experience of conducting research in a cutting-edge arena with faculty experts as guides.

From June 15 to Aug. 22, the DTC became a second home to 15 students from Minnesota and beyond who participated in the first Bioinformatics Summer Institute (BSI). DTC received funding from the National Institutes of Health (NIH) and the National Science Foundation (NSF) to run the institute each summer through 2006.

"The NIH and NSF recognize the impact that computational biology and bioinformatics are having on biomedical research," says Yiannis Kaznessis, BSI director, assistant professor of chemical engineering and materials science, and DTC faculty member. "Through this

program, they want to introduce undergraduates to the field and encourage them to consider it as a possibility for graduate study and a potential career path."

Faculty members from more than 12 departments and the DTC worked in a collaborative spirit to organize and support the institute. The DTC provided crucial support, by bringing faculty from different areas together to work as part of the institute, by offering a top-notch facility and resources for the undergraduates, by providing administrative support, and by lending additional resources to the initiative, says Kaznessis. "The DTC played a very important role in proposal development and acceptance," he says.

The backing of faculty from areas as diverse as chemical engineering, mathematics, physics, biochemistry, plant biology, and computer science and engineering made it possible to offer students an impressive array of research projects, as well as to give them a thorough overview of bioinformatics.

"The main goal of the BSI is to provide the highest possible quality education and research experiences in

bioinformatics and computational biology," says Kaznessis.

The institute attracted 90 applicants, with high grade point averages, some research experience, and varied backgrounds including chemistry, math, biology, computer science, and engineering.

As a student at the University of California at San Diego with an interest in biomedical engineering, Breslauer considered a number of opportunities. "I was looking for an internship program for the summer where I could interact with other students and work on an exciting research project," he says. "This program offered research and collaboration with other students and faculty."

At the BSI, he applied his long-standing interest in computing with his biological studies as he worked on a research project to predict protein interactions. "I wanted to be able to choose a project, work independently, and test out ideas and theories, and that was what I was able to do. It was great. The experience really gave me insights into research."

Carvalho enjoyed the summer program so much that she decided to continue with her research project after the internship ended. "I was really excited to apply mathematics to biological questions."

Working with Hans Othmer, mathematics professor and DTC faculty member, and postdoctoral students, she explored issues of cell growth, attempting to detect and predict patterns. She took advantage of DTC computing resources and ran computer programs that assisted with data analysis. "The internship introduced me to this field."

As part of the institute, students attended workshops in the morning for four weeks. In the afternoon, they worked in the lab on their research project. Guest visitors from Eli Lilly, Cargill, and IBM also shared their perspectives on bioinformatics careers and bioinformatics research at their companies with the students. During the last six weeks, students focused on their



Professor Yiannis Kaznessis (far left) and the 2003 BSI interns.

research and made a final presentation in the last week.

“We wanted them to understand bioinformatics concepts, so they can apply information technology solutions to understanding biological systems,” says Kaznessis. “We wanted them to also gain an appreciation of working together with other scientists from different backgrounds.”

The 15 faculty members from four colleges throughout the University guided students, adding to the institute’s diversity. For Arkady Khodursky, College of Biological Sciences professor who worked with two institute students

this summer, rewards came from the students’ eagerness to explore and their excitement in learning.

“I always like working with students from different backgrounds who offer different perspectives on issues,” says Khodursky, who directs a lab on the St. Paul campus that uses computational biology to investigate the complexity of gene expression. “For me, it’s always enriching.”

In addition, he also gains practical assistance with research—and supports the future of the field.

“Our goal is to provide them with the flavor of the field,” he says. “As faculty,

we try to attract students from all over the country; if we can increase the pool of students who are interested in bioinformatics, it helps us in building the field and making research advances.”

The institute intends to continue nurturing an interest on the part of its students. “We wanted to give this year’s students the opportunity to come back next year,” says Kaznessis. “We will track students in the next two to three years to see if they decide to pursue graduate studies or a career in the bioinformatics area.”

For Breslauer and Carvalho, the institute already succeeded in generating interest. Both are considering returning next summer. “The internship opened my eyes for graduate school in bioinformatics,” says Carvalho. “It’s an area that I hadn’t considered before.”

For more information about the Bioinformatics Summer Institute, visit <http://www.bsi.umn.edu/>.

SUMMER 2003 BSI STUDENTS

The Digital Technology Center welcomed students for its first Bioinformatics Summer Institute in June. The institute attracted some 15 talented participants from throughout the country. The list below highlights those students, their projects, and their faculty advisors.

Atif Ahmed, California State University at Fresno
Project: Evolutionary Relationships and Orthologs Among MYB and WRKY Transcription Factors from Arabidopsis, Medicago, and Glycine
Faculty Advisor: Nevin Dale Young

Benjamin Anderson, University of Minnesota
Project: Modeling and Design of Antimicrobial Peptides Using Computer Simulations
Faculty Advisor: Yiannis Kaznessis

David Breslauer, University of California at San Diego
Project: Correlated Mutation Analysis Using Amino Acid Property Vectors for the Prediction of Residues at Protein-Protein Complex Interfaces
Faculty Advisor: Yiannis Kaznessis

Taiala Carvalho, University of Minnesota
Project: Boolean Models of Cell Growth Networks
Faculty Advisor: Hans Othmer

Benjamin Chacko, Taylor University
Project: Evolutionary Relationships and Orthologs Among MYB and WRKY Transcription Factors from Arabidopsis, Medicago, and Glycine
Faculty Advisor: Nevin Dale Young

Howard Chen, University of Minnesota
Project: Oat-Maize Radiation Hybrid Mapping
Faculty Advisor: Ronald Phillips

Meaghan Fitzgerald, Saint Mary’s College
Project: Encoding Metabolic Logic: Predicting Biodegradation
Faculty Advisor: Lynda Ellis

Katayoun Jafari, University of Texas at Austin
Project: Identification of Full-Length cDNAs for Accurate Gene Prediction
Faculty Advisors: Kathryn VandenBosch, Kevin Silverstein

Allison Langham, Rose-Hulman Institute of Technology
Project: Analysis of the Results from the Molecular Dynamics Simulation of the N-Terminus of HIV-1 Glycoprotein 41000 Fusion Peptide
Faculty Advisor: Yiannis Kaznessis

Amber Martell, University of Minnesota
Project: Identification of Full-Length cDNAs in Medicago Trunculata
Faculty Advisors: Kathryn VandenBosch, Kevin Silverstein

Mohamed Moussa, University of Minnesota
Project: Regulator Cross-Talk Between Bacterial DNA Maintenance Modules In Vivo
Faculty Advisor: Arkady Khodursky

Timothy O’Connor, Washington State University
Project: Computational Identification of Transcription Factor Binding Sites in Promoter Regions of Co-Regulated Genes
Faculty Advisors: George Karypis, Ernest Retzel

Matt Rasmussen, University of Minnesota
Project: Scaleable Bootstrap Clustering of Microarray Data
Faculty Advisor: Arkady Khodursky

Rori Rohlfs, Carnegie Mellon University
Project: Computational Identification of Transcription Factor Binding Sites in Promoter Regions of Co-Regulated Genes
Faculty Advisors: George Karypis, Ernest Retzel

Elizabeth Saftalov, Purdue University
Project: Seeking the Vertebrate Secretome
Faculty Advisor: Lynda Ellis

Grid at Work

DTC faculty spearhead project to make the most of computing resources

The computational grid allows DTC and the University to make the most of its resources, offering a more cost-efficient alternative to buying additional computing power.

In the newly remodeled Walter Library, the University's Academic Distributed Computing Services runs a computer laboratory for use by students. The lab includes more than 60 personal computers and more than 30 Macintosh computers.

Just a wall away, researchers at the Digital Technology Center (DTC) Laboratory for Computational Science and Engineering (LCSE) use computing power to turn huge data sets into videos. The laboratory's PowerWall acts as a projection screen that fills the room and its technology increases the display resolution, allowing researchers to view and analyze the motion of gases within stars in a way not possible before.

To generate and run such videos and other types of simulations requires a significant amount of computational resources. That's why when Paul Woodward, astronomy professor and LCSE director, first realized the identity of his neighbor, he saw a slightly different vision for the student lab.

"I could see this top-of-the-line student laboratory as a sea of movie-creating engines," says Woodward.

Woodward's vision fit well with the expertise, needs, and vision of the DTC and its researchers. DTC faculty recognized the opportunity to develop a computational grid. The grid, as it turns out, not only supports researchers such as Woodward, but also is a research project in and of itself, as DTC

faculty explore an important emerging area of computing—the development of grids that can tap the collective power of high-performance computational resources.

The conversations then began. With the University's Office of Information Technology as a collaborator, DTC faculty prepared a proposal to the National Science Foundation and received funding in late 2002 to launch the grid. The project also involves DTC faculty Jon Weissman, an expert in the development of computational grids, and David Du, who leads the DTC Intelligent Storage Consortium, as well as Woodward, Ernie Retzel from the Academic Health Center, and graduate students.

Faculty began to configure the laboratory's computers in a way that would put them to work during the hours they were not in use by students. They completed much of this work in 2003 and recently began testing data transfers. The fully operational grid will serve as a:

- high-capacity and high-aggregate bandwidth storage area network
- image rendering farm
- genomics data mining engine
- distributed computing platform and grid computing testbed

The computational grid allows DTC and the University to make the most of its resources, offering a more cost-efficient alternative to buying additional computing power. "If you can use the power of existing systems, you can save the cost of additional personal computers," says Du. The grid also can provide a place to store data.

Because of their potential efficiencies and power, grids are becoming increasingly more attractive to researchers. "The personal computers today are almost as powerful as the supercomputers of 10 or 20 years ago," says Du. "Applying those resources in a computing grid opens powerful possibilities."

The student lab project helps researchers as they work on other grid studies. "The work that we put into this system helps us better understand the building blocks for bigger systems," says Du.

Other researchers throughout the University also may be interested in applying the computing grid resources to their research, says Woodward.

As one of the earliest initiatives that resulted from DTC collaborations, the project can trace its roots back directly to the DTC. "Without the DTC, it probably never have happened," says Woodward. "We couldn't have done it on our own. It's a great example of what can happen when a place brings together faculty with different pieces of the puzzle."



With funding from the NSF, DTC researchers are turning the computers in a Walter Library student lab into a computation grid that also supports their work. From left to right: Professors David Du, Paul Woodward, and Jon Weissman, collaborators on the grid project.

Productive Pursuit

Workshop helps build stronger Intelligent Storage community

In May, representatives from industry, academia, and national laboratories gathered at the Digital Technology Center (DTC) for the first in a series of workshops to explore business and technical issues that relate to making storage devices, subsystems, and applications more intelligent.

The Intelligent Storage Workshop attracted participation from companies such as Storage Tek, Veritas, Seagate, IBM, Intel, Cisco, Sun, Compellent, and SGI. The DTC Intelligent Storage Consortium (DISC) arranged the event in cooperation with the IEEE Mass Storage Systems Technical Committee and SNIA.

“Overall the workshop was a great first step in building a focused community around the research and development of Intelligent Storage technology and business,” says Tom Ruwart, DISC technical manager. “Participants gained valuable insights on the diverse aspects of current research.”

The DTC plans to host an annual Intelligent Storage Workshop, as well as smaller, more focused events. This first workshop involved faculty, students, and industry representatives who discussed research directions. The workshop featured the following presentations:

- **Mark Bakke** of Cisco provided a network-centric view of storage networks as they exist now and as they might exist with Object-Based Storage and more intelligent storage devices. He also discussed challenges in maintaining data integrity and security in this environment.
- **David Du**, director of the Intelligent Storage Consortium and computer science and engineering professor, described Datanomic Computing, data or computation resources that either move data closer to the computation or move the computing resource closer to the data.
- **Jim Hughes** of Storage Tek provided a glimpse at the many complex issues surrounding secure data storage in a distributed environment. This includes data at rest on a storage device, data in flight over a network, and data that has been presumably erased.



In May, the DTC welcomed representatives from industry, academia, and national laboratories who explored the latest developments in intelligent storage at the first in a series of such workshops.

- **Rob Kauffman** of the Carlson School of Management, along with two of his colleagues, Alok Gupta and Gedas Adomavicius, explored the business issues that surround emerging, potentially disruptive data storage technology.
- **Tom Lanzatella** from Veritas Software described the current state of many technology areas and discussed possible evolutionary paths in his keynote talk. He also mentioned a variety of advanced data storage research projects that could benefit from Object-Based Storage and ultimately from Intelligent Storage in some way.
- **Jai Menon** of IBM Almaden Research presented an overview of research issues under investigation at the Almaden Research Center.
- **Gary Orenstein** of Compellent, a Minneapolis-based data storage company, outlined data storage services and their operation in a distributed storage environment.
- **Erik Riedel** of Seagate Technologies talked about the rationale behind moving individual disk drives to an Object-Based Storage Device interface and subsequently moving more intelligent functions into the disk drive itself.
- **Julian Satran** of the IBM Haifa Research Center in Israel discussed the concepts of Object-Based Storage, an integral component of Intelligent Storage. Satran explained Storage Tank, a project within IBM that uses Object-

Based Storage concepts and is expected to evolve into an Intelligent Storage system over the coming years.

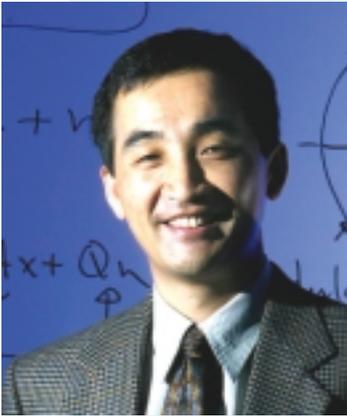
- **Rumi Zahir** of Intel Labs presented information about Lustre, a research and development project funded by the Department of Energy Accelerated Strategic Computing Initiative (ASCI) program that includes HP, Intel, Cluster File Systems, and the ASCI TriLabs (Livermore, Los Alamos, and Sandia). Lustre provides an open-source Object-Based Storage Device platform on which to experiment with even more advanced concepts including intelligence in storage devices.

Participants also spent time in a joint discussion about the ways that DTC and DISC could help move Object-Based Storage and Intelligent Storage forward. Those ways included a demonstration of the technology, its benefits to the user, the associated costs in intelligent storage deployment and use, and identification of a “Killer Application” for Intelligent Object-Based Storage Devices.

The DTC will host the second Intelligent Storage Workshop May 19-20, 2004, at the DTC in Minneapolis. For information about DTC and DISC, as well as the presentations from this workshop, visit <http://www.dtc.umn.edu> or contact Tom Ruwart (tmruwart@dtc.umn.edu).

DTC welcomes new ADC Chair

As professor, Canada Research chair, and department head at McMaster University in Hamilton, Ontario, Tom Luo collaborated with international



technology leaders such as Nortel Networks and Mitel on research to improve wireless communications.

When a colleague called him about a position at the University of Minnesota's Department of Electrical and Computer Engineering (ECE) and the Digital Technology Center (DTC), he found an intriguing opportunity. "I wasn't thinking about moving until I learned more about the DTC," he says. "The DTC offers a stimulating research environment

and the ability to collaborate with high-caliber colleagues and students on joint initiatives."

The National Science Foundation already has funded Luo's first proposal since he arrived at the DTC as an ADC Chair in Wireless Communication in April. His work focuses on the design and analysis of algorithms in data communication, information theory, and signal

processing for wireless systems. Luo received his bachelor's degree in applied mathematics from Peking University in China and his Ph.D. degree in operations research from the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology.

Luo joins Georgios Giannakis, professor of electrical and computer engineering, as the second holder of an ADC endowed chair in Wireless Communications. The ADC Foundation is funding five chairs, designating two chairs to support the research of faculty in wireless communications, two chairs to support the research of faculty in networking, and the fifth chair to support the DTC director.

Giannakis explores ways to improve the speed and performance of wireless services, including research on ultra-wideband communications and the application of multiantenna technology. His work has attracted the attention of several companies, which are considering licensing his patented technology for next-generation systems.

"I enjoy the collaborations here and the energy and ideas that come from those collaborations," says Luo. "They open new opportunities for me and my research."

The *DTC Bulletin* is published by the Digital Technology Center (DTC) at the University of Minnesota. Direct comments or questions to: Editor, The Digital Technology Center, 499 Walter Library, 117 Pleasant St. SE, Minneapolis, MN 55455.

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