Breaking Barriers

Projects explore cutting-edge research in diverse areas and support new partnerships

In 2004, the Digital Technology Center (DTC) launched its Initiatives in Digital Technology Program. In May, the DTC selected 11 projects for funding based on their fit with the center’s mission of promoting interdisciplinary collaborations, acting as a gateway for industry, and expanding educational opportunities (see page 3 for additional information). The projects involve interdisciplinary partnerships among University researchers, as well as with industry experts in several cases. A brief description of the projects follows.

Seeing tiny biological events

Detection and nanotechnology open new possibilities for methods to visualize biology at work. In this project, researchers will use near infrared wavelengths to visualize biological systems, a non-invasive approach that permits imaging at much greater depths than previously thought possible.

The project leverages the expertise of researchers in the Institute of Technology and Medical School, as well as the University’s Biomedical Image Processing Laboratory.

INVESTIGATORS: Allison Hubel, Mechanical Engineering; Marc Jenkins, Microbiology; Sundaram Ramakrishnan, Pharmacology; Jerry Sedgewick, Biomedical Image Processing Laboratory

Improving American Sign Language instruction

Faculty and students in American Sign Language classes at the University currently use video to evaluate their performance. This project seeks to take that method to a new level—one that improves their ability to assess proficiency and enhances learning opportunities.

Researchers will build a new language learning environment that takes advantage of computer networking technology and general outcome measures to advance instructional quality. The project involves several key milestones:
• Development of a flexible, fast, valid, and reliable technique for measuring student progress and promoting early detection of learning difficulties
• Computer-based assessment system that integrates the measurement technique

INVESTIGATORS: Simon Hooper, Curriculum and Instruction; Susan Rose, Education and Psychology

Tracking online reactions

In what ways do users relate to online communities? What attracts the user’s eye on web sites?

Answers to those questions only will help increase the potential impact of the web as a business and social tool. As part of this project, researchers will purchase an eye-tracking system and conduct studies of online community user interfaces.

In addition, the eye-tracking equipment will allow project investigators, other University researchers, and potential industry partners to study how users react to different online images and text on an ongoing basis in the DTC Usability Laboratory.

INVESTIGATORS: Joe Konstan and Loren Terveen, Computer Science and Engineering

Building computational biology expertise

Computational biology offers a way for researchers to better understand biological networks and ultimately biological function. Because of the structural similarity of biological networks, researchers from diverse areas can exchange ideas and develop computational tools to study different scales of biological organization.

This project helps bring together a community of researchers and resources for computational analysis of biological networks. It will support:
• A year-long graduate seminar series that will include invited speakers

continued next page
Learning from chimpanzees

The Jane Goodall Center for Primate Studies at the University houses the archives of all research materials from the world-famous study of chimpanzees in Gombe National Park, Tanzania. The center plans to create a searchable digital library of these resources to advance scientific research in biology, anthropology, and medicine.

The DTC is currently assisting the center with image digitization and storage. This project focuses on creating a database to index and access this visual material and investigating content-based retrieval techniques. It will result in a demo of the digital library.

INVESTIGATORS: Anne Pusey, Ecology, Evolution, and Behavior; Shashi Shekhar and Jaideep Srivastava, Computer Science and Engineering

Increasing the ease of programming robots

Robots offer the potential to handle repetitive tasks in manufacturing, semi-repetitive tasks in loading, unloading, and stacking in military, industrial, medical, and home applications, and non-repetitive tasks in home and healthcare applications.

In real-world applications, such cases also may require that a non-expert program the robot. In this project, researchers will combine speech- and gesture-based modalities in a robot programming interface that allows users with limited formal training to quickly implement and refine unoptimized solutions for quasi-repetitive tasks, such as stacking and retrieving non-uniform objects.

INVESTIGATORS: Jeanette Gundel, Linguistics; William Schuler and Richard Voyles, Computer Science and Engineering

Exploring biomedical concepts

With different ways to express biomedical concepts, it can be challenging to understand what they share in common.

In this project, researchers from the University of Minnesota Duluth and Mayo Clinic will develop measures to quantify the ways in which two concepts are similar or related to one another. They will evaluate the effectiveness of semantic similarity measures and adapt and extend one or more of these measures to the biomedical domain.

INVESTIGATORS: Ted Pedersen, Computer Science, University of Minnesota Duluth; Serguei Pakhomov, Mayo Clinic

Improving the process for analyzing mammograms

Each day, radiologists scrutinize the results of mammograms to detect any signs of breast cancer. In this project, researchers plan to develop the system for a mammogram database, a tool to assist radiologists in detecting small and potentially malignant lesions.

In collaboration that involves the National Digital Mammogram Center, the project will make use of the latest tools of information technology and visualization to develop a user-friendly interface that radiologists can access over the Internet. The tools of pattern recognition and computer vision will help enhance mammogram images and extract salient features to shed light on the early formation of breast cancer.

INVESTIGATORS: Robert Hoolebeek, National Digital Mammogram Center in Philadelphia; Dzwinel Witold, Computer Science and Engineering; and David Yuen, Geology and Geophysics and Minnesota Supercomputer Institute

Understanding the impact of the digital divide

Questions about the digital divide remain. Does it exist and to what extent? How are management strategies, including online commerce, online services, and policies that promote access, impacted by the notion of a digital divide?

This project supports a research symposium, “The Impact of the Digital Divide on Management and Policy: Determinants and Implications of Unequal Access to Information Technology,” to address these issues. Set for Aug. 27-28 at the Carlson School of Management, the symposium brings together
researchers who are studying contributing factors and business implications.

INVESTIGATORS: Robert Kauffman and Frederick J. Riggins, Information and Decision Sciences, Carlson School of Management

Delivering speedups to circuit simulations

As semiconductor technologies continuously shrink, circuit simulators are verifying larger and larger circuits with increases in computation time. Researchers are searching for techniques that improve the efficiency of such computation without resulting in any loss of functionality.

INVESTIGATORS: We-Chung Hsu, Computer Science and Engineering; Jaijeet Roychowdhury, Electrical and Computer Engineering

Exploiting an existing wealth of data

In the medical world, databases store more and more information—from the genomes of many species to the results of laboratory tests.

INVESTIGATORS: George Karypis, Jaideep Srivastava, and Vipin Kumar, Computer Science and Engineering; Piet de Groen, Mayo Clinic College of Medicine

FROM THE DIRECTOR

New Faces, New Projects

In 2004, the Digital Technology Center (DTC) moved forward with new initiatives that promote new partnerships, expand research in exciting new ways, and lay the foundation for applications.

In May, I was pleased to announce the recipients of the first Initiatives in Digital Technology Program (see story on page 1). We launched the program because it supports so many aspects of our mission:

• Acting as a gateway for industry to connect with University expertise in areas related to digital technology. Not only will the research likely attract industry interest, the projects also are bringing together faculty and industry partners.

For example, the Mayo Clinic will participate in research projects about measuring similarities in biomedical concepts and applying bioinformatics to analyze existing data for a better understanding of disease. Another project involves the National Digital Mammogram Center, which will work with University researchers to develop a tool that helps radiologists analyze mammograms.

• Promoting interdisciplinary collaboration within the University to advance research in digital technology. As a place where faculty from diverse disciplines can unite to pursue questions, the DTC facilitates advancements in ways that aren’t possible without such collaboration.

We received 48 applications for the Initiatives in Digital Technology Program, and those applications came from colleges and departments throughout the University, including the Carlson School of Management, the College of Liberal Arts, the Academic Health Center, the College of Biological Sciences, and the University of Minnesota Duluth.

The program succeeded in introducing new faculty to the DTC, as well as helping faculty who are already affiliated with the DTC establish relationships with other faculty and expand the scope of their research efforts.

• Preparing the next generation of scientists and engineers to make their mark in high-technology industries. Graduate students will assist in many projects, but one particular project will focus on building a community of graduate students and faculty in computational biology.

We are excited by the potential of these projects. Our program may give a project the spark it needs to attract additional funding sources. In other cases, the benefits of the partnerships that result may continue well after the first project ends. We look forward to sharing the results of these projects in the future.

All our activities help us deliver our mission. As we expand our reach, I want to welcome new faculty, students, and industry partners to the DTC. I hope that you will find our environment stimulating and productive—one that generates new ideas and inspires your work. Please visit us often.

Andrew Odlyzko is the DTC director, an ADC Professor in the School of Mathematics, and Assistant Vice President for Research. He can be reached at odlyzko@umn.edu.
Since the transistor revolutionized electronics, its popularity increased and its size decreased—both quite dramatically.

Ever-shrinking electronic components power cell phones, the smallest of computers, and medical devices, to name only a few. Exactly how much smaller can they go? And what will happen once they can go no smaller?

The questions are of vital interest to the electronics industry and the many other industries that depend on resulting technological innovations. An interdisciplinary collaboration of researchers is at the forefront of the theories that offer the potential for new solutions.

In 2003, the Institute for the Theory of Advanced Materials in Information Technology (ITAMIT) formed, when the National Science Foundation approved the University of Minnesota proposal and granted funding. The Digital Technology Center serves as home for ITAMIT, assisted researchers during the NSF-proposal process, and continues to offer resources to ITAMIT efforts.

“We were very fortunate to have support from the DTC,” says Jim Chelikowsky, chemical engineering and materials science professor and institute director. “The DTC provides office and lab space and access to the computational resources of the Minnesota Supercomputer Institute.”

The fit with DTC is a natural one. The center plays an important role in fostering interdisciplinary connections that advance key areas of digital technology. The institute brings together a unique collaboration of leading researchers—at Minnesota and other national institutions—as well as industry and international experts who participate as members of the institute’s Industrial Board and International Board, respectively (see related story).

ITAMIT relies on computational resources to explore the scientific and technological issues that arise as device features shrink to nanoscale dimensions where quantum mechanical effects become important. The research agenda of the Institute for the Theory of Advanced Materials in Information Technology currently includes the following areas.

- **Spintronic Materials**
  Made of dilute magnetic semiconductors alloyed with a magnetic element, these materials open the door to “spintronic” applications—devices based on electron charge and spin.

- **High-Performance Algorithms**
  The development of new algorithms for calculating the electronic and structural properties of systems with a large number of atoms allows researchers to investigate complex material properties and in some cases even replace experiments with theoretical simulations.

- **Quantum Dots**
  Usually consisting of bulk fragments of microcrystal, quantum dots also can be optically active.

- **Organic Semiconductors**
  Organic semiconductors offer potential for a novel kind of electronics; research looks at increasing the understanding of the electronic structure and charge transport in these systems.

- **Carbon Nanotubes**
  Long, thin tubes of pure carbon only 10 nanometers across, carbon nanotubes offer great resilience, strength, thermal stability, and current-carrying capacity.

Chelikowsky has studied silicon—the material that has helped make possible the miniaturization of electronic components—for much of his career. Research at the institute looks at silicon, as well as exploring new material possibilities. His partnership with Yousef Saad, ITAMIT associate director and computer science professor, and Renata Wentzcovitch, University of Minnesota, is an example.

The Institute for the Theory of Advanced Materials in Information Technology casts a wide net with national, international, and industry participants.

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<td>Jim Chelikowsky, director, University of Minnesota</td>
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<td>Renata Wentzcovitch, University of Minnesota</td>
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and engineering professor, has helped both faculty members expand knowledge in their areas.

“My research focuses on algorithms and numerical methods, and I’ve been applying that work to investigate material properties,” says Saad, who says the institute will only serve to further broaden interdisciplinary work. “One of our main goals is to get faculty together and foster collaboration of different groups. The institute helps us expand the horizon of problems and increases the momentum to solve them.”

NSF funding supports research and outreach initiatives, such as visitors, graduate students, and other events.

ITAMIT organized its first international workshop on methods in computational materials science in April.

“We will continue to look for ways to involve the community of academic and industry researchers as we increase our activities,” says Chelikowsky.

No doubt, ITAMIT will attract attention. Says Saad, “This is an area where there is much potential for breakthroughs.”

This plot illustrates the distribution of electrons in a quantum dot of silicon containing a phosphorous atom. The orange and blue areas indicate large concentrations of electronic charge. Such maps help researchers understand the nature of the chemical bond in matter at very small length scales.
When entrepreneur Larry Lamb began talking to Nora Paul of the School of Journalism and Mass Communication about a shopping game application, the seeds were sown for a new interdisciplinary initiative.

As Paul started conversations within the University, she found that games were serious business for faculty members in diverse disciplines. Soon, that expertise came together and found a home in the Game Research and Virtual Environment Laboratory (GRAVEL).

As a joint project of the Institute for New Media Studies, the Digital Technology Center (DTC), and the Digital Media Center, GRAVEL explores the structure of game and virtual reality environments, striving to gain a better understanding of their implications and applications.

“There were faculty who were working on different aspects but no mechanism for them to come together and really expand their work,” says Paul, institute director. In October 2003, an inaugural GRAVEL event drew representatives from 13 different departments.

The following projects received funding as part of the GRAVEL Seed Grant Program, supported by the DTC.

### Emotional Modeling in Computer Games
**Peter Border, Physics**

This project looks to advance knowledge about simulating emotional responses in games. It includes studying emotional response methods in existing games, making classes that keep track of the emotional status and history of characters and that provide emotional response, and developing a testing environment for evaluation and prototyping.

### Social Agent Behavior
**Steven Damer, Computer Science and Engineering**

This research explores social behavior for computer agents with the aim of creating a system that supports the many areas of research into social behavior. This system will help analyze different types of social communication in different contexts and will assist in developing more effective and realistic social behaviors for computer-driven entities in games.

### Impact of learning style in game-based delivery
**Barbara Martinson and Sauman Chu, Design, Housing, and Apparel Department**

Do students with a particular learning style prefer the game as a learning tool? Will those students do better on tests that include content from the game? Will students remember material from the game better than from lectures and readings?

This project examines the relationship of learning style to achievement when teachers use a game as part of instruction. Testing students will help researchers better understand the impact of games on instruction.
As one of its first activities, GRAVEL wanted to encourage research projects from the myriad disciplines that involve some angle of game research. The DTC helped fund a seed grant program (see related story for project descriptions).

The program supports faculty as they develop promising research ideas in some aspect of digital game, simulation, or virtual reality development, use, utility, social implications, or innovative applications. Faculty may use results in subsequent proposals for additional external funding.

“We are grateful to the DTC for its support,” says Paul. “They have been very helpful in launching the seed grant program and in helping GRAVEL increase its interdisciplinary work.”

Researchers will present their results in October. GRAVEL also plans to host a conference in the future and will request a new round of proposals in the fall. “GRAVEL allows us to start identifying and nurturing the available gaming expertise at the University,” says Paul. “Collectively, we can build on an existing knowledge base.”

Design of symbols in strategy games
Sauman Chu and Barbara Martinson, Design, Housing, and Apparel Department
Symbols or icons play a role in almost every game. This project focuses on the ways that strategy games make use of symbols by documenting each symbol in terms of design, function, or intended messages and by classifying similar messages. Ultimately, researchers plan to propose a set of standardized symbols that can be applied across different computer games.

Transportation and traffic modeling
Ted Morris and Chenfu Liao, Center for Transportation Studies
In this project, researchers plan to integrate transportation models and simulations with the spatial representation of the University’s East Bank, which incorporates geographic information systems with representative 3D models of structures. The project will result in a resource for studying navigation, map cognition, and urban design, as well as in the development of a transportation game.

DTC plans Oct. 1 open house
The Digital Technology Center (DTC) will host an open house for industry, Friday, Oct. 1, at its Walter Library facilities. The DTC sponsors the event to encourage discussion among industry and University researchers, as well as to share DTC research with industry representatives.

The first DTC open house, held May 2, 2003, attracted more than 150 participants who explored digital technology research, trends, and innovations. Look for updates about the open house on the DTC web site at www.dtc.umn.edu.

Industry representatives welcome at Aug. 26 DDC event
The Digital Design Consortium (DDC) welcomes companies with an interest in learning about cutting-edge information technology design advancements to its first open house, set for Aug. 26 in Walter Library.

The DDC brings together researchers from diverse disciplines to develop tools that allow architects, landscape architects, and other design and building professionals to experience designs. Its facilities include a laboratory on the first floor of Walter where researchers are creating a virtual reality design environment. Look for updates about the open house on the DTC web site at www.dtc.umn.edu.

Intelligent Storage Consortium Workshop attracts researchers
On May 19, at the second Intelligent Storage Workshop, industry and University researchers gathered to delve into a variety of business and technology issues that relate to making storage devices, subsystems, and applications more intelligent.

The DTC Intelligent Storage Consortium arranged the event in cooperation with the IEEE Mass Storage Technical Committee and SNIA. The workshop featured a keynote on Autonomic Storage Management by Dilip Kandlur of IBM, sessions with industry and University researchers, and poster presentations.

Security issues explored at WEIS conference
At the Third Annual Workshop on Economics and Information Security (WEIS04), experts examined questions about the investment in security technologies and the economics of security solutions. The DTC co-sponsored the workshop, held May 13-14 at the DTC.

Other sponsors included Center for the Development of Technological Leadership, Department of Computer Science and Engineering, Counterpane Internet Security, Department of Economics, Department of Rhetoric, Department of Electrical and Computer Engineering, Internet Studies Center, MIS Research Center, and the Law School. For general information about the conference, visit www.dtc.umn.edu/weis2004/.
DISC welcomes new members

Engenio (formerly LSI Logic) and Sun Microsystems recently joined StorageTek and Veritas as DTC Intelligent Storage Consortium (DISC) members. DISC focuses on developing the next generation of system level storage architecture and brings together University researchers and industry experts who explore cutting-edge issues. A research grant from Los Alamos National Laboratory and contributions from Cisco and Intel also support DISC. For information about DISC, visit www.dtc.umn.edu/programs/DISC.html.

DTC announces new faculty member

In fall 2004, Nihar Jindal will join the DTC and the Department of Electrical and Computer Engineering faculty. Jindal received his Ph.D. in electrical engineering from Stanford University. His research interests include multiple-user/multiple-antenna communications networks; communication limits of sensor/ad-hoc networks; multi-user information theory; and optimal resource allocation for wireless communication.

Congratulations to new McKnight Professors

The University recently named the following DTC-affiliated faculty members as Distinguished McKnight University Professors:

- **Graham Candler**, Aerospace Engineering and Mechanics, also a faculty member of the Minnesota Supercomputer Institute
- **Guillermo Sapiro**, Electrical and Computer Engineering, also a DTC faculty member
- **Nevin Young**, Plant Pathology, a contributor to the DTC Summer Bioinformatics Institute

The University awards the McKnight Professorships to honor and support the research and careers of outstanding junior faculty members.