Cover image provided by Professor Xavier Tricoche. His visualization research investigates turbulent flows in aerodynamics applications using a state-of-the-art advancing front algorithm that produces smooth, high-quality stream surfaces for even the most complex flow features. His method uses a highly accurate integration scheme to properly handle high curvature and strong spatial variation of the vector field. (Reprinted from AIAA Paper 2004-2153 by permission of the American Institute of Aeronautics and Astronautics, Inc.)
Students discuss career opportunities with corporate partners during the annual CS Career Fair.

William Gorman congratulates graduating students at the annual reception held in their honor.

CS honored outstanding alumni Mr. Eric Meyer, Dr. Chonchanok (Nok) Viravan, and Ms. Anne Schowe.

SmartAn Inc. placed first in the Gold Division of the 21st Annual Burton D. Morgan Entrepreneurial Competition.

Corporate partner representatives announce scholarships and awards at the annual CS Awards Banquet.
Greetings from faculty, staff, and students of the Department of Computer Science! The 2007-08 year was one of change and growth—and that for the better. The first change you might notice is in the format of this annual report. The report moves away from an alphabetic listing of faculty and now focuses on faculty by research areas. In that spirit, we are proud to mention the addition of two new faculty members to our roster: Professors Alex Pothen and Charles (Chip) Killian. Alex adds to our strength in the area of computational science and engineering and Chip brings expertise to distributed computing. We have seen growth, albeit slight, in our undergraduate enrollments. Our graduate program, on the other hand, saw a 55% growth in enrollment from the previous year. Faculty approved two new options for undergraduate students—an interdisciplinary specialization in Software Engineering (SE) and an integrated 5-year BS/MS program. The SE specialization allows undergraduates from the departments of Computer Science, Electrical and Computer Engineering, and Industrial Engineering to attain expertise in areas such as software requirements analysis, design, and testing that makes them a good fit for the software industry. The 5-year BS/MS combined degree allows students to receive both a BS and an MS degree in five years, rather than six. It offers students an intermediate platform from where to decide whether to move into a doctoral program or into the commercial world. The multi-core initiative was approved by the faculty and launched with the offering of an experimental course titled “Introduction to Programming with Concurrency.” Experience gained in this freshman class will guide the revision of our existing offerings in the area of problem solving through computation.

Awards, Honors, and Promotions
Members of our outstanding faculty continue to earn significant honors and awards. Professor Xiangyu Zhang earned the prestigious ACM SIGPLAN dissertation award for his dissertation “Fault Location via Precise Dynamic Slicing.” IEEE Intelligent Systems May/June 2008 issue declared Professor Jennifer Neville an AI leader of the future. Neville is one of ten researchers highlighted in the IEEE 2008 “AI’s 10 to Watch” list. Professor Yuan (Alan) Qi received the prestigious Microsoft Research A. Richard Newton Breakthrough Research Award for his research in Bayesian machine learning and computational biology. Professors Ananth Grama and Ahmed Sameh are significant members of a 35-researcher team across the university in a new multidisciplinary center for Prediction of Reliability, Integrity, and Survivability of Microsystems (PRISM). This multi-million dollar center is supported primarily through a grant from the Department of Energy. Professor Greg Frederickson was inducted into the Purdue University Book of Great Teachers. The induction ceremony took place on August 28, 2008 in the North Ballroom of the Purdue Memorial Union. The Book of Great Teachers inducts new members once every five years. Professor Susanne Hambrusch was elected to the CRA Board of Directors for a three-year term that began July 1, 2008. Professor Suresh Jagannathan was named a University Faculty Scholar for his outstanding work in the area of semantics and implementation of high-level programming languages. Professor Mikhail Atallah was named a Distinguished Alumnus of the American University in Beirut. Professor Eugene Spafford was named a Fellow of the ISC2 and received the Information Security Security 7 Award for his contributions to the field of information security. Professor Christoph Hoffmann teamed with Professors Gary Bertoline from the College of Technology and Beverly Sypher from the College of Liberal Arts and received a prestigious 2008 Mira Award for the Purdue Serious Gaming Initiative.

As always, our students continue to perform well in a variety of areas. Erik Ackermann was selected for an Honorable Mention in the Computing Research Association’s Outstanding Undergraduate Award for 2008. The CRA Outstanding Undergraduate Award program recognizes undergraduate students in North American universities who show outstanding research potential in an area of computing research. CS undergraduate student Rob Gevers received the Best Abstract Award for Mathematics/Computational Science at the Undergraduate Research and Poster Symposium on March 31, 2008. Gevers’ poster, entitled Function Guided Clustering of Protein-Protein Interaction Networks, was a snapshot of his ongoing research with Professor Olga Vitek. PhD student Nwokedi Idika ranked third in the
2008 entrepreneurial contest sponsored by the Indiana Venture Center. PhD student Muralikrishna Ramanathan teamed with Sirsa Chatterjee from Economics to win the 21st Annual Burton Morgan Entrepreneurial Competition. Professors Ananth Grama and Suresh Jagannathan advised this team. CS undergraduate John Bohlmann, along with management student Amit Pahwa, and philosophy student Daniel Poynter took second place in the Morgan contest student division.

The Future

Computer Science is a fast changing discipline when compared with several other disciplines in Science and Engineering. New technologies come and replace or sideline existing ones. Arrival of multi-core chips and the ever growing importance of concurrent programming, an enormous increase in the application of information retrieval and artificial intelligence, enhanced focus on interdisciplinary research especially at the interface of Computer Science and Biology, are just a few examples of areas that are positioning themselves alongside traditional areas such as operating systems, programming languages and compilers, and networking. This change poses a challenge to any existing curriculum that must continually adjust to the prevailing reality. And our faculty and students are ready to meet this challenge. A significant revision of the existing undergraduate curriculum is under discussion. The revision will allow flexibility to students in the choice of paths through the curriculum while retaining focus on the fundamental tools and skills such as those acquired through foundation classes in problem solving through computation, discrete mathematics, and algorithms. Changes are also being sought in the graduate curriculum to account for the emergence of new areas of research that are widely respected and considered on par in their intellectual substance with the traditional areas. Faculty are also working on a proposal to improve student retention in freshman classes in problem solving and programming through the use of embedded devices such as robots and smart phones, and by offering entry level courses that account for the computing background of the incoming students.
Faculty in the area of bioinformatics and computational biology apply computation methodologies such as databases, machine learning, and discrete, probabilistic, and numerical algorithms, and methods of statistical inference to problems in molecular biology, systems biology, structural biology, and molecular biophysics.

Bioinformatics and Computational Biology depends on the availability of massive amounts of data. Current work addressing this need includes the design and implementation of biological databases and text/data mining for life sciences, in particular, automatic gene function annotation from the literature.

Advances in molecular biology and systems biology involve the extraction of information and patterns from data. Work in this area includes finding context-sensitive modules from multiple cancer networks, identifying protein-DNA binding sites, analyzing flow cytometry data to find cancer stem cells, algorithms and statistical approaches for functional annotation of molecules based on their sequences, identifying protein biomarkers for lung and prostate cancer using clinical data and experiments with model organisms, and studies of biomolecular networks.

Data for these projects are obtained by a variety of technologies, which include gene expression microarrays, protein-DNA binding data, flow cytometry data, sequence data, mass spectrometry-based proteomics and metabolomics, and ionomic profiling.

Progress in structural biology and molecular biophysics requires models that incorporate physical properties of biomolecules as well as data. Work in this direction includes prediction and analysis of the relationship among protein sequence, structure and function, determining protein structure via NMR, determining transition paths of conformational change of proteins and free energies of protein-ligand binding, and simulating DNA dynamics and self-assembly.

Faculty involved in bioinformatics and computation biology at Purdue include Ananth Grama (p. 7), Daisuke Kihara, Gopal Pandurangan (p. 23), Alex Pothen (p. 7), Yuan (Alan) Qi, Luo Si (p. 17), Robert Skeel (p. 7), Wojciech Szpankowski (p. 23), and Olga Vitek.

Rob Gevers, an undergraduate student working under the direction of Professor Olga Vitek, conducts research in low dimensional euclidean embedding. This image shows multiple views of a protein-protein interaction network.
Selected Publications


Computational science and engineering, or scientific computing, provided impetus for many of the early Computer Science departments in the 1960s. Purdue is one of the few programs nationwide that have consistently maintained a leadership position in this important discipline. The scientific computing group is comprised of seven full-time faculty members (one with a joint appointment in Mathematics). The group’s research activity primarily focuses on the development of algorithms (combinatorial as well as numerical), parallel and distributed techniques, software infrastructure, and novel computing platforms. These research efforts are driven by state-of-the-art applications in modeling of materials and bio-chemical processes (ranging from atomistic to systems-level models), novel micro-electromechanical systems, structural mechanics and control, robotics and advanced manufacturing, image processing and visualization (with applications in life-sciences and healthcare), and critical infrastructure protection (e.g., power-grids and other civil infrastructure).

The algorithmic research activities concern the development of novel solvers (linear and non-linear system solvers, eigenvalue/singular-value decompositions), techniques for real-time control, numerical methods for modeling many-body systems, combinatorial methods in network analysis, and computational geometry algorithms for reasoning about shapes and mechanisms. Systems development efforts support these applications through the development of advanced compilers, runtime systems, data management and storage, and data analysis on scalable parallel platforms and distributed infrastructure.

Faculty involved in computational science and engineering at Purdue include Ananth Grama, Christoph Hoffmann (p. 13), Bradley Lucier, Alex Pothen, Elisha Sacks (p. 13), Ahmed Sameh, and Robert Skeel.

Selected Publications

A digitized mammogram X-ray taken from the side shows a microcalcification cluster (small deposits of calcium) indicated by an arrow. The images, provided by Professor Bradley Lucier, show how he and colleagues have compressed the data in Figure a to produce a smaller file used to form the reconstructed mammogram in Figure b. Figure b is produced with a compression rate of 113:1, and yields a 94kB file as compared to the 11MB original image in Figure a, yet radiologists interpreted the reconstructed compressed images more accurately than the originals. The inset image indicates the changes caused by removing much of the data from the original digitized mammogram. (Reprinted from M. Kallergi M, B. J. Lucier, C. G. Berman et al, “High-performance wavelet compression for mammography: localization response operating characteristic evaluation,” Radiology, 2006, 238:62-73.)


The database and data mining group at Purdue is composed of Professors Walid G. Aref, Elisa Bertino, Bharat Bhargava, Christopher Clifton, Ahmed Elmagarmid, Susanne Hambrusch, Jennifer Neville, Sunil Prabhakar, Luo Si, and Jeffrey Vitter; Research Assistant Professors Tanu Malik and Mourad Ouzzani; and over thirty graduate students. The group conducts fundamental and cutting-edge research in database systems, database privacy and security, data mining, web search, information retrieval, and natural language processing. Current projects and topics include:

- Context aware database management systems (Aref, Bhargava, Ouzzani)
- Cyber infrastructure (Elmagarmid, Malik, Ouzzani)
- Data and service integration and schema matching (Elmagarmid, Ouzzani)
- Data quality (Elmagarmid, Ouzzani)
- Database security and online auctions (Bertino, Bhargava)
- Location privacy (Aref, Bertino, Bhargava)
- Privacy enhancing technologies for data, text, and data mining (Clifton)
- Private and secure data dissemination (Bhargava)
- Scientific data management (Aref, Elmagarmid, Malik, Ouzzani)
- Search and Intelligent Tutoring (Si)
- Self-learning disk scheduling (Bhargava)
- Spatiotemporal data management (Aref, Ouzzani, Prabhakar)
- Statistical relational models (Neville)
- Stream Data Management (Aref, Elmagarmid, Prabhakar)
- Uncertainty data management (Hambrusch, Neville, Prabhakar)

Members of the database and data mining group engage in high-impact multidisciplinary projects and collaborations that involve multiple disciplines including Agronomy, Biology, Chemistry, Chemical Engineering, Physics, and Social Sciences.

Since 2003, the database and data mining group has graduated over 17 Ph.D. students who have started their careers in various universities (e.g., Calgary, Minnesota, Rutgers, SUNY Albany, Texas at Dallas, and Waterloo) and industry (e.g., Google, IBM, and Microsoft).

Details about the above research conducted and the multidisciplinary projects can be found in www.cs.purdue.edu/icds.

Selected Publications


Jaideep Vaidya, Chris Clifton, Murat Kantarcioglu, and A. Scott Patterson, “Privacy-preserving decision trees over vertically partitioned data”, *The ACM Transactions on Knowledge Discovery from Data (TKDD)*, 2(3), 2008.


The distributed systems group focuses on designing distributed systems that are scalable, dependable, and secure, behaving according to their specification in spite of errors, misconfigurations, or being subjected to attacks. Areas of focus include:

**Virtualization technologies.** One thrust is developing advanced virtualization technologies for computer malware defense and virtual distributed computing. Researchers at the FRIENDS lab (Lab For Research In Emerging Network & Distributed Systems) have developed a virtualization-based experimental platform for malware containment, observation, and analysis.

Ongoing research efforts in the computer malware defense area include: operating system level information flow tracking for user-level malware investigation; virtual machine (VM) introspection for stealthy malware monitoring and detection; and VM memory shadowing for kernel-rootkit prevention and profiling. In the virtual distributed computing area, the lab has proposed and instantiated the concept of “virtual networked environment” for creating virtual infrastructures on top of a shared physical hosting infrastructure. The concept and its enabling techniques have been applied to support a number of emerging applications such as scientific job execution, virtual organizations, and tele-immersion.

**Intrusion tolerant systems.** Researchers at the Dependable and Secure Distributed Systems Laboratory (DS2) are designing distributed systems, networks and applications that can tolerate insiders, while maintaining acceptable levels of performance. Recent research lies in designing intrusion-tolerant systems in the context of (1) replication services, (2) routing for wireless ad hoc networks, and (3) unstructured overlays for peer-to-peer streaming.

**Model checking and simulation testing.** Another thrust is studying the utility of distributed-system model checking and simulation testing by coupling it with dynamic program slicing and machine learning. Each of these techniques have the ability to summarize and focus the massive amounts of available information so the programmer-designer can focus on the significant parts of the execution while ignoring the rest. The goal is to develop enabling technologies and prototype frameworks for collaborative high-performance distributed computing and simulation that may be adapted and enhanced to deploy scalable and portable systems.

**Experimental analysis.** Researchers at the RAID laboratory are conducting scientific research in a variety of subjects related to experimental analysis such as: communication experiments for distributed applications, network communication measurement experiments, experimental analysis of communication infrastructure, adaptability experiments for distributed systems, replication and recovery experiments for distributed database systems, concurrent check-pointing and rollback-recovery algorithms, concurrency control for distributed database systems, efficient implementation techniques for distributed systems, digital library, and mobile communication.

Faculty involved in distributed systems at Purdue include Bharat Bhargava (p. 9), Patrick Eugster (p. 21), Ananth Grama (p.7), Antony Hosking (p. 21), Suresh Jagannathan (p. 21), Charles Killian, Cristina Nita-Rotaru (p. 15), Gopal Pandurangan (p. 23), Kihong Park (p. 19), Vernon Rego, Dongyan Xu, and David Yau (p. 19).
Selected Publications


The graphics group performs research in graphics, visualization, computational geometry, and related applications. We describe five projects on which we focused this year.

**Model acquisition.** We developed self-calibrating methods for acquiring high-quality geometric models (accuracy as high as 0.05mm) of objects and of room-size scenes. We combined photometric measurements with geometric measurements and used algebra to eliminate many calibration parameters. This approach led to better algorithms for capturing dynamic scenes, for acquiring models of highly specular and interreflective scenes, and for changing the appearance of objects.

**Simulation.** In collaboration with civil engineers, we produced a high-fidelity simulation of the 9/11 attack on the World Trade Center. The interest in such a simulation transcends civil engineering and includes emergency response, defense, and society in general. The simulation follows the laws of physics as closely as possible. The results are presented through a visualization that is eloquent to users outside of civil engineering. The visualization has been downloaded over five million times.

**Visualization.** Computer simulations and modern measuring devices produce an overwhelming volume of data. To turn this information into insight, we are developing visualization techniques that allow domain experts to focus on salient properties. We combine powerful mathematical models and expressive visual representations to offer a precise structural picture of complex phenomena. We are applying these techniques to fluid dynamics and aeronautics, fusion research, bioengineering, and medical imaging.

**Urban modeling.** We are working on the acquisition and simulation of large urban environments. The goal is to obtain digital models of large-scale urban structures in order to simulate physical phenomena and human activities. The models should be easily modifiable in order to simulate response policies in unforeseen scenarios and to guide urban development. We have developed algorithms that use ground-level imagery, aerial imagery, procedural modeling, and street and parcel data to create and modify 3D geometry and 2D layouts.

**Robust computational geometry.** Computational geometry algorithms are formulated in a model where arithmetic operations have infinite accuracy and unit cost. The robustness problem is how to implement the algorithms in computer arithmetic, which has unit cost, but is approximate. The main difficulty is that even tiny numerical errors can cause arbitrarily large output errors. Our strategy is to develop algorithms that enforce consistency constraints and whose error and cost are polynomial in the number of input inconsistencies. We developed robust versions of five core algorithms and validated them on examples that far exceed the capabilities of prior work.

Faculty involved in graphics and visualization at Purdue include Daniel Aliaga, Christoph Hoffmann, Voicu Popescu, Elisha Sacks, and Xavier Tricoche.

**Selected Publications**


Research in information security and assurance is carried out by faculty, most of whom are affiliated with the university-wide Center for Education and Research in Information Assurance and Security (CERIAS). CERIAS is generally considered to be the top-ranked such group in the world, with faculty from over a dozen departments at Purdue. Their research covers all aspects of computer and network security, privacy, and cyber crime investigation. Areas of special focus by CS faculty include:

**Identification, authentication, and privacy.** There is a tension between increased confidence and granularity of authorization provided by better identification of online entities, and with the need to protect the privacy rights of individuals and organizations. This area includes research in role-based access control, privacy-protecting transformations of data, privacy-protecting data mining methods, privacy regulation (e.g., HIPAA), oblivious multiparty computation, and digital identity management systems.

**Incident detection, response, and investigation.** Systems are attacked, and sometimes attacks succeed. This area of our expertise includes intrusion and misuse detection, integrity management issues, audit and logging analysis, sensor and alarm design, intrusion mechanisms, dynamic reconfiguration, honeypots and ‘jails,’ cyberforensics.

**Cryptology and rights management.** Controlling information from being read or altered by others, preserving marks of ownership and origin, and breaking the code of adversaries are all of interest in information security. Research interests include encryption, number theoretic foundations, cryptanalysis, and watermarking.

**Data security.** Data is often the most important asset that organizations have and it is the target of almost all attacks. Relevant research includes: secure architectures for databases, security of streaming data, high-assurance integrity systems for databases, anomaly detection and response system mechanisms for databases.

**System security.** Advanced virtualization-based techniques are developed for the detection, prevention and profiling of both user-level and kernel-level computer malware. Research includes the use of these techniques for protection from botnets.

**Trusted social and human interactions.** How does IT change our interactions, and how can more trustworthy IT change them further? This includes studies of on-line trust, ecommerce (business-to-business and business-to-consumer), digital government services, e-conferencing, on-line personae and anonymity, online news, on-line research and the ephemeral nature of information, on-line propaganda, and spam.

Faculty involved in information security and assurance at Purdue include Mikhail Atallah, Elisa Bertino, Bharat Bhargava (p. 9), Christopher Clifton (p. 9), Sonia Fahmy (p. 19), Ninghui Li, Cristina Nita-Rotaru, Kihong Park (p. 19), Sunil Prabhakar (p. 9), Vernon Rego (p. 11), Eugene H. Spafford, Jan Vitek (p. 21), Samuel Wagstaff, Dongyan Xu (p. 11), and David Yau (p. 19).

**Selected Publications**


Machine Learning and Information Retrieval

With massive data available from various engineering, scientific, and social disciplines, machine learning and information retrieval have played an imperative role in discovering hidden patterns or relationships between intertwined components (e.g., people, web pages, or genes, in a complex system), understanding properties of various systems, and making meaningful predictions for a variety of applications.

In the past few years, Purdue has grown a strong machine learning and information retrieval group with strengths in multiple areas of this field. In particular, Professor Jennifer Neville works on multiple problems in relational modeling, such as fusion and analysis of multi-source relational data, and modeling relational communication on distributed team effectiveness. Her team also integrates machine learning methods with agent-based models to form a compositional model, which will combine components that are learned from data with components that are hand-engineered using traditional methods. This combination will produce powerful tools for understanding the emergent behavior of complex social and organizational systems. Professor Luo Si develops federated text search, which is the search beyond traditional engines such as Google, Yahoo! or MSN by finding information that is “hidden” behind many search engines. His team also uses cutting-edge computer science techniques to construct an exploratory but fully functioning differentiated instructional system of mathematical word problem solving. Professor Christopher Clifton (p. 9) addresses problems in privacy-preserving data mining by developing technology that share some information to calculate correct results, where the shared information can be shown not to disclose private data. Professor S.V.N. Vishwanathan works on kernel methods and interactions between machine learning and optimization. Professor Yuan (Alan) Qi’s (p. 5) research interests span several areas in machine learning and computational biology. His team develops new methods to detect context sensitive modules for complex biological and social networks, combines statistical learning with ab-inito methods for computational materials design, and design Bayesian matrix factorization methods for collaborative filtering (with applications to online recommendation systems) and text clustering.

Faculty in this area have obtained significant funding support for their research activities. They have also received external recognition such as the IEEE “AI’s 10 to watch” for Prof. Neville, an NSF career award for Prof. Si, and Microsoft Breakthrough research award (one out of ten nationally) for Prof. Qi.
Selected Publications


Luo Si, Jamie Callan, Suleyman Cetintas, and Hao Yuan, “An effective and efficient results merging strategy for multilingual information retrieval in federated search environments”, *Journal of Information Retrieval*, 2008.


Networking and Operating Systems

Faculty in the area of networking and operating systems are tackling fundamental problems at different layers of the network protocol stack, ranging from the medium access control layer all the way up to the application layer. The group uses theoretical models, simulation, emulation, and extensive testbed experimentation to develop and evaluate their proposed solutions. The group has leveraged techniques from game theory, information theory, complexity theory, optimization and cryptography in their solutions. The group has implemented their methods on a variety of platforms, ranging from large clusters, to network processors, and resource-constrained wireless sensor motes.

Projects that the faculty have undertaken during the past year include fault localization in enterprise networks; packet classification, queueing, and scheduling in Internet routers; secure and scalable media streaming over the Internet; secure network coding in wireless mesh networks; design of defenses against Internet worms and malware; scalable network simulation; and coverage, localization and data fusion in energy-constrained wireless sensor networks.

A recent project led by Professor Douglas Comer investigates hybrid packet schedulers that achieve low delay and a high degree of fairness. Comer and researchers in his group are investigating the implementation of their algorithms on network processors to achieve performance sufficient for a 10 Gbps link.

Another recent project, led by Professor Sonia Fahmy, considers scalable network security experiments. A primary reason for lack of deployment of network security mechanisms is that most mechanisms have not been validated under realistic conditions, or at sufficiently large scales.

The project includes two complementary efforts to address both the fidelity and scale challenges in security experiments by designing: (1) high-fidelity yet scalable models for routers and other devices based on simple device measurements under a few well-crafted scenarios, and (2) techniques to simplify experimental scenarios before studying them using simulation, emulation, or testbed experiments.

Faculty involved in networking and operating systems at Purdue include Douglas Comer, Sonia Fahmy, Charles Killian (p. 11), Ramana Kompella, Cristina Nita-Rotaru (p. 15), Kihong Park, Dongyan Xu (p. 11), and David Yau.

Selected Publications


*During the period of this annual report, Professor Douglas Comer was on leave at Cisco Systems.
The programming languages and compilers group at Purdue is engaged in research spanning all aspects of software systems design, analysis, and implementation. Our faculty have active research projects in functional and object-oriented programming languages, both static and dynamic compilation techniques for scalable multicore systems, scripting languages, distributed programming abstractions and implementations, realtime and embedded systems, mobile and untrusted computing environments, and runtime systems with special focus on memory management and parallel computing environments.

The software engineering group conducts research on applying advanced program analyses towards problems related to fault isolation, various kinds of bug detection including those related to race conditions in concurrent programs, and specification inference for large-scale software systems. Aspect-oriented abstractions and new program slicing and mining techniques are some of the mechanisms that are being explored to address these issues.

Faculty involved in programming languages, compilers, and software engineering at Purdue include H. E. Dunsmore, Patrick Eugster, Antony Hosking, Suresh Jagannathan, Zhiyuan Li, Aditya Mathur, Vernon Rego, Eugene H. Spafford, Jan Vitek, and Ziangyu Zhang.

Selected Publications


Research interests of the members of the theory of computing and algorithms group range over many areas of algorithms. These areas include analysis of algorithms, parallel computation, computational geometry, digital watermarking, data structures, graph algorithms, network algorithms, distributed computation, computational biology, information theory, analytic combinatorics, random structures, external memory algorithms, approximation algorithms, data mining, bioinformatics, and text indexing. Much of the research reflects interaction with other areas of the field, such as information security, databases, and geographic information systems.

The ongoing research at Purdue includes theoretical advances, theoretical improvements on applied problems, and algorithms with immediate potential for application. The group has made notable contributions on topics such as updating minimum spanning trees, shortest paths in planar graphs, computing approximate minimum spanning trees distributively, low-diameter P2P networks, parallel computational geometry, cascading divide and conquer, query indexing and velocity constrained indexing, external memory graph algorithms, compressed suffix arrays, and the analysis of Lempel-Ziv codes.

Faculty involved in theory of computing and algorithms at Purdue include Mikhail Atallah, Saugata Basu, Greg Frederickson, Susanne Hambrusch, Gopal Pandurangan, Wojciech Szpankowski, and Jeffrey Vitter.

Selected Publications


*During the period of this annual report, Professor Jeffrey Vitter was a faculty member in the Purdue Department of Computer Science. He is currently with Texas A&M University.*
Aliaga, Daniel

Aref, Walid

Atallah, Mikhail J.

Bertino, Elisa
Bhargava, Bharat

Clifton, Christopher

Dunsmore, H.E. (Buster)

Elmagarmid, Ahmed K.
**Eugster, Patrick**

**Fahmy, Sonia**

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Image illustrating research on semantics-aware program analysis by Kevin Hoffman under supervision of Professors Patrick Eugster and Suresh Jagannathan. The image shows three different views of the same code excerpt, with arrows linking distinct representations of the same program statements. Kevin Hoffman has implemented this novel analysis in RPrism, a tool that allows for highly precise and scalable analysis of software based on pluggable views.

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**Execution Trace (and Thread View)**
entry(1,2, 'T.main', 1, call(LG-1, addMsg, '<Handling...>')

entry(3, 'T.main', 1, return(LG-1, addMsg, _)
entry(4, 'T.main', 1, call(SP-1, setReqType, '<text/html>')

entry(7, 'T.main', 1, call(SP-1, setReqType, '<text/html>')

entry(9, 'T.main', 1, return(SP-1, ogae, _))

entry(9, 'T.main', 1, call(SP-1, setReqType, '<text/html>')

entry(10, 'T.main', 1, call(SP-1, setReqType, '<text/html>')

entry(11, 'T.main', 1, set(SP-1, _newConv, Conv, 12)

entry(12, 'T.main', 1, set(SP-1, _newConv, Conv, 12)

entry(13, 'T.main', 1, return(SP-1, _newConv, Conv, 12)

entry(20, 'T.main', 1, call(LG-1, addMsg, '<Set req...>

entry(25, 'T.main', 1, return(SP-1, setReqType, _))

---

**Object View for LOG Object #1**
entry(1, 'T.main', 1, call(LG-1, addMsg, '<Handling...>')

entry(3, 'T.main', 1, return(LG-1, addMsg, _)

entry(5, 'T.main', 1, call(LG-1, addMsg, '<text/html>')

entry(7, 'T.main', 1, call(LG-1, addMsg, '<text/html>')

entry(9, 'T.main', 1, return(LG-1, addMsg, _)

entry(11, 'T.main', 1, return(LG-1, addMsg, _)

entry(12, 'T.main', 1, return(LG-1, addMsg, _)

entry(13, 'T.main', 1, return(LG-1, addMsg, _)

---

**Method View for SP.setRequestType**
entry(7, 'SP.setRequestType', SP-1, 1, call(SP-1, setReqType, '<text/html>')

entry(9, 'SP.setRequestType', SP-1, 1, return(SP-1, setReqType, '<text/html>')

entry(9, 'SP.setRequestType', SP-1, 1, return(SP-1, setReqType, '<text/html>')

entry(11, 'SP.setRequestType', SP-1, 1, return(SP-1, setReqType, '<text/html>')

entry(12, 'SP.setRequestType', SP-1, 1, return(SP-1, setReqType, '<text/html>')

entry(13, 'SP.setRequestType', SP-1, 1, return(SP-1, setReqType, '<text/html>')

---

**Method View for SP.setResponseType**
entry(20, 'SP.setResponseType', SP-1, 1, call(SP-1, setReqType, '<text/html>')

entry(25, 'SP.setResponseType', SP-1, 1, return(SP-1, setReqType, _)}
Gram, Ananth Y.


Ananth Y. Grama and Suresh Jagannathan. Profile-Guided Speculation for Multicore Architectures. INTEL. 2006-2035, $80,000.
Hambrusch, Susanne E.

Hoffmann, Christoph M.
Christoph M. Hoffmann. Northwest Indiana Computational Grid: A joint project at the University of Notre Dame, Purdue University-West Lafayette and Purdue University-Calumet. Department of Energy. 2006-2009, $2,970,001.

Image provided by Professor Susanne Hambrusch shows a course project in “Introduction to Computational Thinking,” a course developed as part of the SECANT project funded through the NSF CPATH program. The image shows the results of a demon algorithm for a 2D Ising model visualizing the magnetization of a lattice of spins.
Hosking, Antony
Tony Hosking. Scalable Concurrent Compacting Garbage Collection for Commodity Multi-Core Processors. National Science Foundation. 2007-2010, $275,000.

Jagannathan, Suresh
Ananth Y. Grama and Suresh Jagannathan. Profile-Guided Speculation for Multicore Architectures. INTEL. 2006-2035, $80,000.
Kihara, Daisuke

Kompella, Ramana

Li, Ninghui

Li, Zhiyuan
Zhiyuan Li. Parametric Compiler Optimization for Multi-Core Architectures. National Science Foundation. 2007-2010, $275,000.
Mathur, Aditya P.


Neville, Jennifer


Nita-Rotaru, Cristina


Cristina Nita-Rotaru. REU supplement- Career. National Science Foundation. 2006-2009, $6,000.


Pandurangan, Gopal


Park, Kihong


Popescu, Voicu

Prabhakar, Sunil K.

Qi, Yuan (Alan)

Rego, Vernon

Sameh, Ahmed
Si, Luo


Skeel, Robert


Spafford, Eugene H.


Research Funding

Szpankowski, Wojciech

Vitek, Jan
Vitter, Jeffrey

Xu, Dongyan
Dongyan Xu. CAREER: Towards Virtual Distributed Environments in a Shared Distributed Infrastructure. National Science Foundation. 2006-2011, $400,000.
Michael McLennan, Gerhard Klimeck, and Dongyan Xu. SDCI NMI Improvement: nanoHUB Middleware. National Science Foundation. 2007-2010, $1,350,000.

Yau, David

Zhang, Xiangyu
Courtesy Faculty

Shreeram Abhyankar, Mathematics
David Anderson, Engineering
Saurabh Bagchi, Electrical and Computer Engineering
Alok Chaturvedi, Management
William Cleveland, Statistics
Melissa Dark, Technology
David Ebert, Electrical and Computer Engineering
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Ness Shroff, Electrical and Computer Engineering
T N Vijaykumar, Electrical and Computer Engineering

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Elias Houstis
Robert Lynch
John Rice
John Steele
### PhD Graduates

#### December 2007

**Abhilasha Bhargav-Spantzel**  
"Protocols and Systems for Privacy Preserving Protection of Digital Identity"  
Advisor: E. Bertino  
Employer: Intel; Santa Clara, California

**Thanaa Mohamed Ghanem**  
"Supporting Views in Data Stream Management Systems"  
Advisors: A. K. Elmagarmid and W. G. Aref  
Employer: not reported

**Md-Abdul Maleq Khan**  
"Distributed Approximation Algorithms for Minimum Spanning Trees and Other Related Problems with Applications to Wireless Ad Hoc Networks"  
Advisor: G. Pandurangan  
Employer: Virginia Biocomputing Institute, Virginia Polytechnic Institute and State University; Blacksburg, Virginia

**Maxim S. Martynov**  
"Design and Implementation of Hybrid Packet Scheduling Algorithms for High Speed Networks"  
Advisor: D. E. Comer  
Employer: Cisco Systems; San Jose, California

**Qiqi Wang**  
"Interactive Visualization of Three-Dimensional Confocal Microscopy Data"  
Advisor: Y. Sun  
Employer: Microsoft Corporation; Redmond, Washington

#### May 2008

**Asad Khan Awan**  
"Macroprogramming Scalable Sensor Networks"  
Advisor: A. Y. Grama  
Employer: Conviva; San Mateo, California

**Roman Chertov**  
"A Device Independent Router Model: From Measurements to Simulations"  
Advisor: S. Fahmy  
Employer: Santa Barbara Labs; Santa Barbara, California

**Mihai Mudure**  
"Efficient and Versatile 3D Scene Modeling by Sparse-Depth Dense-Viewpoint Acquisition"  
Advisor: V. S. Popescu  
Employer: Google; Mountain View, California

**Murali Krishna Ramanathan**  
"Path-Aware Analysis of Program Invariants"  
Advisor: S. Jagannathan  
Employer: Coverity; San Francisco, California

**Amit Jayant Shirsat**  
"Self-Configuration Algorithms for Mobile Ad Hoc Networks"  
Advisor: B. Bhargava  
Employer: Yahoo!

**Changjiu Xian**  
"Collaborative Power Management between Operating Systems and Applications"  
Advisors: Y.-H. Lu (ECE) & Z. Li  
Employer: Microsoft Corporation; Seattle, Washington

**Mingwu Zhang**  
"Supporting Fine-Grained Database Lineage Tracking"  
Advisors: S. K. Prabhakar & X. Zhang  
Employer: Microsoft Corporation; Seattle, Washington

#### August 2008

**Wei Jiang**  
"Incentive-Driven and Privacy-Preserving Collaborative Computing"  
Advisor: C. W. Clifton  
Employer: Missouri Institute of Science and Technology; Rolla, Missouri
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Nathan Robert Andrysco
Muhammad Umer Arshad
Sahan Sajeewa Bamunavita Gamage
Samer Samir Barakat
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Access and Success Campaign
In the spring of 2008, President France Córdova announced the Access & Success campaign with a goal of $304 million over the course of seven years to support programs and scholarships at Purdue. Scholarships will be offered to more students than ever, including out-of-state, international, and middle-income students. Students in a variety of disciplines and from a broad spectrum of backgrounds will not only be able to attend Purdue, but also be able to graduate with fewer financial obligations. It is only through continued and generous gifts that we are able to provide scholarships, enhance our programs, and attract world-class faculty to the Computer Science Department. Please contact Javier Magallanes, Director of Development, for more information at jmagalla@purdue.edu.

Cisco TelePresence Unveiled at Purdue
The Purdue Department of Computer Science dedicated the Cisco TelePresence video conferencing room in the Lawson Computer Science Building on October 15, 2008. Cisco has provided this technology to several top research universities nationwide. "University researchers are a critical component of Cisco’s innovation strategy and provide us with a direct pulse on the next wave of technology," said Douglas Comer, vice president of Cisco Research and Distinguished Professor of Computer Science at Purdue. "We believe this is an important step in fostering an open, more collaborative research environment for innovation in the 21st century and beyond."

The Cisco TelePresence dedication events included a message exchange between Cisco representatives and Purdue researchers. The 65” high-definition screen created a virtual meeting space that gave participants a feeling of being in the same room as Cisco colleagues. The $650,000 gift (including three years of networking and support costs) from Cisco breaks down the barriers of distance, and makes collaborative research more productive and inexpensive by eliminating travel restraints and costs.

Lawson Building Recognized for Design Excellence
Architectural firm Gibraltar Design was recognized for educational design excellence by the American School and University (AS&U) magazine. The 107,000 square foot Richard and Patricia Lawson Computer Science Building was designed to showcase computer science technology, and accommodate the interactive nature of the field. Gibraltar architect Bill Cotterman presented the 2007 Outstanding Design Excellence Award plaque to the Purdue Computer Science Department and the University Architect's Office on July 17, 2008.
K-12 Outreach
The main purpose of the Department of Computer Science K-12 Outreach Program is to promote scientific literacy and stimulate interest in computer science among students in the K-12 school systems. Visits to K-12 schools include presentations, workshops, and teacher consultations.

A secondary goal of our program is to inspire educators by equipping them with the confidence they need so they may incorporate the use of technology and computer science concepts into their classrooms on a daily basis. This goal is achieved mainly through professional development seminars as well as statewide and national conference presentations.

New this year is a pilot program sponsored by the NCWIT Academic Alliance Seed Fund Grants titled “Are You Smarter than YOUR 5th Grader?” This program seeks to engage parents alongside their child in learning about computer science.

The ROCS: Reaching Out for Computer Science project continues to grow. This group is composed of undergraduate and graduate students passionate about computer science. Purdue undergraduate students in this service-learning program receive course credit. Students travel to high schools and middle schools to give interactive presentations and assist with other outreach programs.

A mainstay of the Computer Science Outreach Program is the annual Summer Camps for Middle School students. There are Beginner and Advanced Level Camps. Additionally, former campers are invited to participate in a Junior Counselor program. Another expansion of the K-12 Outreach Program is a summer workshop for Mathematics teachers. The goal of the workshop, called “Linking Mathematics and Computer Science” is to show these teachers how topics in the mathematics curriculum relate naturally to many concepts in computer science.
Corporate Partners
The Corporate Partners Program (CPP) was launched to foster close communication between the Department of Computer Science and private industry in the context of a mutually beneficial relationship. The department enjoys the benefit of financial contributions, nurturing experiences for our student, and faculty research collaboration with industry leaders. Members in our CPP reap the benefit of increased visibility, priority access to top students who may become future employees, and priority access to faculty who are experts in relevant technical fields.

Companies participate through strategic, unrestricted donations at tier levels and are involved in many core activities of the department. Company representatives take advantage of opportunities to speak in classes, sponsor student projects, and make significant contact with CS students and faculty. Members of the CPP include giants of the information technology industry; as well as companies, large and small, in a wide variety of sectors. Partner members represent Indiana-based companies and other outstanding firms nationwide. This diverse and dynamic membership provides CS students with exposure to a myriad of career opportunities across the United States.

The Corporate Partners meet twice each year to provide input and feedback to departmental and college leadership. Recent contributions of the council include assistance in revising the undergraduate and graduate curricula, suggestions regarding recruiting, retention and enrollment issues, collaborative efforts with faculty and student research, as well as alerting the department to industry areas of concern.

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Development of Private Support

With support from its alumni and friends, Purdue Computer Science competes for the best faculty, recruits top students, provides scholarships, supports research, and funds new program initiatives. The department is deeply grateful to these donors who made contributions and pledges in the 2007-08 academic year.

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The Department of Computer Science is committed to diversity in our students, faculty, and staff, supporting both the participation and success of underrepresented minorities as well as addressing the underrepresentation of women in computer science.

We have redesigned computer science recruiting materials to emphasize the variety of career options available to CS graduates--career options that appeal to a diverse group of students. The department supports a number of events, programs, and other initiatives aimed at increasing the pipeline of women and underrepresented minorities. These initiatives reinforce the fact that successful companies depend on a variety of contributions from a diverse group of employees. Examples of current activities include middle school summer camps to expose underrepresented students to the excitement of computer science, training workshops for high school math teachers to help them link classroom activities to computer science topics, and a student-led high school visitation program called “ROCS: Reaching Out for Computer Science”.

We work closely with the Midwest Crossroads AGEP program office at Purdue, offer summer-bridge programs to incoming students, and participate in conferences aimed at recruiting underrepresented minorities. We also host GEM consortium fellows and Science Bound summer interns.

We have an active presence at conferences including the Grace Hopper Celebration of Women in Computing and the CIC Summer Research Opportunities Program (SROP). We visit minority serving institutions and high schools with high enrollment of underrepresented minorities and encourage students to join our program.

The departmental Computer Science Women’s Network (CSWN) is an organization of students, faculty, and staff dedicated to helping all members succeed in computer science. Over the past several years we have been successful in hiring outstanding female faculty. We held our first annual Women in Computer Science Career Day, targeting high school juniors. The career day event presented young women with fun lab activities that allowed them to explore computer science as a career and Purdue Computer Science as a way to get there.
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Department
Aditya Mathur, Department Head
Mikhail Atallah, Associate Head
John T. (Tim) Korb, Assistant Head
Karla Cotter, Administrative Assistant

Business Office
Mary Bell, Business Manager
Renda Bryant, Account Clerk
Linda Byfield, Account Clerk
Jessica Gretencord-Stein, Account Clerk
Robynne McCormick, Account Clerk
Tammy Muthig, Account Clerk

Office of Development
Javier Magallanes, Director of Development
Jean Jackson, Corporate Relations
Pat Morgan, Secretary

Facilities
Brian Board, Hardware
Ron Castongia, Facilities Manager
Melanie Church, Windows Software
Charles Fultz, UNIX Software
Kip Granson, Windows Software
Nick Hirschberg, Webmaster and DBA
Mike Motuliak, Hardware
Steve Plite, UNIX Software
Dan Trinkle, Tech. System Administrator
Candace Walters, Assistant Director, Facilities

Graduate Office
William J. Gorman, Assistant to the Head
Amy Ingram, Graduate Secretary
Renate Mallus, Graduate Office Coordinator

Support Staff
William Crum, Instructor
Mindy Hart, Outreach Coordinator
Gary McFall, Instructor
Patti Minniear, Copy Center Operator
Paula Perkins, Department Secretary
Nicole Piega, Secretary
Gustavo Rodriguez-Rivera, Instructor
K. C. VanZandt, Instructor
Connie Wilson, Department Secretary

Undergraduate Office
Carol Paczolt, Advisor
Janice Thomaz, Advisor
Karen Wiens, Advisor
The department is dedicated to providing high-quality computing facilities for use by computer science faculty, students, and administrative personnel. The facilities are operated by a technical staff who are not only responsible for the installation and maintenance of the systems, but who also assist faculty and students in the development of software systems for research projects. The staff includes a director, facilities manager, administrative assistant, network engineer, hardware engineer, six system administrators, and several student assistants.

General Facilities
General computing facilities are available for both administrative activities (such as the preparation of research reports and technical publications) and research needs that are not supported by other dedicated equipment. The main server systems are multi-core multiprocessors with large main memories and large disk arrays for storage. Personal workstations and laptops from a variety of vendors are used by faculty, staff, and students throughout the department.

Education Facilities
The Computer Science department operates nine instructional laboratories in two buildings. These labs are used for both undergraduate and graduate computer science courses and include over 200 Intel- and Sun SPARC-based workstations. Supported operating systems include Windows XP, Vista, Linux, Solaris x86, and Solaris SPARC. Two labs are collaboration team project labs dedicated to group learning with the assistance of interactive SMARTboard technology.

I/O Equipment
The department operates both special-purpose output devices as well as general output equipment, including more than 75 laser printers, color printers, color scanners, copiers, video projectors, digital video recording and editing capabilities as well as phone and a variation of video conferencing equipment. The CS department provides video conferencing in dedicated locations as well as mobile video conferencing stations. Recently the CS department has added a new state of the art Cisco Telepresence video conference room.

Networking Services
The department is strongly committed to state-of-the-art networking technology to provide access to and communication among its systems, as well as to those elsewhere on campus and throughout the world. Our departmental infrastructure supports gigabit per second data rates to the desktop throughout our two buildings using over 65 Ethernet VLAN-capable switches from Force10 and Cisco Systems. Wiring in the Lawson Building is based on Panduit augmented CAT6 data cable and patch panels, capable of 10 gigabit per second speeds. This network infrastructure is biconnected to the campus backbone by two 1 gigabit per second redundant fiber links. The campus is connected to multiple high speed Internet backbones, including Abilene/Internet2 and I-Light. DSL, cable, and cellular data services are widely used for remote access.

Information Technology at Purdue (ITaP)
In addition to the facilities described above, students and faculty have access to computing systems owned and operated by ITaP. General instructional facilities operated by ITaP include large Sun SPARC servers and several Sun and Intel workstation laboratories. In addition, ITaP provides systems for use in courses taught by the CS Department. These systems include UNIX-based Sun SPARC stations for undergraduate computer science courses and Microsoft Windows-based Intel personal computers for use in an introductory course for non-majors (CS 110). Departmental research projects make use of other facilities provided by ITaP. These include a large IBM SP cluster and the Envision Center for Data Perceptualization.
Events

Representatives of the CS Corporate Partners Program play pool and bowl with students during the CS Student Mixer.

CS hosts Corporate Partner members for Company Day in the Commons to expose students to the different companies looking to hire graduates.

The annual CS Career Fair is a favorite event for students and corporate recruiters.

The spring Graduating Student Reception honors graduate and undergraduate students graduating during the year.
Purdue Computer Science faculty, staff, and students gather in the Lawson Commons to recognize the accomplishments of colleagues at the CS Employee Recognition Celebration.

CS 2008 Distinguished Alumnus, Dr. Daniel Reed talks to faculty, staff, and students about his experiences in the field.

CS hosts many community building social events during the academic year.