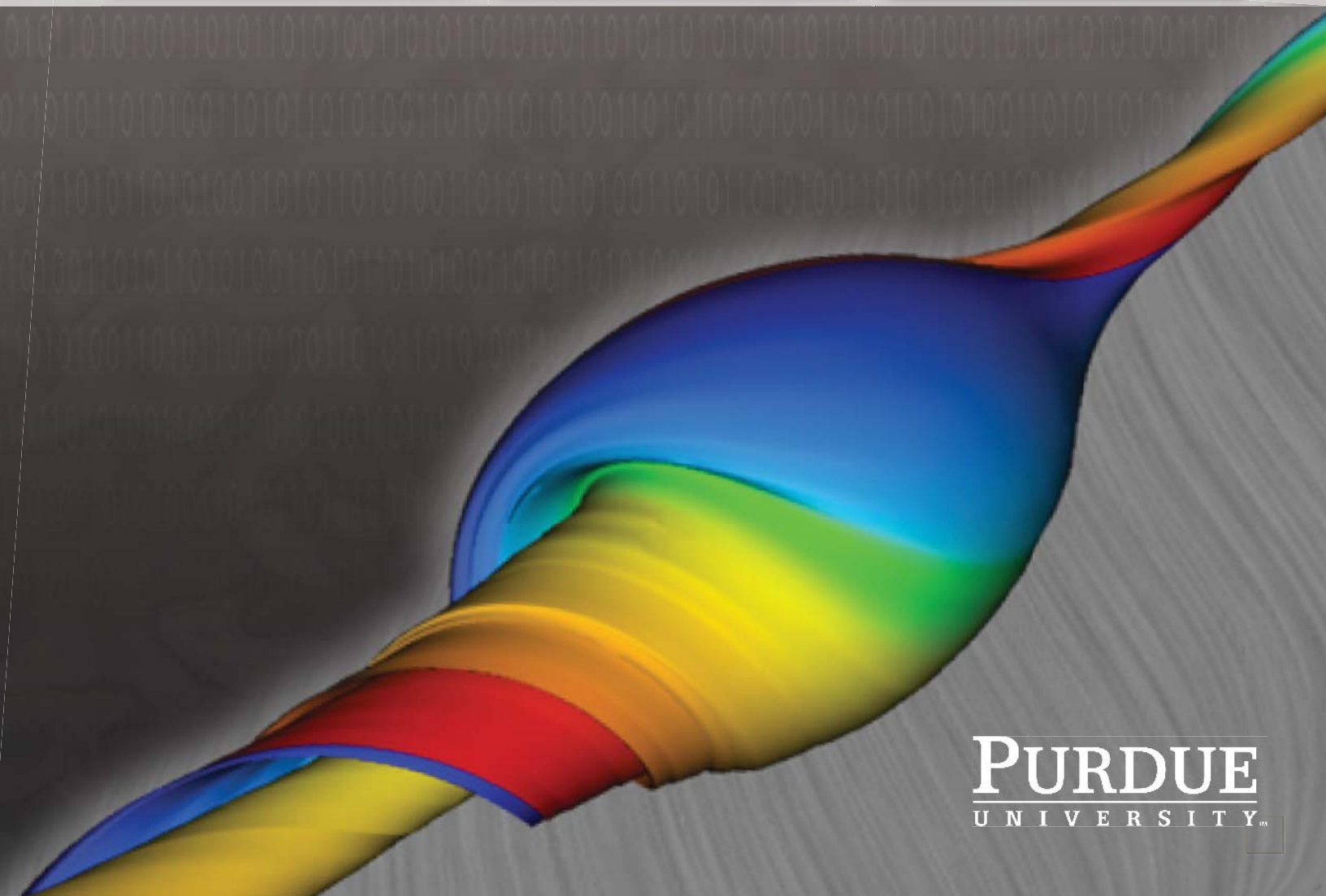
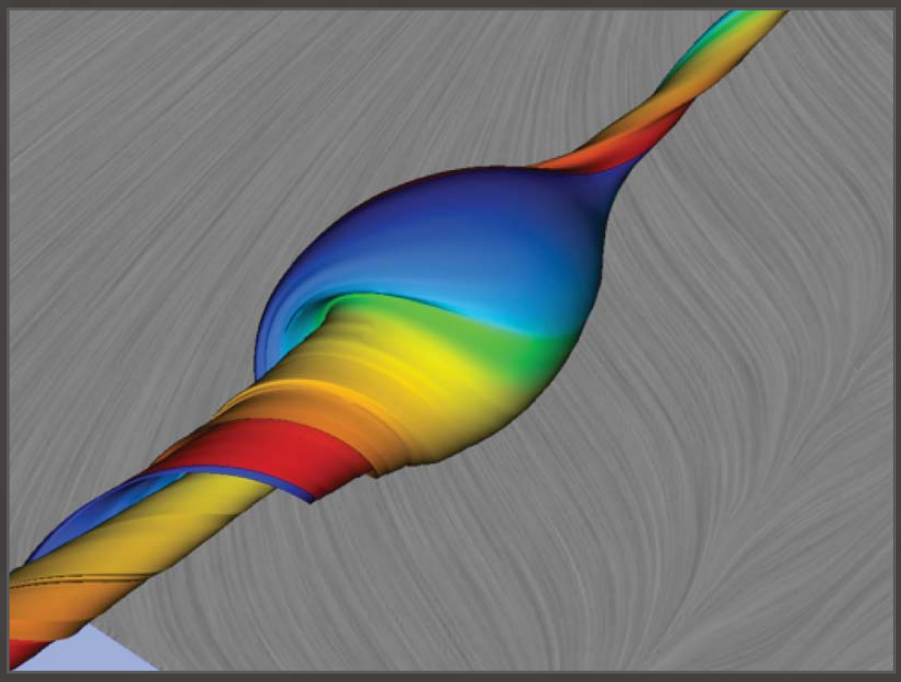
The Department of
COMPUTER SCIENCE
2007-08 Annual Report



PURDUE
UNIVERSITY



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.)

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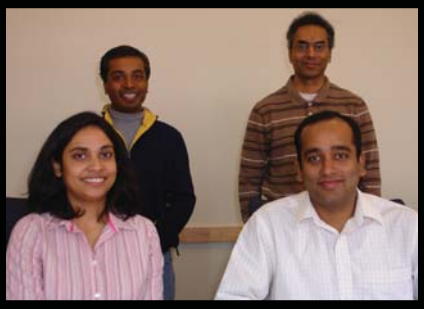
Students discuss career opportunities with corporate partners during the annual CS Career Fair.

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.

Year in Review

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 ISC^2 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.

Kathy Korb, Tim Korb, Sonia Fahmy, Mikhail Atallah, Jean Jackson, Christoph Hoffmann, and Karen Hoffmann attended the 9th annual TechPoint Mira Awards Gala.

Greg Frederickson (center) was recognized at the Book of Great Teachers induction by Provost Randy Woodson (left) and President France Córdova (right).

Bioinformatics and Computational Biology

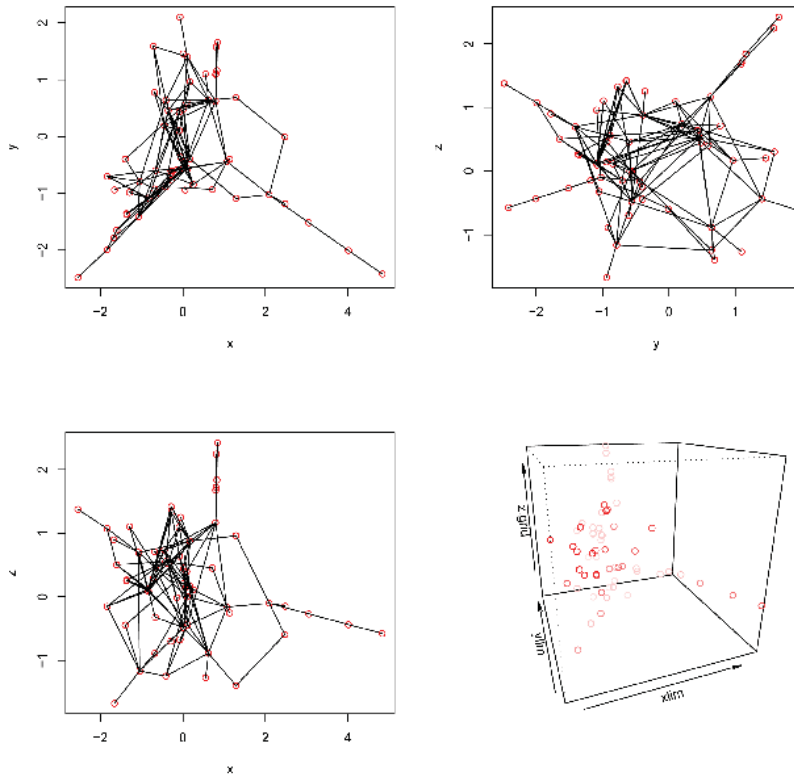
Faculty in the area of bioinformatics and computational biology apply computation methodologies such as databases, machine learning, and discrete, probabilistic, and numerical algorithms, and methods of statistical inference to problems in molecular biology, systems biology, structural biology, and molecular 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.

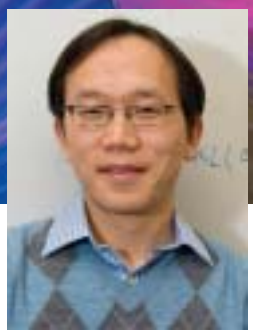
Progress in structural biology and molecular biophysics requires models that incorporate physical properties of biomolecules as well as data. Work in this direction includes prediction and analysis of the relationship among protein sequence, structure and function, determining protein structure via NMR, 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.

Daisuke Kihara



Yuan (Alan) Qi

Olga Vitek

Selected Publications

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Yen Hock Tan, He Huang, and Daisuke Kihara, "Statistical potential-based amino acid similarity matrices for aligning distantly related protein sequences", *Proteins: Structure, Function, Bioinformatics*, Volume 64: pp.587-600, 2006.

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Y. Qi, M. Szummer, and T. P. Minka, "Diagram Structure Recognition by Bayesian Conditional Random Fields", *Proceedings of International Conference on Computer Vision and Pattern Recognition*, 2005.

S. Letarte, M.-Y. Brusniak, D. Campbell, J. Eddes, C. J. Kemp, H. Lau, L. Mueller, A. Schmidt, P. Shannon, K. S. Kelly-Spratt, O. Vitek, H. Zhang, R. Aebersold, and J. D. Watts, "Differential Plasma Glycoproteome of p19ARF Skin Cancer Mouse Model Using the Corra Label-Free LC-MS Proteomics Platform", *Proteomics: Clinical Applications*, 4, p. 105-116, 2008.

I. R. Baxter, O. Vitek, B. Lahner, B. Muthukumar, M. Borghi, J. Morrissey, M. L. Guerinot, and D. E. Salt, "The leaf ionome as a multivariable system to detect a plant's physiological status", *Proceedings of the National Academy of Sciences*, 105, p. 12081–12086, 2008.

L. Hohmann, J. Eng, A. Gemmill, J. Klimek, O. Vitek, G. Reid, and D. Martin, "Quantification of the compositional information provided by immonium ions on a quadrupole-TOF mass spectrometer", *Analytical Chemistry*, 80, p. 5596–5606, 2008.

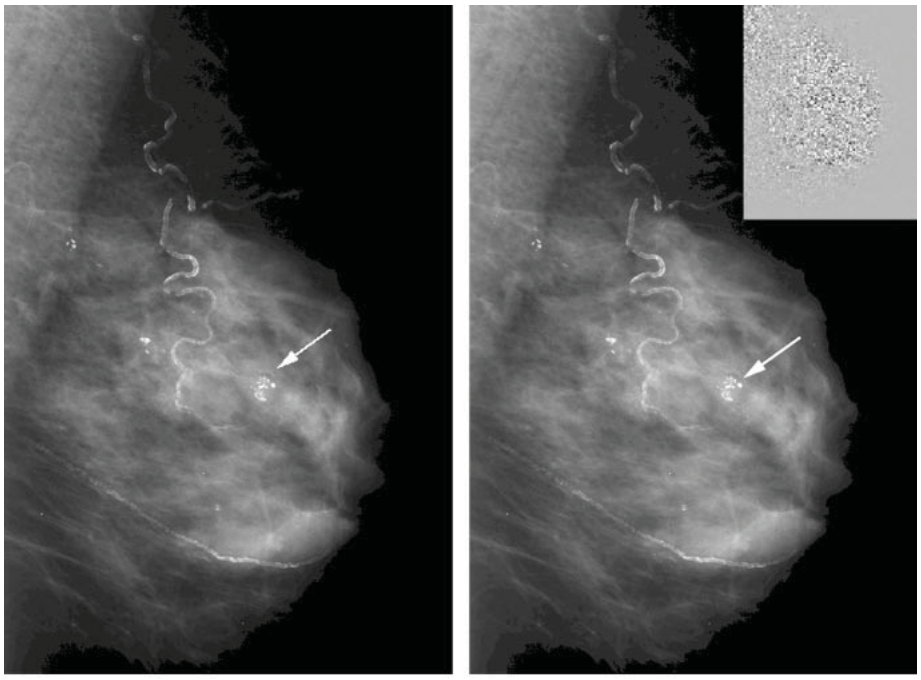
Computational Science and Engineering

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. b.

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.)

Ananth Grama

Bradley Lucier

Alex Pothen

Ahmed Sameh

Robert Skeel

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Mehmet Koyuturk, Yohan Kim, Shankar Subramaniam, Wojciech Szpankowski, and Ananth Grama, "Detecting conserved interaction patterns in biological networks", *Journal of Computational Biology*, 13(7), 1299-1322, 2006.

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Antonin Chambolle, Ronald A. DeVore, Namyong Lee, and Bradley J. Lucier, "Nonlinear Wavelet Image Processing: Variational Problems, Compression, and Noise Removal through Wavelet Shrinkage", *IEEE Transactions on Image Processing: Special Issue on Partial Differential Equations and Geometry-Driven Diffusion in Image Processing and Analysis*, 7(3):319-335, 1998.

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Maria Kallergi, Bradley J. Lucier, Claudia G. Berman, Maria R. Hersh, J. Kim Jihai, Margaret S. Szabunio, and Robert A. Clark, "High-performance wavelet compression for mammography: localization response operating characteristic evaluation", *Radiology*, 238(1):62-73, 2006.

Assefaw Gebremedhin, Arijit Tarafdar, Fredrik Manne, and Alex Pothen, "New acyclic and star coloring algorithms for computing Hessians", *SIAM Journal on Scientific Computing*, Vol. 29 (3), pp. 1042-1072, 2007.

Bruce Hendrickson and Alex Pothen, "Combinatorial scientific computing: The enabling power of discrete algorithms in computational science", *Procs. VECPAR 2006*, LNCS, Vol. 4395, pp. 260-280, 2007.

A. Pothen, A.H. Gebremedhin, F. Dobrian, E.G. Boman, K.D. Devine, B.A. Hendrickson, P. Hovland, B. Norris, J. Utke, U. Catalyurek, and M.M. Strout, "Combinatorial Algorithms for Petascale Science", *SciDAC Review*, Issue 5, pp 26-35, Fall 2007.

E. Polizza and A. Sameh, "SPIKE: A Parallel Environment for Solving Banded Linear Systems", *Computers and Fluids,* 36, 1, pp. 113-120, 2007.

Lixia Liu, Zhiyuan Li, and Ahmed Sameh, "Analyzing Memory Access Intensity in Parallel Programs on Multicore", *Prceedings of 22nd ACM/SIGARCH International Conference on Supercomputing*, June 7-12, 2008.

M. Manguoglu, A. Sameh, T. Tezduyar, and S. Sathe, "A Nested Interative Scheme for Computation of Incompressible Flows in Long Domains", *Computational Mechanics*, 43, No. 1, December 2008.

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W. Wang and R. D. Skeel, "Fast Evaluation of Polarizable Forces", *J. Chem. Phys.*, 123, 164107 (12 pages), 2005.

J. C. Phillips, R. Braun, W. Wang, J. Gumbart, E.Tajkhorshid, E. Villa, C. Chipot, R. D. Skeel, L. Kale, and K. Schulten, "Scalable molecular dynamics with NAMD", *J. Comput. Chem.,* 26, 2005, 1781-1802.

Databases and Data Mining

The database and data mining group at Purdue is composed of Professors Walid G. Aref, Elisa Bertino (p. 15), Bharat Bhargava, Christopher Clifton, Ahmed Elmagarmid, Susanne Hambrusch (p. 23), Jennifer Neville (p. 17), Sunil Prabhakar, Luo Si (p. 17), and Jeffrey Vitter (p. 23); 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.

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Moustafa A. Hammad, Walid G. Aref, and Ahmed K. Elmagarmid, "Query processing of multi-way stream window joins", *The VLDB Journal*, 17(3): 469-488, 2008.

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Walid Aref

Bharat Bhargava

Christopher Clifton

Ahmed Elmagarmid

Sunil Prabhakar

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M. Jenamani, Y. Zhong, and B. Bhargava, "Cheating in Online Auction: Towards Explaining the Popularity of English Auction", *Journal of Electronic Commerce Research and Applications (ECRA)*, Vol. 6, PP. 53-62, 2007.

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S. Singh, C. Mayfield, R. Shah, S. Prabhakar, S. Hambrusch, J. Neville, and R. Cheng, "Database Support for Probabilistic Attributes and Tuples", *Proc. of the IEEE International Conference on Data Engineering (ICDE)*, Cancun, Mexico, 2008.

Mingwu Zhang, Xiangyu Zhang, Xiang Zhang, and Sunil Prabhakar, "Tracing Lineage Beyond Relational Operators", *The International Conference on Very Large Data Bases (VLDB)*, Auckland, NZ, 2007.

Yi-Cheng Tu, Song Liu, Sunil Prabhakar, Bin Yao, and William Schroeder, "Using Control Theory for Load Shedding in Data Stream Management", *Proc. of the IEEE International Conference on Data Engineering (ICDE)*, 2007.

Distributed Systems

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 **F**or **R**esearch **I**n **E**merging **N**etwork & **D**istributed **S**ystems) 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).

Charles Killian

Vernon Rego

Dongyan Xu

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Charles Killian, James W. Anderson, Ranjit Jhala, and Amin Vahdat, "Life, Death, and the Critical Transition: Finding Liveness Bugs in Systems Code", *Proceedings of Networked Systems Design and Implementation*, 2007.

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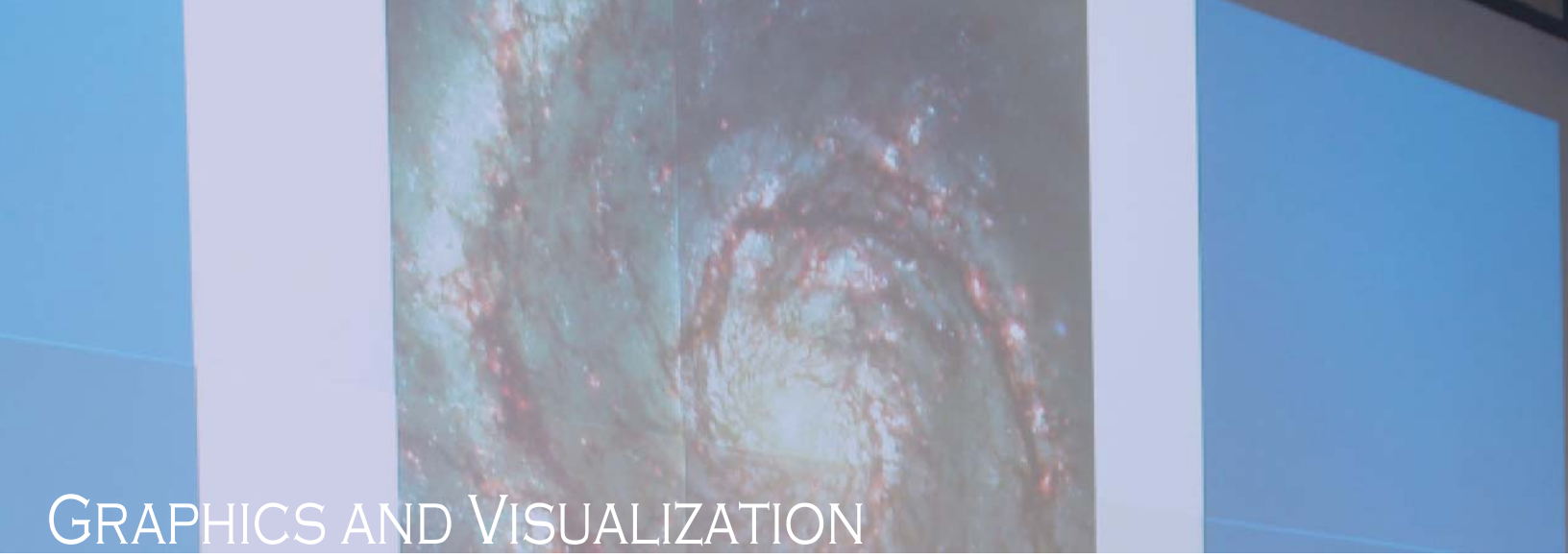

Graphics and Visualization

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.

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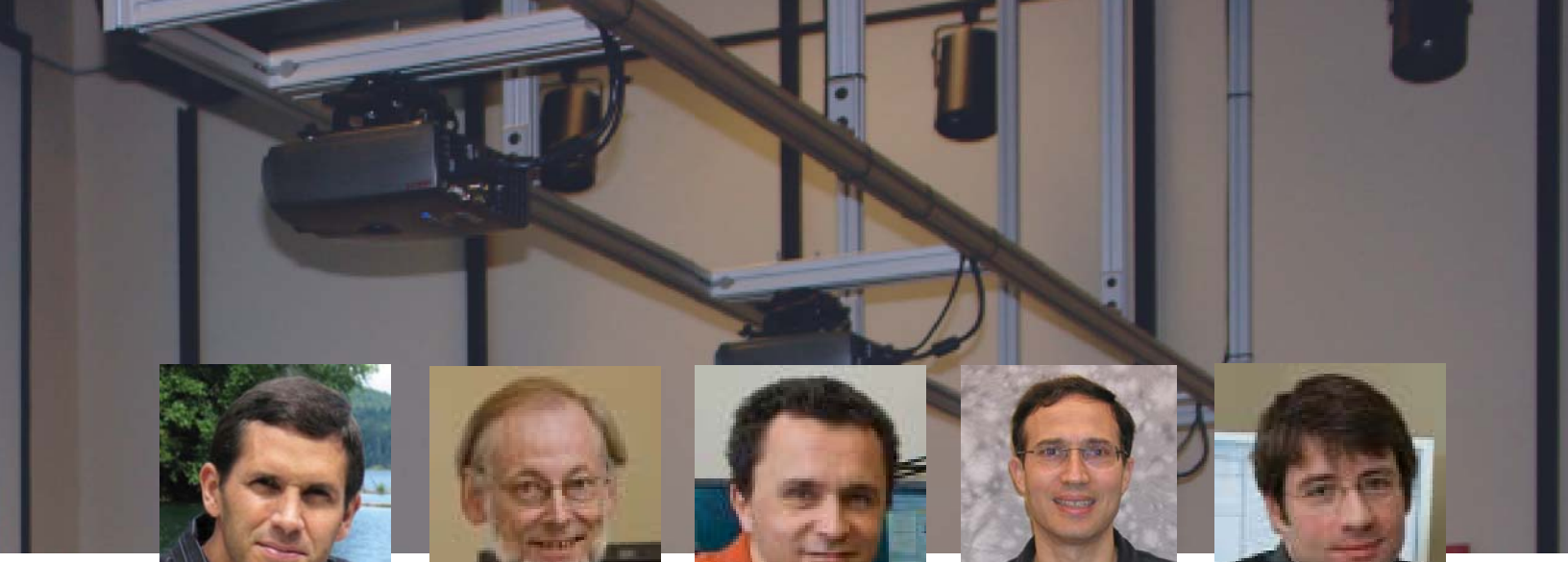

Daniel Aliaga

Christoph Hoffmann

Voicu Popescu

Elisha Sacks

Xavier Tricoche

D. Aliaga and Y. Xu, "Photogeometric Structured Light: A Self-Calibrating and Multi-Viewpoint Framework for Accurate 3D Modeling", *Proceedings of IEEE Computer Vision and Pattern Recognition*, 2008.

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C. Garth, F. Gerhardt, X. Tricoche, and H. Hagen, "Efficient Computation and Visualization of Coherent Structures in Fluid Flow Applications", *IEEE Transactions on Visualization and Computer Graphics*, 13(6), 1735-1742, 2007.

Information Security and Assurance

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 on-line 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, strike-back 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).

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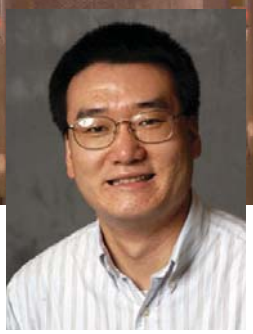
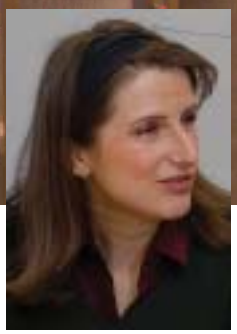
Mikhail Atallah

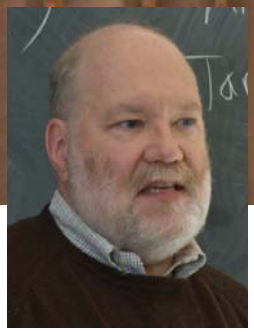
Elisa Bertino



Ninghui Li



Cristina Nita-Rotaru



Eugene H. Spafford

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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.

Jennifer Neville

Luo Si

S.V.N. Vishwanathan

Selected Publications

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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.

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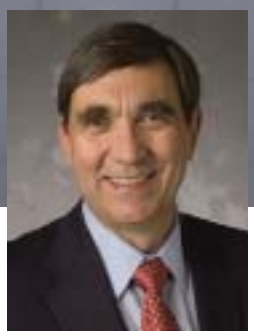

Douglas Comer*

Sonia Fahmy

Ramana Kompella

Kihong Park

David Yau

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*During the period of this annual report, Professor Douglas Comer was on leave at Cisco Systems.

Programming Languages, Compilers, and Software Engineering

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 (p. 11), Eugene H. Spafford (p. 15), Jan Vitek, and Ziangyu Zhang.

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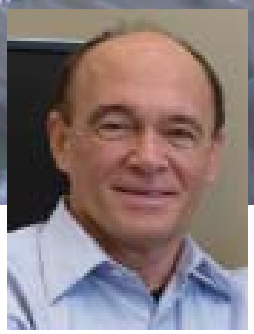
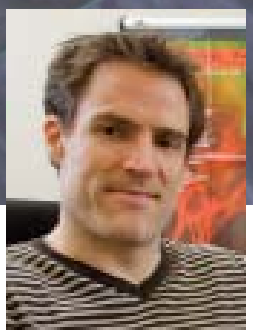


H. E. (Buster) Dunsmore

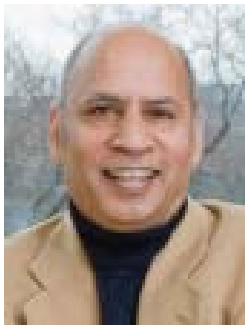


Patrick Eugster

Antony Hosking

Suresh Jagannathan

Zhiyuan Li



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Theory of Computing and Algorithms

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 (p. 15), Saugata Basu, Greg Frederickson, Susanne Hambrusch, Gopal Pandurangan, Wojciech Szpankowski, and Jeffrey Vitter.

Selected Publications

Saugata Basu, "Combinatorial Complexity in O-minimal Geometry", *Proceedings of the London Mathematical Society,* An extended abstract appeared in the *Proceedings of ACM Symposium on Theory of Computing (STOC)*, 2007.

Saugata Basu, "Computing the Top Betti Numbers of Semi-algebraic Sets Defined by Quadratic Inequalities in Polynomial Time", *Foundations of Computational Mathematics*,Vol 8, 45-80, 2008., *Proceedings of ACM* Preliminary version appeared in the *Proceedings of Symposium on Theory of Computing (STOC)*, 2005.

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Greg N. Frederickson, "Ambivalent data structures for dynamic 2-edge-connectivity and k smallest spanning trees", *SIAM Journal on Computing*, Volume 26, pp. 484-538, 1997.

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Mohamed Mokbel, Xiaopeng Xiong, Walid Aref, Susanne Hambrusch, Sunil Prabhakar, and Moustafa Hammad, "PLACE: A Query Processor for Handling Real-time Spatio-temporal Data Streams", *Proceedings of the 13th International Conference on Very Large Data Bases (VLDB)*, pp. 1377-1380, 2004.

Saugata Basu

Greg Frederickson

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Gopal Pandurangan

Wojciech Szpankowski

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S.E. Hambrusch, C.-M. Liu, and S. Prabhakar, "Broadcasting and Querying Multi-dimensional Index Trees in a Multi-channel environment", *Information Systems*, Vol. 31, pp 870-886, 2006.

Sarvjeet Singh, Chris Mayfield, Sunil Prabhakar, Rahul Shah, and Susanne E. Hambrusch, "Indexing Uncertain Categorical Data", *23rd IEEE International Conference on Data Engineering (ICDE 2007)*, 2007.

M. Khan, F. Kuhn, D. Malkhi, G. Pandurangan, and K. Talwar, "Efficient Distributed Approximation Algorithms via Probabilistic Tree Embeddings", *Proceedings of the ACM Symposium on Principles of Distributed Computing (PODC)*, 2008.

M. Khan and G. Pandurangan, "A Fast Distributed Approximation Algorithm for Minimum Spanning Trees", *Distributed Computing*, vol. 20, 2008, 391-402, (Invited paper), *20th International Symposium on Distributed Computing (DISC)*, 2006.

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M. Drmota and W. Szpankowski, "Precise Minimax Redundancy and Regrets", *IEEE Trans. Information Theory*, 50, 2686-2707, 2004.

P. Flajolet, W. Szpankowski, and B. Vallee, "Hidden Word Statistics", *Journal of the ACM*, 53, 1-37, 2006.

M. Koyuturk, Y. Kim, S. Subramaniam, W. Szpankowski, and A. Grama, "Detecting conserved interaction patterns in biological networks", *J. Computational Biology*, 13, 1299-1322, 2006.

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*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.

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Aliaga, Daniel

Daniel Aliaga. Digital Inspection and Virtual Restoration of 3D Objects. Indiana University School of Medicine. 2008-2009, $50,000.

Daniel Aliaga, Rao Govindaraju, Devdutta Niyogi, and Indrajeet Chaubey. INTEROP: A Community-based Drought Information Network for Multidisciplinary Applications. National Science Foundation. 2008-2011, $750,000.

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Aref, Walid

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Atallah, Mikhail J.

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Bhargava, Bharat

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Bharat Bhargava and Leszek Lilien. Vulnerability Analysis and Threat Assessment Avoidance. National Science Foundation. 2003-2009, $212,472.

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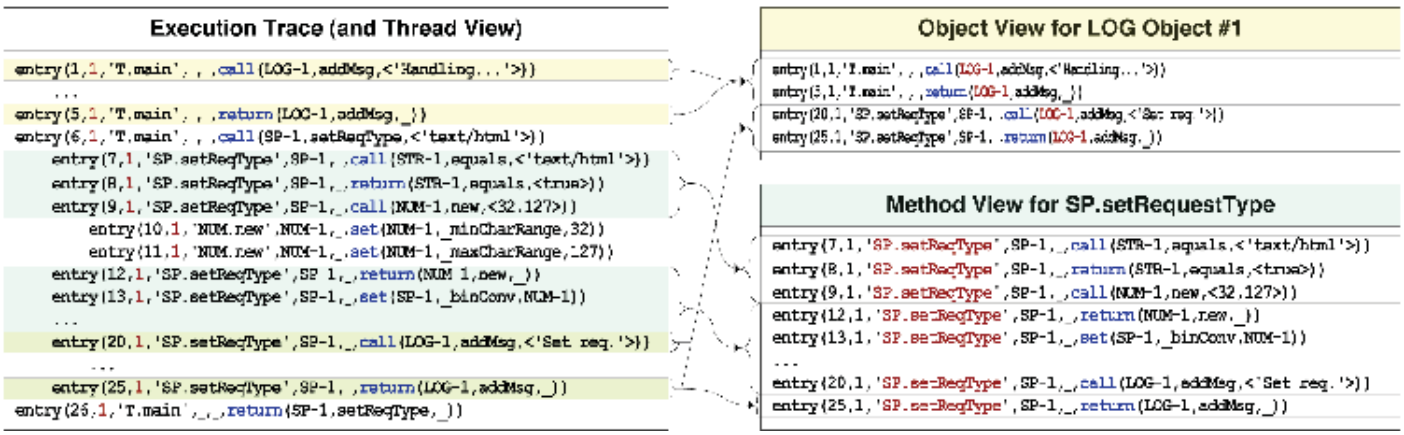

Image illustrating research on semantics-aware program analysis by Kevin Hoffman under supervision of Professors Patrick Eugster and Suresh Jagannathan. The image shows three different views of the same code excerpt, with arrows linking distinct representations of the same program statements. Kevin Hoffman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

Grama, Ananth Y.

Ahmed Sameh, Ananth Y. Grama, and Christoph M. Hoffmann. ITR/AP Collaborative Research: Model Reduction of Dynamical Systems for Real-time Control. National Science Foundation. 2003-2008, $958,502.

Wojciech Szpankowski and Ananth Y. Grama. Algebraic, Combinatorial and Probabilistic Methods for Biological Sequences. National Institutes of Health. 2003-2008, $924,865.

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Wojciech Szpankowski, Ananth Y. Grama, and Daisuke Kihara. Information Transfer in Biological Systems. National Science Foundation. 2008-2012, $480,000.

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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.

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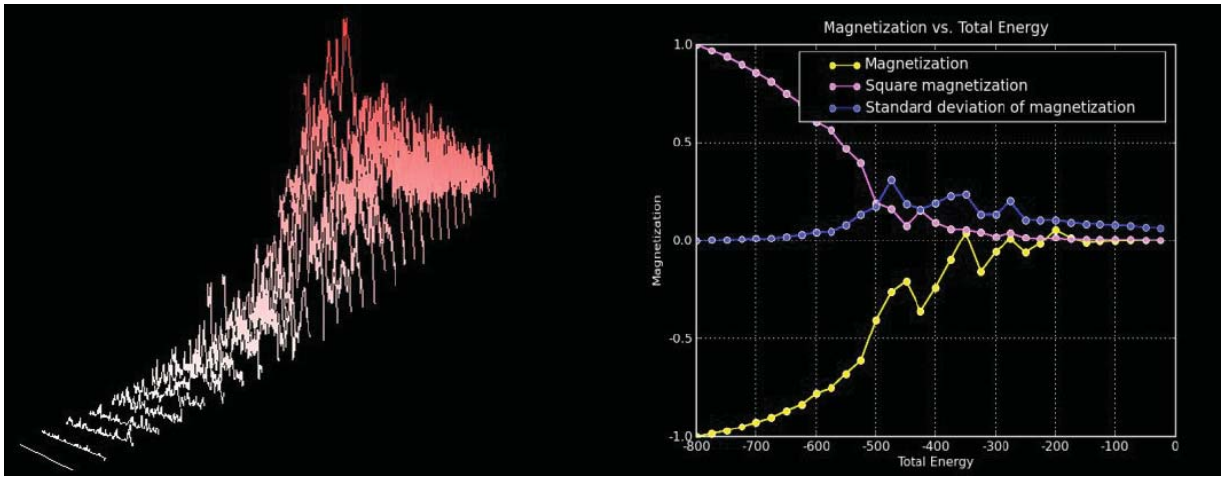
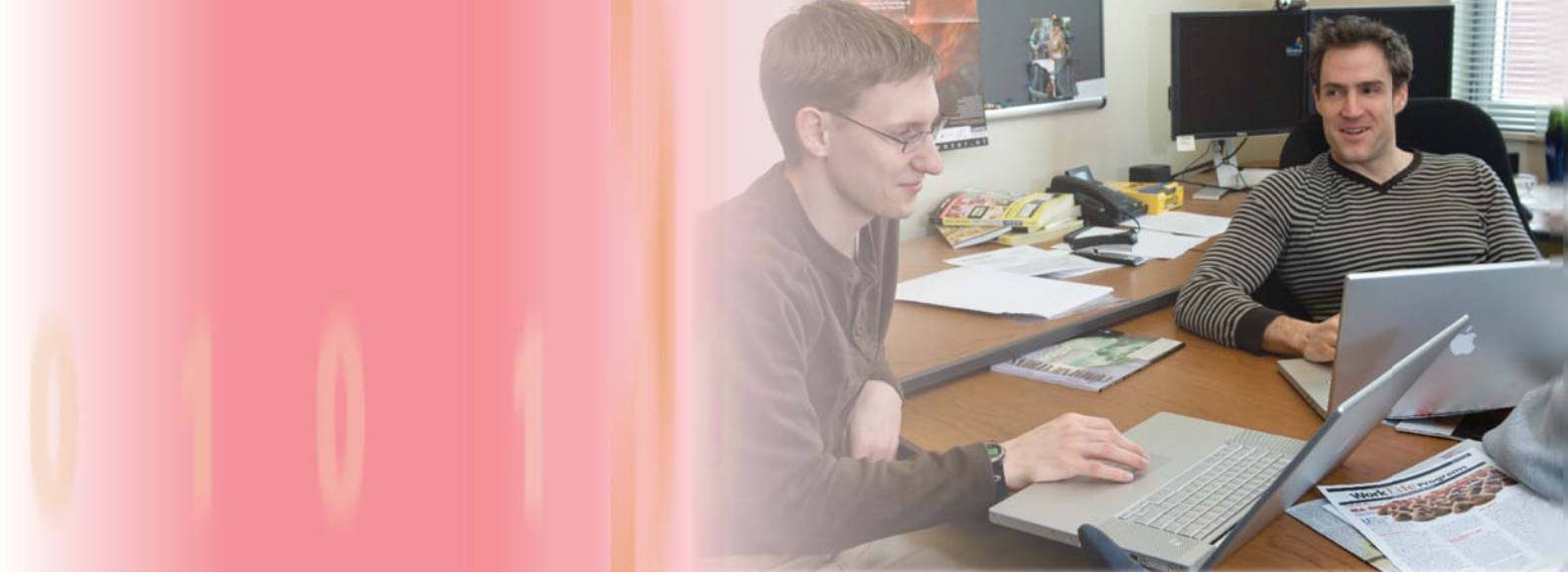


Image provided by Professor Susanne Hambrusch shows a course project in "Introduction to Computational Thinking," a course developed as part of the SECANT project funded through the NSF CPATH program. The image shows the results of a demon algorithm for a 2D Ising model visualizing the magnetization of a lattice of spins.



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Li, Ninghui

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

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Rego, Vernon

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Si, Luo

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Skeel, Robert

Robert Skeel. Collaborative Research: Scalable Algorithms for Generalized Poisson Equations with Point Charge Source Terms. National Science Foundation. 2007-2010, $193,809.

Robert Skeel and Carol Post. Transition Pathways for Biomolecular Systems: Theory and Computation. National Institutes of Health. 2007-2011, $1,179,386.

Spafford, Eugene H.

Eugene H. Spafford. SEED: Developing Instructional Laboratories for Computer Security Information. National Science Foundation. 2006-2010, $60,000.

Eugene H. Spafford. Cyber Security Collaboration and Information Sharing. The Institute for Information Infrastructure Protection (I3P) Research Fellowship. 2007-2009, $300,000.

Dongyan Xu and Eugene H. Spafford. Process Coloring: An Information Flow-Preserving Approach to Malware Investigation. IARPA/Air Force Research Laboratory. 2007-2009, $416,631.

Eugene H. Spafford. Collaborative Research: Transparency and Legal Compliance in Software Systems. National Science Foundation. 2007-2009, $229,593.

Elisa Bertino, Christopher Clifton, Ninghui Li, and Eugene H. Spafford. A Framework for Managing the Assured Information Sharing Lifecycle. University of Maryland Baltimore County. 2008-2013, $1,500,000.

Eugene H. Spafford, Pascal Meunier, and Keith Watson. A High-Assurance, High Capacity Platform for Information Operations. Lockheed Martin. 2008-2010, $200,000.

Eugene H. Spafford. A Dual-Track Masters Degree Program for Infosec Specialists. National Science Foundation. 2001-2007, $3,320,314.

Elisa Bertino, Eugene H. Spafford, Melissa Dark, Howard Sypher, Marc Rogers, Victor Raskin, and Juline Mills. ITR: The Design & Use of Digital Identities. National Science Foundation. 2004-2008, $900,000.

Eugene H. Spafford. CT-ISG: Designing Next-Generation Reliable Internet Servers. National Science Foundation. 2005-2009, $473,787.

Eugene H. Spafford. Zero Condition Toolkit. Pikewerks Corporation. 2007-2008, $225,000.

Eugene H. Spafford, Randal Bond, Edward Finkler, and Pascal Meunier. New Product Design Risk Assesment. Ingersoll Rand Company. 2008, $29,404.

Eugene Spafford, Timothy Collins, and Fariborz Farahmand. Assessing Risk of Insider Threats to Information Systems. Dartmouth College. 2007-2009, $300,000.

Research Funding

Szpankowski, Wojciech

Wojciech Szpankowski and Ananth Y. Grama. Algebraic, Combinatorial and Probabilistic Methods for Biological Sequences. National Institutes of Health. 2003-2008, $924,865.

Wojciech Szpankowski. Crossroads of Information Theory and Computer Science: Analytic Algorithmics, Combinatorics, and Information Theory. National Science Foundation. 2005-2009, $243,862.

Wojciech Szpankowski. Collaborative Research: Nonlinear Equations Arising in Information Theory & Computer Sciences. National Science Foundation. 2005-2009, $122,661.

Wojciech Szpankowski. Information Transfer in Wireless Networks. Purdue Research Foundation. 2007-2008, $14,627.

Wojciech Szpankowski. Asymptotic Solutions to Some Functional Equations Arising in Computer Science. National Security Agency. 2008-2010, $68,358.

Wojciech Szpankowski, Ananth Y. Grama, and Daisuke Kihara. Information Transfer in Biological Systems. National Science Foundation. 2008-2012, $480,000.

Wojciech Szpankowski. Collaborative Proposal: Information Theory of Data Structures. National Science Foundation. 2008-2011, $282,129.

Vitek, Jan

Jan Vitek. Assured Software Composition For Real-Time Systems. National Science Foundation. 2003-2008, $500,000.

Jan Vitek and Pascal Meunier. Develpoment of a Safe, Virtual Imaging Instrument for Logically Destructive Experiments. National Science Foundation. 2004-2009, $800,000.

Jan Vitek. CSR/EHS: Aspectual Configuration of Real-time Embedded Middleware. National Science Foundation. 2005-2008, $240,000.

Suresh Jagannathan and Jan Vitek. CSR/AES: Fault Determination and Recovery in Cycle-Sharing Infrastructures. National Science Foundation. 2005-2009, $350,000.

Antonio Cunei and Suresh Jagannathan. CT-ER: Controlled Declassification with Software Transactional Memory. National Science Foundation. 2007-2009, $249,857.

Jan Vitek. EHS: High-throughput Real-time Stream Processing in Java. National Science Foundation. 2007-2010, $210,000.

Suresh Jagannathan and Jan Vitek. CSR/AES: Fault Determination and Recovery in Cycle-Sharing Infrastructures (Supplement). National Science Foundation. 2008-2009, $23,000.

Jan Vitek and Tony Hosking. CPA-CPL Certified Garbage Collection for Highly Responsive Systems. National Science Foundation. 2008-2011, $390,000.

Suresh Jagannathan, Jan Vitek, Tony Hosking, and Ananth Y. Grama. CRI: A Computational Infrastructure for Experimentation on Relaxed Concurrency Abstractions and their Applications. National Science Foundation. 2006-2008, $99,979.

Jan Vitek. Multi-sponsor. Microsoft Corporation. 2007, $2,500.

Jan Vitek. Multi-sponsor. International Business Mahcines Corporation. 2008, $1,000.

Jan Vitek. Multi-sponsor. Intel Corporation. 2007, $6,000.

Vitter, Jeffrey

Mithuna Thottethodi, Vijay Pai, T.N. Vijaykumar, Jeffrey Vitter, and Rahul Shah. Performance Models & Systems Optimization for Disk Bond Applications. National Science Foundation. 2006-2009, $889,788.

Xu, Dongyan

Dongyan Xu. CAREER: Towards Virtual Distributed Environments in a Shared Distributed Infrastructure. National Science Foundation. 2006-2011, $400,000.

Dongyan Xu and Eugene Spafford. Process Coloring: An Information Flow-Preserving Approach to Malware Investigation. IARPA/Air Force Research Laboratory. 2007-2009, $416,631.

Dongyan Xu. CSR-EHS: Collaborative Research: H-Media: The Holistic-Multistream Environment for Distributed Immersive Applications. National Science Foundation. 2007-2010, $145,000.

Dongyan Xu. CT: ISG: Collaborative Proposal: Enabling Detection of Elusive Malware by Going Out of the Box with Semanticaly Reconstructed View (OBSERV). National Science Foundation. 2007-2010, $130,000.

Michael McLennan, Gerhard Klimeck, and Dongyan Xu. SDCI NMI Improvement: nanoHUB Middleware. National Science Foundation. 2007-2010, $1,350,000.

Gerhard Klimeck, Thomas Hacker, and Dongyan Xu. Accelerating Nano-Scale Transistor Innovation Though Petascale Simulation. National Science Foundation. 2007-2011, $1,599,205.

Dongyan Xu, Sebastien Goasguen, and Gerhard Klimeck. NMI Deployment (ENG): nanoHub. National Science Foundation. 2004-2008, $2,967,804.

Yau, David

David Yau. System Support for Detection, Identification, and Tracking Tasks in Sensor-Cyber Networks. Oak Ridge National Laboratory. 2006-2009, $200,000.

David Yau. Collaborative Research: A Component-based Software Environment for Simulation, Emulation, and Synthesis of Network Protocols in Next Generation Networks. National Science Foundation. 2004-2009, $187,000.

David Yau. Northwest Indiana Computational Grid: A Joint Project of the University of Notre Dame, Purdue University-West Lafayette, and Purdue University-Calumet. Department of Energy. 2005-2007, $15,569.

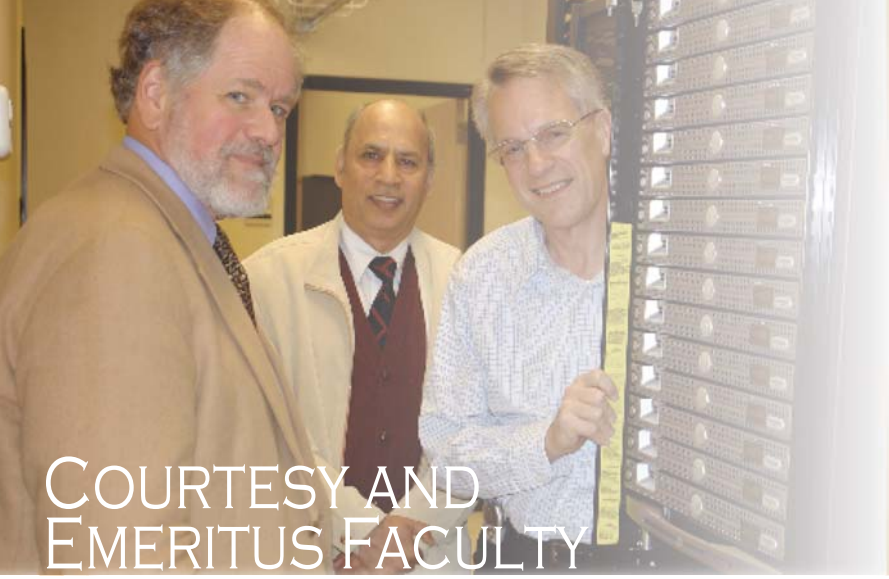
David Yau. Robust and Deeply Embedded Plume Detection, Identification, & Tracking Sensor-Cyber Networks. Purdue Research Foundation. 2007-2008, $16,375.

David Yau. Student & Minority Faculty Travel Grant Program to Attend ICNP 2007. National Science Foundation. 2007-2008, $35,000.

Zhang, Xiangyu

Xiangyu Zhang. CSR-AES-RCS: Collaborative: Scalable and Efficient Dynamic Information Flow Tracking in Multithreaded Programs. National Science Foundation. 2007-2009, $100,000.

Xiangyu Zhang. Collaborative Research: CRI: IAD An Advanced Infrastructure for Generation, Storage, and Analysis of Program Execution Traces. National Science Foundation. 2007-2008, $50,000.



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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
Michael Gribskov, Biology
Y. Charlie Hu, Electrical and Computer Engineering
Sabre Kais, Chemistry
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Ness Shroff, Electrical and Computer Engineering
T N Vijaykumar, Electrical and Computer Engineering

Emeritus Faculty

Walter Gautschi
Elias Houstis
Robert Lynch
John Rice
John Steele

EDUCATION

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 Bioinformatics 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 Versitile 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

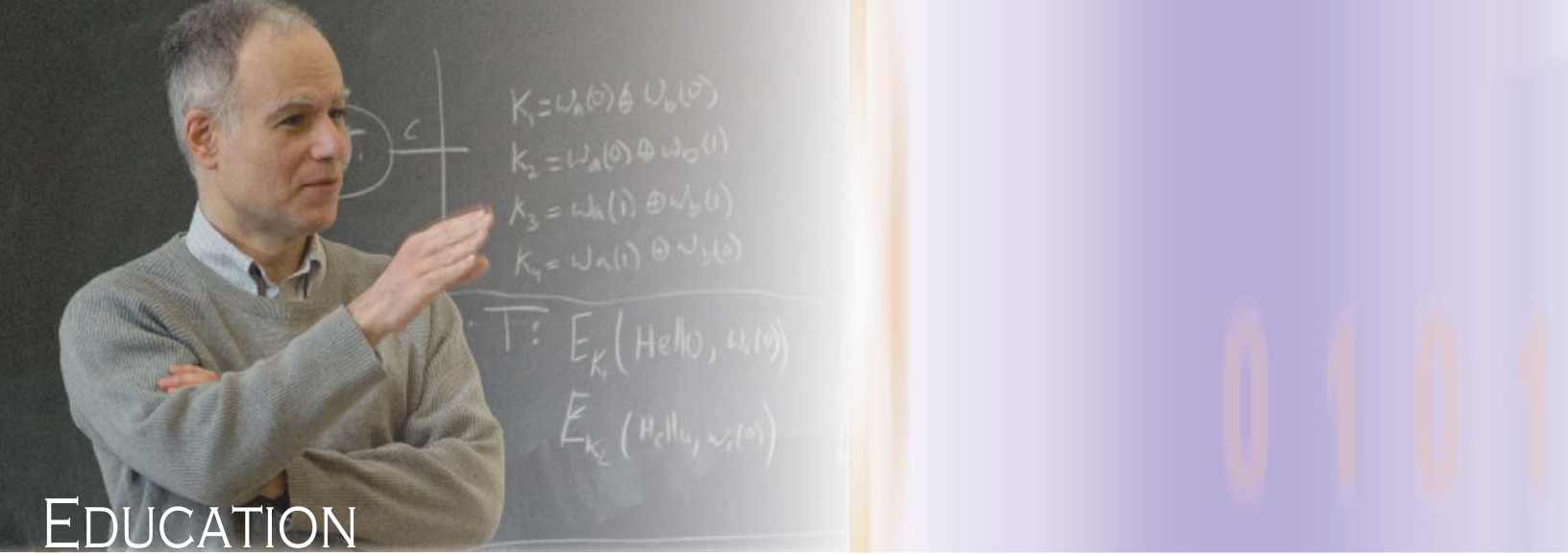
Amit Jayant Shirsat
"Self-Configuration Algorithms for Mobile Ad Hoc Networks"
Advisor: B. Bhargava
Employer: Yahoo!

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



Education

Graduate Teaching Assistants

Ferit Akova
Nathan Robert Andrysco
Muhammad Umer Arshad
Sahan Sajeewa Bamunavita Gamage
Samer Samir Barakat
Ethan Lee Blanton
Suleyman Cetintas
Trishabh Chadda
Meghana Vasant Chitale
Youn Sun Cho
Vasil Stefanov Denchev
Derek Mark Drake
Hicham Galal Elmongui
Yi Fang
Mohamed Raouf Fouad
Ashish Gandhe
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Salman Javed
Chamikara Madhusanka Jayalath
Wei Jiang
Fredrick Prashanth John Berchmans
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Michael Scott Kirkpatrick
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Jia-Hong Wu
Yu Hong Yeung
Hao Yuan
Yu Zhang
Zhen Zhu

Graduate Research Assistants

Ahmed Hamdy Ibrahim Abdel-Gawad
Ahmad Mohammad Abu Salah
Ferit Akova
Hasan Metin Aktulga
Muhammad Umer Arshad
Asad Khan Awan
Alok Kumar Bakshi
Sahan Sajeewa Bamunavita Gamage
Bhagyalaxmi Bethala
Abhilasha Bhargav-Spantzel
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Hoda Mohamed Eldardiry
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Hwan Jo Heo
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Wei Jiang
Jayaram Kallapalayam Radha
Ashish Kamra
Ardalan Kangarlou-Haghighi
Md-Abdul Maleq Khan
Ravish Khosla
HyoJeong Kim
Michael Scott Kirkpatrick
Alvin Jon-Hang Law
Myungjin Lee
Tiancheng Li
Zhiqiang Lin
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Lixia Liu
Yu Tak Ma
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Murat Manguoglu
Christopher Scott Mayfield
Philip McGachey
Carl Christian Kjelgaard Mikkelsen
Mohamed Yoosuf Mohamed Nabeel
Mummoorthy Murugesan
Maxim Naumov
Armand Navabi
Rimma Vladimirovna Nehme
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Mehmet Ercan Nergiz
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Sarvjeet Singh
Tion A. Thomas
Ping Wang
Rongjing Xiang
Hao Yuan
Lukasz Ziarek

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Ruy De Oliveira
Gabriel Ghinita
Tomas Kalibera
Dan Lin
Anna Squicciarini
Samuel Wrigstad
Huiying Xu
Ruijun Zhao

Visiting Assistant Professor
Pascal Meunier

Visiting Professor
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Hyojin Kim
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Hyo Sang Lim
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Yiqing Sun
Danfeng Yao
Suk Dea Yu

ENGAGEMENT

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.

Gibraltar Design presented the Purdue Computer Science Department and the University Architect's Office with the American School and University AS&U educational design excellence award on July 17, 2008.

Engagement

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.

Tearchers at the summer workshop engage in an algorithmic thinking exercise called "Programming with Peanut Butter."

Middle school campers team up to build Lego robots during the annual CS Summer Camp.

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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Engagement

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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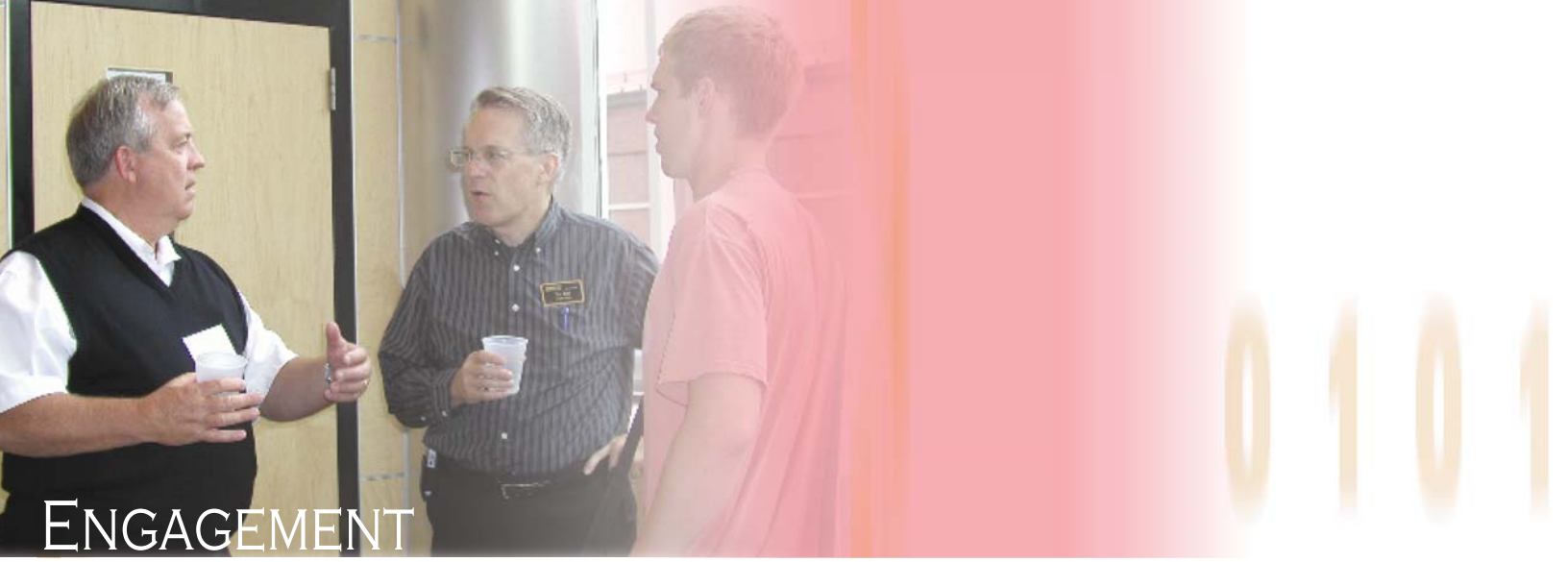

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DIVERSITY

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.

Faculty, staff, and students attend the 2007 Grace Hopper Celebration for Women in Computing hosted by the Anita Borg Institute for Women and Technology.

Students in grades six through nine can participate in the annual CS Summer Camp. The program aims to expose underrepresented students to computer science and the careers that are available to a CS graduate.

Guest Speakers

DATE	SPEAKER/AFFILIATION	TALK TITLE
8/27/2007	Prof. Andries van Dam, Brown University	When is the Pen Mightier Than the Keyboard?
8/29/2007	Pau-Chen Cheng, PhD; IBM T.J. Watson Research Center	Fuzzy MLS: An Experiment on Quantified Risk Adaptive Access Control
8/30/2007	Prof. Alex Pothen; Old Dominion University	Coloring Graphs to Compute Derivatives: Combinatorial Algorithms Enabling Computational Science and Engineering
9/4/2007	Prof. Klemens Böhm; Universität Karlsruhe (TH)	Indirect Partner Interaction in Peer-to-Peer Networks -- Stimulating Cooperation by Means of Structure
9/13/2007	Nathaniel Nystrom, PhD; IBM Research	User-defined Language Extensions in X10
9/20/2007	Prof. Yair Amir; Johns Hopkins University	SMesh: a Seamless Multi-homed Wireless Mesh Network with Fast Handoff
9/24/2007	Frances Allen; IBM	Compilers and Multicore Computing Systems
10/5/2007	Prof. Surendar Chandra; University of Notre Dame	Mobile Collaboration Applications
10/11/2007	Prof. Jun Li; Tsinghua University	Packet Classification and Pattern Matching Algorithms for High Performance Network Security Gateway
10/15/2007	Prof. Christos Faloutsos; Carnegie Mellon University	Graph Mining: Laws, Generators and Tools
10/22/2007	Prof. Indranil Gupta; University of Illinois, Urbana Champaign	Wizards and Fruitflies -- Using Eternal and Ephemeral Overlays for Monitoring Distributed Systems
11/5/2007	Prof. Yao Liang; Indiana University-Purdue University, Indianapolis	Energy Efficient and Reliable Communication in Wireless Sensor Networks
11/5/2007	Prof. Robby Findler; University of Chicago	DrScheme, Why Programming Matters
11/12/2007	Prof. Robert Sedgewick; Princeton University	The Role of Science and Mathematics in Software Development
11/15/2007	Khaled Elmeleegy; Rice University	Enhancing Ethernet's Reliability
11/19/2007	Mark Danks; Sony	PlayStation-edu
11/19/2007	Marcelo Weinberger, PhD; Hewlett-Packard Labs	Information Theory in an Industrial Research Lab
12/3/2007	Neal Glew, PhD; Intel	Ct and Pillar: Building a Foundation for Many-Core Programming
1/11/2008	Prof. Rob Reeder; Carnegie Mellon University	Expandable Grids Prototypes for Visualizing and Authoring Policies in Security, Privacy, and Other Domains
1/23/2008	Prof. John Reppy; The Manticore project	The Manticore project
1/28/2008	Prof. Joan Feigenbaum; Yale University	Sensitive Information in a Networked World
1/30/2008	Richard Patton; Lawson Software	The Lawson Landmark Domain Specific Design Language
2/5/2008	Alex Orso; Georgia Tech	Dynamic Tainting and its Application to Effective Memory Protection
2/11/2008	Weihua Geng; Michigan State University	The Matched Interface and Boundary method based high-order Poisson-Boltzmann equation solver and its application to computing solvation forces
2/18/2008	Nikhil Swamy; University of Maryland	End-to-end Security for Web Applications : A Language-based Approach

DATE	SPEAKER/AFFILIATION	TALK TITLE
2/25/2008	Prof. Jesus Izaguirre; University of Notre Dame	Accelerated Molecular Dynamics using Normal Mode Analysis
2/27/2008	Ulrich Hetmaniuk, PhD; Sandia National Laboratories	Eigenspace Computations in Linear Structural Dynamics
3/4/2008	Andrew McGregor, PhD; University of California, San Diego	Computing on Streams: New Results and Directions
3/6/2008	Prof. Luis Ortiz; University of Puerto Rico, Mayague	Solving Problems in Complex Systems
3/17/2008	Prof. Randall Burns; The Johns Hopkins University	A Reduction in Scale? Querying the Cosmos across the Globe
3/19/2008	Chi-Keung (CK) Luk, PhD; Intel	Dynamic Compilation in Practice: From Instrumentation to Parallelization
3/24/2008	Christoph Csallner; Georgia Institute of Technology	Combining Static and Dynamic Analyses for Automated Bug-Finding
3/26/2008	Charles Killian; University of California, San Diego	Mace: Systems and Language Support for Building Correct, High-Performance Networked Services
3/26/2008	Prof. David Lee; Ohio State University	Network Court Protocol and Secure Internet Business
3/28/2008	Karthik Pattabiraman; University of Illinois, Urbana-Champaign	Application-aware Checking for Error and Attack Detection
3/31/2008	Desmond Lun, PhD; Harvard Medical School	Making Fuel- and Drug-Producing Microbes through Analysis, Modeling, and Computational Design
4/1/2008	Yiying Tong, PhD; Michigan State University	Discrete Geometry: From Graphics to Computational Science
4/3/2008	Arvind Seshadri; Carnegie Mellon University	Secure Computing on Untrusted Computer Systems
4/4/2008	Prof. Peng-Jun Wan; Illinois Institute of Technology, Chicago	Minimum-Latency Communication Scheduling in Multihop Wireless Networks
4/7/2008	Prof. Victor Raskin; Purdue University	How Does Linguistics Get To Be Computational: NL IAS and Other Joint Applications of LING and CS
4/10/2008	Daniel Reed, PhD, Microsoft	Personal Reflections on Computing
4/14/2008	Andreas Krause; Carnegie Mellon University	Optimizing Sensing from Water to the Web
4/15/2008	Adam J. Lee; University of Illinois, Urbana-Champaign	Towards Practical and Secure Decentralized Attribute-Based Authorization Systems
4/16/2008	Sergei Evdokimov, PhD; Humboldt-Univeristät zu Berlin	RFID and Multipolarity for the Object Naming Service
4/21/2008	Prof. Umut Acar; Toyota Technological Institute at Chicago	Self-Adjusting Computation
4/23/2008	Prof. Shriram Krishnamurthi; Brown University	A Programming Language for the New Web
4/24/2008	Kathi Fisler, PhD; Watson Pharmaceuticals, Inc.	How Playing Cards Changed my View of Access-Control Policies
4/28/2008	Adam Welc, PhD; Intel	Design and Implementation of Transactional Constructs for C/C++
5/2/2008	Rica Gonen, PhD; Yahoo!	Truthful Adaptive Sponsored Search Mechanisms
5/12/2008	John Field, PhD; IBM Research	The Reactor Model: New Abstractions for Programming Internet-Scale Applications
5/13/2008	Bard Bloom, PhD; IBM Research	A Taste of Erlang
5/22/2008	Bradley Steffens; author	Ibn al-Haytham: The First “Mad” Scientist

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Facilities

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.

Genearl 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 SPARCservers 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.

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.

Purdue Computer Science faculty, staff, and students gather in the Lawson Commons to recognize the accomplishments of colleauges at the CS Employee Recognition Celebration.

PURDUE
UNIVERSITY

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