2005 SUMMARY OF ENGINEERING RESEARCH

A Report of Activities during 2004

This .pdf is part of the larger 2005 Summary of Engineering Research, available on the Web at www.engr.uiuc.edu/research and on CD-ROM. The Summary of Engineering Research represents the extensive engineering research program conducted in 2004 at the University of Illinois at Urbana-Champaign. Detailed statistics about research in the College of Engineering are included in the Directory of Engineering and Engineering Technology Programs and Research, published by the American Society for Engineering Education, Washington, D.C.

How to Use the Summary of Engineering Research: Research projects are listed by title, followed by the names of the investigators and the sponsoring agencies. Projects are sorted by major topic areas. Project descriptions are brief. Additional information on each project may be obtained from the investigator in charge (denoted by an asterisk). Mailing addresses are provided on the introductory page.

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The 2005 Summary of Engineering Research is produced by the Office of Engineering Communications, University of Illinois at Urbana-Champaign.

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For more than fifty years, the Department of Computer Science at the University of Illinois has quietly led a revolution that has redefined the meaning of computing. Our students and faculty have designed and built the world’s fastest computers, created the user interfaces that popularized the World Wide Web and helped make distributed collaboration possible, invented the compilation techniques for automatic programming parallelization, co-founded the field of computer arithmetic, discovered new techniques for numerical solution of stiff ordinary differential equations, and carried out seminal work in parallelizing compilers.

The department offers an array of powerful computers and software for instruction, as well as research laboratories maintained by individual faculty. All systems are connected to a high-speed network with multiple wireless networks also available. The department also provides computer clusters, printers, file services, and other technology services for all of its users. In early 2004, the department relocated to the Thomas M. Siebel Center for Computer Science, which serves as a living laboratory for exploring and evaluating 21st century computing environments.

Current research areas include the following: algorithms and theory; artificial intelligence in the areas of machine learning, vision, and robotics; computer architecture and compilers; databases and information systems; graphics and visualization; human–computer interfaces; networking; operating systems and security; parallel processing; programming languages, formal systems, and software engineering; real-time and embedded systems; and scientific computing.

The department is also home to the Center for Simulation of Advanced Rockets (CSAR) and the Center for Advanced Research in Information Security (CARIS). It has many collaborative ties with units throughout campus, including the National Center for Supercomputing Applications (NCSA), Beckman Institute for Advanced Science and Technology, and the Coordinated Science Laboratory (CSL).

Faculty and Their Interests

Sarita Adve
Computer architecture, low-power design, adaptive systems, real-time and network processing, performance evaluation methods, parallel

Vikram Adve
Compilers, software reliability, performance analysis, computer architecture computing

Gul A. Agha
Developing new abstractions for building open distributed systems and reasoning about their behavior, parallelism, coordination, real-time behavior

Eyal Amir
Automated reasoning and machine learning

Brian P. Bailey
User interface tools that better support early design tasks, systems and environments that help users maintain information awareness, tools for multimedia authoring and design, interfaces that foster social interaction, human–computer interaction

Geneva G. Belford, Emeritus
Databases and information systems, distributed systems

Stephen Bond
Numerical analysis and scientific computing, with applications in statistical mechanics, and biochemistry; understanding methods that bridge the temporal and spatial scales in multiscale biomolecular modeling using techniques from geometric integration and adaptive finite element methods

Marco Caccamo
Real-time operating systems, real-time scheduling and resource management, wireless sensor networks, quality of service control in next-generation digital infrastructures

Roy H. Campbell
Security, distributed operating systems, ubiquitous computing
Kevin C.-C. Chang  
Databases, Internet information access, and digital libraries, with focuses on information integration of heterogeneous sources, Internet query processing, web databases, and ranked top-k query processing

Gerald DeJong  
Artificial intelligence

AnHai Doan  
Databases, data integration and sharing, data mining, information discovery on the Web, efficient use and maintenance of meta-data, schema matching, machine learning

Jeffrey G. Erickson  
Algorithms, data structures, and lower bounds; computational and discrete geometry

Margaret Fleck  
Automated reasoning and machine learning

David Forsyth  
Artificial intelligence, computer vision, machine learning

Michael Garland  
Computer graphics, geometric modeling, human–computer interaction, visualization

Carl A. Gunter  
Security, networks, software engineering, programming languages

Elsa Gunter  
Formal systems

Indranil Gupta  
Distributed systems, distributed protocols, probabilistic protocols, design methodologies, sensor networks

Jiawei Han  
Database systems, data mining, data warehousing, stream data mining, Web mining, spatiotemporal data mining, bio-data mining

Mehdi T. Harandi  
Artificial intelligence, information systems, HCI, software engineering

Sariel Har-Peled  
Algorithms, data structures, computational geometry, clustering, learning, computer graphics

Luddy Harrison  
System architecture

John C. Hart  
Computer graphics, computational topology

Michael T. Heath  
Scientific computing, parallel computing

Jennifer C. J. Hou  
Multicast routing and multicast, protocol design and implementation for Quality-of-Service (QoS) control, wireless QoS, network modeling and simulation, distributed systems and applications, real-time computing

Laxmikant V. Kale  
Numerical, parallel, and scientific computing, operating systems

Samuel N. Kamin  
Programming languages, software components, functional programming applied to scientific computation, denotational semantics, program specification and verification, domain-specific languages

Karrie Karahalios  
Human–computer interfaces

Thomas Kerkhoven  
Numerical and scientific computing

Robin H. Kravets  
Mobile computing and communication, location management, power management, transport protocols, ad hoc networks, personal area networks

Steven M. LaValle  
Robotics, motion planning, computational geometry, artificial intelligence, computational biology, computer vision, computer graphics, control theory

Haiyun Luo  
Networking and distributed systems

M. Dennis Mickunas, Emeritus  
Operating systems, parallel computing, programming languages
Jose Meseguer
Formal executable specification and verification; software composition, reflection, and metaprogramming; object-oriented specification and software architecture; concurrent, distributed, and mobile computing; logical frameworks and formal interoperability; logical and semantic foundations

Saburo Muroga, Emeritus
Computer-aided design of digital systems

Klara Nahrstedt
Quality-of-Service (QoS) management, integration of guaranteed and best effort services for audio/video/DATA traffic, QoS-aware resource management, QoS routing, multimedia security, soft real-time scheduling, middleware support for distributed multimedia applications

David A. Padua
Computer architecture and systems, parallel computing, compilers

Lenny Pitt
Artificial intelligence, theoretical computing

Jean A. Ponce
Computer vision, robotics, computer graphics

Edgar A. Ramos
Computational geometry: randomized algorithms and derandomization, optimization and approximation algorithms, triangulation and mesh generation, topological methods and algorithms, parallel algorithms

Sylvian Ray, Emeritus
Artificial intelligence

Larry Rendell
Artificial intelligence

Grigore Rosu
Software and software related aspects; design, semantics, and implementation of programming and specification languages; automated software engineering and formal methods, especially “push-button” techniques for certification, monitoring, synthesis, and modularization; automated reasoning about computer systems, applications of logics, theorem proving; algorithms, (co)algebra, category theory

Dan Roth
Artificial intelligence, theoretical computing

Lui Sha
Distributed real-time computing systems, dynamic real-time architecture, Quality-of-Service (QoS) driven resource management, security and fault tolerance in networked embedded systems

Robert D. Skeel, Emeritus
Numerical analysis and scientific computing, computational methods for biomolecular simulation

Marc Snir
Large-scale parallel and distributed systems, parallel computer architecture, grid computing, parallel programming

Eric de Sturler
Iterative methods, eigenvalue problems, large-scale optimization

Josep Torrellas
Parallel and sequential computer architecture, processor-memory integration, thread-level speculation, low power design, reliability

Mahesh Viswanathan
Analysis and validation of software systems, including design of efficient algorithms, characterization of computational limitations, development of formal models for system specification, and implementation of software tools for program analysis

Marianne S. Winslett
Databases, security, parallel computation

Yizhou Yu
Appearance modeling, animation, computer graphics and vision, image and video processing

ChengXiang Zhai
Text processing and management, statistical natural language processing, machine learning, bioinformatics

Yuanyuan Zhou
Operating systems, file and storage systems, architecture, distributed systems, parallel systems, system support for database

Craig Zilles
Computer architecture, dynamic optimization, compiler construction, simulation methodologies, software engineering
Approximation in Computational Geometry
S. Har-Peled*
University of Illinois

This research has concentrated on the development of approximation algorithms. These algorithms provide a close-to-optimal solution and tend to be simple and easy to implement. Research encompasses both theory and implementation, with a focus on developing general techniques that perform well in practice. The research also will explore applying the insights and techniques from computational geometry to other fields, such as databases, data mining, graphics, and geographic information systems.

Artificial Intelligence: Machine Learning, Vision, and Robotics

Domain Knowledge, Explanation-Based Control, and Reinforcement Learning
G. DeJong,* A. Laud, Q. Sun, V. Moskovich
Office of Naval Research, N00014-01-1-0063

Prior research has shown that complex skill-like decision policies can be acquired by combining an inferential symbolic reasoning with a numeric component. The approach is called Explanation-Based Control. Reinforcement Learning (RL) is a popular machine learning approach that also automatically acquires skill-like policies. However, it is difficult or impossible to exploit a domain expert’s knowledge. This means that RL cannot learn complex policies in an example-efficient manner. This research explores combining the two approaches to achieve greater example efficiency on the practical side and a clearer conceptual foundation theoretically.

ITR: An Integrated Approach to 3-D Photography Using Shape, Texture, and Motion Cues
J. Ponce*
National Science Foundation, IIS-03-12438; Beckman Institute for Advanced Science and Technology

The ability to acquire realistic visual models of complex 3-D scenes from collections of images, known as 3-D photography, is becoming useful for a wide array of IT applications, including film, game, and Web-content production, TV advertising, electronic commerce, teleconferencing, and architectural walkthroughs. This project addresses some of the scientific challenges to this technology. This would involve advances in three research areas: construction of topological mesh models of complex surfaces from weakly-calibrated photographs; automated matching and registration of photographs of textured surfaces taken from different viewpoints; and development of projective and Euclidean structure-from-motion techniques capable of handling large numbers of images in an efficient and uniform manner.

Toward True 3-D Object Recognition
J. Ponce*
National Science Foundation, IIS-03-08087

This project addresses four fundamental instances of the 3-D object recognition problem: modeling rigid 3-D objects from a small set of unregistered pictures and recognizing them in cluttered photographs taken from unconstrained viewpoints; representing and recognizing nonuniform texture patterns under nonrigid transformations; modeling and recognizing articulated objects in image sequences, with applications to the identification of shots that depict the same scene (shot matching) in video clips; and learning and recognizing part-based descriptions of object classes in photographs and video clips.

Large-Scale Temporal Associative Memory
S. R. Ray,* S. Swarup
University of Illinois

The basic problem addressed is to research methods for learning to store and recognize a large body of temporal sequential percepts (presented in any order) utilizing neuroscience compatible techniques. Further, the system must be capable of stable learning and forgetting of randomly presented samples. In spite of a decade or more of research in artificial neural networks, temporal sequence associative memory is still very poorly understood. Researchers are studying, analyzing, and simulating a number of different models.

Model of Superior Colliculus with a Spatiotemporal Neuron Model
S. R. Ray,* C. Seguin, T. Anastasio
Defense Advanced Research Projects Agency

The superior colliculus is a region of the central nervous system that fuses input data from several modes (visual, auditory, somatosensory, and so forth) and computer orienting output for directing attention, such as head rotation. This project uses a neuron model with trainable
temporal response. Spatiotemporal maps are learned by self-organizing algorithms that simulate known functions of the superior colliculus. The result is expected to have engineering applications.

**Neural Network Methods for Temporal Sequence Processing**
S. R. Ray,* H. Shah  
*University of Illinois*

The storage of long temporal vector sequences and their recognition and recall is a subject of considerable interest both in engineering application and in neuroscience. A new method for storing long temporal sequences that can be content-addressed and retrieved from the starting point is under study. The method applies multilayer “chunking” of invertible vectors in feature map architectures. This multilayer method has the potential to store a quantity of distinct sequences in the same elements and to demonstrate the property of replay of long experiential memories discovered by Wilder Penfield in human subjects some decades ago.

**Self-Aiming Camera**
S. R. Ray,* T. Anastasio, P. Patton  
*University of Illinois*

The superior colliculus in vertebrates appears to be a primary agent in deciding the direction of saccades and head-turning actions. Multisensory information, especially visual, audible, and somatosensory, feeds the two-layer neural network that comprises the superior colliculus. This research team has developed and continues to develop models of the SC that learn to adapt to variations in the head dimensions and visual/auditory properties. To demonstrate the overall system, including learning, researchers are constructing a camera and microphone system that will supply input to the model SC and respond to its directives. The camera/microphone system is fully operative on a physically fixed frame.

**Context-Sensitive Natural Language Inferences**
D. Roth,* A. Carlson  
*National Science Foundation, IIS-9801638; IBM Corp*

The future of intelligent human–machine interaction is in the ability to perform context-sensitive inferences. These are knowledge intensive tasks that are difficult to make without a significant learning component. This research studies a learning approach that targets knowledge intensive language understanding related tasks and directly addresses the issue of scalability. It is tailored to large-scale processes in terms of data and computation.

The approach developed can be applied to support a variety of inferences of the sort required in intelligent human–machine interactions, as demonstrated in this project by development of a system that exhibits a wide coverage and accurate context-sensitive spelling correction.

**Inference with Classifiers**
D. Roth,* V. Punnyankanok  
*National Science Foundation, Information Technology Research, IIS-00-85836*

In many situations it is necessary to make decisions that depend on the outcomes of several classifiers in a way that provides a coherent inference that satisfies some constraint. These constraints might arise from the sequential nature of the data or other domain specific constraints. Researchers are studying two general approaches for this problem and are evaluating those in the context of an important inference problem in natural language—identifying phrase structure. The first approach studied is a Markovian approach that extends standard HMMs to allow the use of a rich observation structure and of general classifiers to model state-observation dependencies. The second is an extension of constraint satisfaction formalisms.

**Intermediate Knowledge Representations that Facilitate Learning**
D. Roth,* S. Agarwal, C. Cumby, W. T. Yih, D. Zimak  
*National Science Foundation, Information Technology Research, IIS-00-85836; NSF IIS-00-85980; Office of Naval Research, Multidisciplinary Research Program of the University Research Initiative Award*

Learning becomes easy once the correct input representation has been chosen. A representation that produces linearly separable point sets is an example. Several projects are aimed at automatically generating intermediate representations to aid supervised learning algorithms, developing methods that allow the use of relational representations and of learning relational definitions, and developing a flexible knowledge representation language that can be used along with feature-efficient learning algorithms. Applications of this general knowledge representation paradigm are studied in the context of learning in the natural language domain and visual recognition.
Learning Coherent Concepts
D. Roth,* A. Garg, V. Punyakanok
*National Science Foundation, CAREER Award, IIS-9984168

This research seeks to develop an integrated view (theoretical understanding, algorithms development, and experimental evaluation) for learning coherent concepts. These are learning scenarios that are common in cognitive learning, where multiple learners co-exist and may learn different functions on the same input, but there are mutual compatibility constraints on outcomes. This effort will consist of developing a learning theory for these situations and of studying algorithmic ways to exploit them in natural language inferences. The theoretical study concentrates on developing a semantics for the coherency conditions and study of it from a learning theory point of view. The goal is to understand ways that learning can become easier and more robust in these situations. The algorithmic study concentrates on developing ways to exploit coherency and makes use of several important problems in natural language processing as a testbed for investigating chaining of coherent classifiers and inferences that rely on the outcomes of several classifiers.

Learning from Data and Additional Knowledge Sources
D. Roth*
*National Science Foundation, IIS-9801638

The majority of the work in learning assumes that the learner interacts with the world via examples. This research focuses on situations in which the learner can interact with many information sources. Some of these may supply the learner with examples, while others may supply other types of information. In text-understanding related tasks, for example, in addition to examples (text) the learner may make use of dictionaries, a thesaurus, experts of various sorts, various general and domain-specific taxonomies, and other sources. In other cases, the additional information can be viewed as cross-modality information. This research is a study of how learning algorithms can make use of this additional information in various learning models and for various applications.

Learning Theory
D. Roth*
*National Science Foundation, IIS-9801638; National Science Foundation CAREER Award, IIS-9984168

This is a study of several questions in learning theory that pertain to the problem of learning a number of concepts from common data. The study encompasses interactions and constraints imposed on outcomes. The main direction is the development of a theoretical framework for learning coherent concepts. This is a study of learning situations in which learning does not occur in isolation. Rather, the input is observed and processed by multiple learners. The goal is to understand what ways learning becomes easier and more robust in these situations.

Learning to Perform Knowledge-Intensive Inferences
D. Roth*
*National Science Foundation, IIS-9801638

The goals of this research are to study an integrated theory of learning, knowledge representation, and reasoning and to evaluate it on large-scale, knowledge-intensive inferences in the natural language domain. Recent studies within the learning-to-reason framework have shown that there is much to gain from studying these issues within a unified framework. This research investigates some of the fundamental issues within this framework, concentrating on a probabilistic setting.

Machine Learning in Natural Language Processing
D. Roth,* Y. Even-Zohar, A. Garg, V. Punyakanok
*National Science Foundation, IIS-9801638, KDI SBR 98-73450

Two main lines of research are being pursued. One focus is on developing a coherent learning theory account of the major statistical approaches to learning in natural language. This is an attempt to develop better learning methods and an understanding of the role of learning in natural language inferences. A second focus is on the study of knowledge representations and learning techniques for various language-understanding related tasks. The emphasis is on learning techniques that tolerate data of high dimensionality and on incorporating additional knowledge. Projects include context-sensitive spelling correction, prepositional phrase attachment, part of speech tagging, shallow parsing, and applications to information extraction.

Robust Methods for Natural Language-based Human and Machine Interaction
D. Roth,* X. Li, V. Punyakanok, W. T. Yih
*Office of Naval Research, Multidisciplinary Research Program of the University Research Initiative Award

This research is direct toward development of robust, freestyle, and adaptive natural language-based human and machine interaction. These include developing robust methods for identifying phrases in sentences. This is a fundamental technology that underlies the ability to extract
key phrases and perform shallow parsing of sentences. The research also targets methods for information extraction, a robust identification of functional phrases in sentences. This is part of an effort to construct a more abstract representation of sentences that will be used to respond to queries and/or access a knowledge base. Another focus is on question–answering. This approach integrates the two other methods with relevant learning, knowledge representation, and inference methods in the natural language domain to a preliminary open-domain question–answering system.

**The Role of Experience in Natural Language**

D. Roth,* K. Bock, J. Cole, G. Dell, C. Fisher, S. Garnsey, A. Goldberg, S. Levinson  
*National Science Foundation, KDI SBR 98-73450*

An integrated multiparadigm approach to the study of learning mechanism in language production and comprehension is studied. The language processing system is constantly changing. It adapts quickly to recent experience while continuing to reflect the accumulated experience of a lifetime of speaking, listening, reading, and writing. This project integrates research efforts in psycholinguistics, linguistics theory, and computational models of learning in an attempt to address the mechanisms that enable the language processor to adapt to experience. In addition, the research will suggest learning mechanisms for language processing technology, particularly for rapid adaptation to changing linguistic environments.

**The SNoW Learning Architecture**

D. Roth,* A. Carlson  
*National Science Foundation, IIS-9801638; NSF KDI SBR 98-73450*

A learning architecture and algorithms that are tailored for learning on large-scale, knowledge-intensive problems are being developed. The SNoW learning architecture is a sparse network of linear units over a common predefined or incrementally learned feature space. It is tailored for learning in domains in which the potential number of features taking part in decisions is very large, but may be unknown a priori. Preliminary versions of SNoW have already been used successfully on a variety of large-scale learning tasks in NLP and in the visual processing domain, including face detection and object recognition.

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**Computer Architecture and Compilers**

**ALP: Efficient Support for All Levels of Parallelism for Complex Media Applications**

S. Adve,* A. Li, R. Sasanka; Y.-K. Chen, E. Debes (Intel)  
*AMD Corp.; Intel Corp.; National Science Foundation, CCR-02-09198, EIA-02-24453*

Real-time execution of contemporary multimedia applications needs processing power and energy efficiency that surpasses the capabilities of current superscalar processors. Many recent projects have proposed architectures for media applications focused on exploiting their large amounts of data-level parallelism (DLP). Our studies have shown that in advanced applications, the DLP is often interspersed with control, and architectures focusing solely on DLP are unlikely to suffice. This project is developing a general-purpose architecture for multimedia applications, called ALP, that seamlessly supports multiple forms of parallelism, including instruction-level parallelism, thread-level parallelism, and various forms of DLP such as sub-word SIMD instructions, vectors, and streams. ALP combines conventional and evolutionary techniques to provide energy-efficient, high-performance for an increasingly important class of applications, without the need for radically different programming paradigms.

**Compiler Optimizations for Multilevel Memory Hierarchies**

V. Adve,* Q. Yi (Rice Univ.), K. Kennedy (Rice Univ.)  
*U.S. Department of Energy ASCI Academic Strategic Alliances Program, B347884*

Managing performance on deep memory hierarchies is widely considered to be a critical open problem for high-performance systems. This research team is exploring a novel class of compiler transformations that provide improved locality at multiple levels of memory hierarchy simultaneously. The transformations exploit the property that recursive algorithms have identical reuse patterns at each level of recursion, providing a hierarchy of working sets. Researchers are developing compiler algorithms to transform existing loop-based codes into efficient recursive form automatically. Such a transformation has wide applicability, including automatic blocking for multiple levels of cache hierarchy and improving communication locality in shared memory codes.

*Denotes principal investigator.
Researchers are developing compiler techniques that enable fast, accurate, and automatic performance modeling of highly scalable applications. One focus of this effort is a compiler-generated program representation that allows one to automate a wide range of analytical, simulation, and hybrid models of parallel programs. A second focus is to use additional compiler analysis, together with this representation, to enable efficient simulation of highly scalable applications. One such compiler technique achieved 10-2000x reduction in memory usage and 2-10x reduction in simulation time for the simulation of large message-passing programs. This work is part of a broader collaboration with five other universities.

Dynamic Energy and Temperature Management for Multimedia Applications
S. Adve,* X. Li, J. Srinivasan
AMD Corp.; Motorola Inc.; National Science Foundation, CCR-00-96126, EIA-02-24453

Power consumption is a first-class design constraint in current systems. The problem manifests itself in terms of energy (which affects battery life) and temperature (which affects cooling costs and system timing). A promising approach to reducing energy consumption and temperature on current hardware is to make the hardware adaptive. The hardware dynamically responds to changes in the application profile to ensure that only the resources required are used and only the performance desired is delivered, thereby reducing energy consumption and temperature. This project has developed control algorithms for adaptive processors for dynamic energy and temperature management for the increasingly important real-time multimedia application domain.

S. Adve,* A. F. Harris, C. J. Hughes, D. L. Jones, R. H. Kravets, K. Nahrstedt, D. G. Sachs, V. Vardhan, W. Yuan
AMD Corp.; National Science Foundation, CCR-02-05638, EIA-02-24453

Mobile devices that primarily process multimedia data are expected to become a dominant computing platform for a variety of application domains. Their design must consider demanding, dynamic, and multiple resource constraints, with energy as a first-class resource. However, the ability of multimedia applications to trade off output quality for system resources offers an opportunity for the design of systems where each system layer can adapt in response to resource or application changes. Reaping the full benefits of a system with multiple adaptive layers, however, requires a careful coordination of those adaptations. This project is developing a cross-layer adaptive system and framework to reduce energy consumption while preserving application quality within available computation and bandwidth resources. The final system prototype will integrate adaptations in the hardware, network, operating system, and application layers, opening up sources of energy savings not possible before.

RAMP: Lifetime Reliability Aware Microprocessors
S. Adve,* X. Li, J. Srinivasan; P. Bose, J. Rivers (IBM)
AMD Corp.; IBM Corp.; National Science Foundation, EIA 02-24453

Ensuring long processor lifetimes by limiting failures due to hard errors is a critical requirement for all microprocessor manufacturers. This project observes that CMOS technology scaling and increased on-chip temperatures will make lifetime reliability targets difficult to meet, that current reliability qualification methodologies (based on worst-case operating conditions) are overly conservative and unnecessarily constrain performance, and that lifetime reliability awareness at the architectural design stage can mitigate this problem by optimizing processors for the expected operating conditions, dynamically tracking workload-specific lifetime reliability estimates, and providing back-up techniques to handle unexpected conditions. Based on these observations, this project is developing lifetime reliability models and architectural techniques that will enable meeting the required lifetime reliability targets of future scaled processors.

Logic Synthesizers for VLSI Chip Design
S. Muroga,* V. Jayasena
University of Illinois

Automated design of logic networks is indispensable for designing a microprocessor with millions of transistors on a single chip. As the line width becomes less than 18 microns, signal propagation increasingly takes more time on connections than logic gates. So, logic networks are designed and the layout is made on a chip, and then logic networks are redesigned with consideration of connection length. The cycle of design and layout must be repeated until a satisfactory outcome is achieved, unlike the former approach of dealing with the layout once and only after logic networks are designed. Researchers are developing new algorithms for this new approach.
Analysis of Irregular Memory Accesses
D. Padua,* Y. Lin
*Defense Advanced Research Projects Agency, DABT63-95-C-0097

This project aims to develop compiler techniques to extract precise information about irregular memory accesses. Traditional loop optimization methods require array subscripts to be closed-form expressions of loop indices. However, in sparse/irregular programs, array subscripts usually do not have this form, leaving many codes unoptimized as a result. Researchers have developed a demand-driven interprocedural array property analysis method for indirectly accessed arrays and a single-indexed array analysis method for irregular single-indexed arrays. The team has successfully improved the precision of data dependence and privatization tests, which has resulted in significant performance improvements for the collection of sparse codes.

Compiler and Run-Time Environment for Numerical Java
D. Padua,* L. V. Kale,* J. Decker, Z. Sura, D. Wong, P. Wu
*National Science Foundation, DMS 98-78945

In this project, compiler and run-time techniques will be developed to achieve a performance comparable to that of Fortran programs for numerical Java applications. The system consists of a Java restructurer, a JVM that supports vector operations efficiently, an optimized native numerical library, and a source-to-source Fortran 95 to Java translator. The restructurer automatically identifies macro-operations (vector operations and BLAS routines) in the source program and replaces them with calls to library routines. The source-to-source translator provides a tool to convert legacy Fortran codes to Java and to produce a convincing testing benchmark suite for the system.

Compilers for Processors in Memory
D. Padua,* J. Torrellas,* J. Lee
*IBM Partnership Award

Processors in memory (PIM) technology integrate processor logic and DRAM in the same chip. The goal of this research is to explore compiler techniques for FlexRAM, a computer system that consists of a commodity host microprocessor and several PIM chips. The research team is exploring compiler techniques to identify macro-operations (such as vector operations) from the source code. The strategy is to partition the source code into several functions based on the profitability of running the functions on the PIM chips or the host processor. This research encompasses performance prediction, parallelism extraction, cache locality enhancement, synchronization overhead reduction, and load balancing.

Compile-Time Performance Prediction
D. Padua,* D. A. Reed,* C. Cascaval
*Defense Advanced Research Projects Agency, N66001-97-C-8532

As part of the Delphi project, University of Illinois researchers have developed compiler techniques to predict the performance of scientific codes on different architectures. The compiler is both the primary tool for estimating the performance and the beneficiary of the results obtained from predicting the program behavior at compile time. The research team developed a simple compile-time performance prediction model that, when augmented with profiling data from very light instrumentation, can be accurate within an average of 20% of the measured performance for codes using both dense and sparse computational methods on uniprocessor machines. A next step is to extend this model to multiprocessors.

Compiling for PC Clusters
D. Padua,* J. Hoeflinger, Y. M. Kim, J. Zhu
*National Science Foundation, ACI 96-19019 COOP

In this project, researchers are retargeting the Polaris parallelizing compiler to a network of Sun workstations and a Windows NT-based cluster using the TreadMarks virtual shared memory system to provide a shared view of memory. Researchers ported TreadMarks to the NT cluster and made it compatible with FORTRAN77 codes. The basic functionality of the compiler for TreadMarks has been built. Some programs from the Spec95 and Perfect Benchmarks have been tested and valid results obtained. Next steps are to measure the performance of a group of benchmark codes and design optimizations to improve their performance.

Signal Processing Algorithm Compiling Engine (SPACE)
D. Padua,* A. Huang, J. Xiong
*Defense Advanced Research Projects Agency, DABT63-98-1-0004

Fast signal processing algorithms have been obtained by properly factorizing the transformation matrix into several matrices. The Tensor Product Language (TPL) was designed to describe linear transformations. Using

*Denotes principal investigator.
predefined parameterized matrices and their operations, TPL can represent several well-known signal processing algorithms. The goal of this project (which is part of a larger project involving researchers from Carnegie-Mellon, Drexel, and the University of Southern California) is to build a compiler to generate efficient programs from TPL formulas. Issues to be studied include techniques to predict the effect of loop unrolling/rerolling on performance and optimization techniques to very long basic blocks.

A MATLAB Just-in-Time Compiler (MaJIC)
D. Padua,* G. Almasi, L. DeRose
National Science Foundation, AC198-70687

In cooperation with researchers at Cornell University, a University of Illinois team is developing MaJIC, a just-in-time compiler for MATLAB. The main goal of the project is to maintain a MATLAB-like working environment while achieving significant speedups. The analysis techniques under investigation are type analysis, dependence analysis (for generating SMP code), code signature generation, and array bounds check analysis (to eliminate superfluous array bounds checks). The compilation and execution phases in MaJIC overlap and can be executed in parallel on multiprocessor machines. Researchers also are considering stepwise refinement of compiled code to improve performance.

Los Alamos Computer Science Institute: Compilation, Systems, and Performance Evaluation of Large Scale Parallel Machines
D. A. Reed, * C. Mendes, K. Pattabiraman, Y. Zhang
U.S. Department of Energy, W-7405-ENG-36

The objective of this Los Alamos Computer Science Institute project is to develop compiler and run-time technology that will help application developers achieve a high fraction of peak performance on large-scale parallel computing systems. As one of the LASCI partners, University of Illinois at Urbana-Champaign researchers seek to develop a new generation of software tools that integrate compilation research with real-time performance measurement, adaptive control systems, and intelligent data visualization and control. The goal of this work is to create an intelligent performance toolkit that allows software developers to create and runtime systems to negotiate performance contracts among software components and hardware/software systems.

Architectural and Application Support to Crack the Protein Folding Problem
National Science Foundation, EIA 00-81307; IBM Corp.

Solving the protein folding problem would have an enormous pay-off: providing a true understanding of diseases and the discovery of more effective drugs. Luckily, advances in processor-memory integration allow us to build computers that, thanks to being more integrated, faster and cheaper, may solve the problem. In this project, researchers in computer hardware, software, and computational biology team up with IBM researchers to design improved algorithms for protein folding and to design a Processor-In-Memory architecture that can speed up the solution of the problem. The work involves using the IBM Blue Gene prototype and will help design its next generation system.

Architectural Support for Speculative Thread-Level Parallelization
J. Torrellas,* M. Cintra, J. Martinez, M. Prvulovic, M. Garzaran
National Science Foundation, EIA 99-75018, CCR 99-70488, EIA 00-81307, EIA 00-72102; IBM Corp.; Intel Corp.

Speculative thread-level parallelization is a technique to execute in parallel code that the compiler cannot fully analyze. In this technique, a program is dynamically divided into tasks and assigned to different threads. The threads execute in parallel, optimistically assuming that sequential semantics will not be violated. As the threads run, the data that they access are tracked. If a dependence violation is detected, the offending threads are stopped. Then a repair action re-executes the offending tasks, possibly after recovering some old, safe state. In this project, researchers examine the support for this technique in both chip multiprocessors and scalable multiprocessors.

Automatically and Manually Programming a Server
J. Torrellas,* D. Padua, B. Fraguela, J. Lee, Y. Solihin
National Science Foundation, EIA 99-75018, CCR 99-70488, EIA 00-81307, EIA 00-72102; IBM Corp.; Intel Corp.

This project addresses the problem of how to program a server with an intelligent memory system, such as FlexRAM. Such a machine includes two classes of processors: one or several off-the-shelf powerful processors and a myriad of simple processors in the memory system. Researchers examine two approaches to
program this machine. The first approach is to implement compiler algorithms so that the compiler can automatically map the code onto the architecture. The second approach is to design language constructs and a programming methodology that make it possible and easy for a programmer to directly write code for the machine.

Dynamically Managing Energy in Chips for Energy and Efficiency
J. Torrellas,* M. Huang, J. Renau, S. Yoo  
National Science Foundation, EIA 99-75018, CCR 99-70488, EIA 00-81307, EIA 00-72102; IBM Corp.; Intel Corp.

While technology is delivering increasingly sophisticated and powerful chip designs, it is also imposing alarmingly high energy requirements on the chips. Many techniques have been proposed to manage the energy consumed, including voltage scaling and various forms of storage reconfiguration. In this project, the different techniques are compared. A framework that applies techniques dynamically, in a fine-grained manner and according to a given policy is built. Goals are to maximize energy savings without extending application execution time beyond a given tolerable limit and to guarantee that the temperature remains below a given limit while minimizing any resulting slowdown.

FlexRAM: An Intelligent Memory Architecture System
J. Torrellas,* D. Padua, D. A. Reed, M. Huang, J. Lee, J. Renau, Y. Solihin, S. Yoo  
National Science Foundation, EIA 99-75018, CCR 99-70488, EIA 00-81307, EIA 00-72102; IBM Corp.; Intel Corp.

Major advances in Merged Logic DRAM (MLD) technology coupled with the popularization of memory-intensive applications provide fertile ground for architectures based on Processors-in-Memory (PIM). In the FlexRAM project, researchers use PIM chips as the memory of an intelligent server. If such a server runs an application without recompiling it, the intelligent memory appears as plain memory. However, if the application is recompiled, the memory becomes a high-performance accelerator. In this project, the focus is on issues related to architecture design, energy dissipation, programming, compilation, run-time system, and applications for the FlexRAM intelligent memory system.

ITR: Automatic On-the-fly Detection, Characterization, Recovery, and Correction of Software Bugs in Production Runs
J. Torrellas,* J. Han, S. Midkiff, Y. Zhou  
National Science Foundation, ITR-03-25603

Software bugs continue to be frequent in computer systems, accounting for as much as 40% of computer system failures. Many bugs that occur in production runs are hard to reproduce when the program is recompiled with heavy instrumentation and executed in a debugging run. Consequently, it is necessary to provide low-overhead debugging support that can be used in production runs. This work proposes to develop a novel, comprehensive debugging system for automatic, on-the-fly debugging of production runs. The system supports all the steps of debugging, namely bug detection, characterization, recovery, and correction. The system integrates innovations in computer hardware, operating system, data mining, and compiler support.

M3T: Morphable Multithreaded Memory Tiles
Defense Advanced Research Projects Agency, F30602-01-C-0078

The M3T system is a novel malleable computing system composed of polymorphous hardware and polymorphous software that can adapt to changing mission demands. The system is built by tiling M3T processor chips. Each processor chip is composed of many general-purpose RISC cores interleaved with memory blocks. Cores and memories are reconfigured at run-time, allowing the chip to morph into a superscalar, VLIW, systolic array, MIMD, SIMD, or fault-tolerant engine, or even a combination of these. The system has a compiler that reconfigures the platform (hardware and run-time system) for which it is generating code.

PERCS: A Highly Productive Computer System
J. Torrellas,* R. Johnson, D. Padua, M. Snir  
Defense Advanced Research Projects Agency; IBM Corporation, INT IBM NBC PERCS

In cooperation with IBM, we are designing a highly adaptable multiprocessor that will yield up to 8 Petaflop/second of sustained performance and a 10-time reduction in time-to-solution in the year 2010-2012 timeframe. The vision centers on the theme of adapting the system layers to the application requirements. Adaptability enhances the technical efficiency of the system as well as its ease of use. Among the issues that we are studying are
novel memory subsystem design, architectural support for
debuggability and fault tolerance, architectural support for
adaptability, and programming languages and compilers to
enhance the ease of use.

Using Architectural Support for Speculation
to Provide Fault Tolerance
J. Torrellas,* M. Garzaran, M. Prvulovic, Z. Zhang
National Science Foundation, EIA 99-75018,
CCR 99-70488, EIA 00-81307, EIA 00-72102;
IBM Corp.; Intel Corp.

Microprocessors occasionally suffer transient faults.
This research is aimed at finding ways to detect transient
faults and recover from them. While past work has
addressed this problem in different ways, speculative
parallelization opens up a potential new approach to detect
and recover from transient faults. Under speculative
parallelization, speculative threads must keep their
memory state buffered until they are proved to be correct.
In addition, they must be able to roll back to a safe state
after a violation is detected. These same architectural
supports can be used to provide fault detection and fault
recovery. This project extends existing architectural
support for speculation to provide inexpensive support
for fault tolerance.

Databases and Information
Systems

AIM: Supporting Efficient Top-k Query Processing
K. C.-C. Chang,* S. Hwang
University of Illinois

Supporting database queries that return ranked results
is critical for decision support applications as well as
multimedia and information retrieval. Such ranked queries
order results by combining the scores of fuzzy predicates
that are evaluated by different sources, which can be a
local database, a multimedia subsystem, or a Web source.
This project develops efficient algorithms for processing
ranked queries.

MetaQuerier: Exploring and Integrating the Deep Web
K. C.-C. Chang,* B. He, C. Li, Z. Zhang
National Science Foundation, CAREER Award
IIS-0133199, ITR Award IIS-0313260; National Center
for Supercomputing Applications Faculty Fellows
Award, 2003

This research seeks to enable effective access to structured
information sources on the Internet. Over the past few
years, a significant and increasing amount of information
has become hidden on the “deep” Web, behind the query
interfaces of searchable databases. A metaquery system
would help users in finding and querying online databases
effectively and uniformly. First, to make the deep Web
systematically accessible, the MetaExplorer will discover
sources to build a “database of online databases” to help
users find sources useful for their purposes. Second, to
make the deep Web uniformly usable, the MetaIntegrator
will help users interact with online databases to ask
queries.

iMAP: Discovering Complex Matches
between the Schemas of Databases
A. Doan,* R. Dhamankar, Y. Lee, A. Halevy, P. Domingos
University of Illinois

Establishing semantic matches between disparate data
sources is fundamental to numerous data sharing efforts.
Manually creating matches is extremely tedious and
error-prone. Hence, many recent works have focused
on automating the matching process. To date, however,
virtually all of these works deal only with one-to-one
(1-1) matches, such as address = location. They do not
consider the important class of more complex matches,
such as address = concat(city,state) and room_price =
room_rate * (1 + tax_rate). In this project we describe a
solution that applies learning and search techniques from
the AI field to semiautomatically discover both 1-1 and
more complex matches with high accuracy.

MOBS: A Mass Collaboration Approach
to Integrate Data Across Disparate Sources
A. Doan,* R. McCann, A. Kramnik, W. Shen,
V. Varadarajan, O. Sobulo
University of Illinois

Today, data integration systems are largely built by hand,
a labor-intensive and error-prone process. A conceptually
new solution to this problem is to consider a data
integration system as having a finite set of parameters
whose values must be set. To build the system the
administrators construct and deploy a system “shell,” then
ask the users to help the system “automatically converge”
to the correct parameter values. Therefore, the burden of system development is lifted from administrators and spread “thinly” over many users. We apply this approach to the problem of schema matching in the context of data integration. Experiments are conducted with both real and synthetic users to show the promise of the approach.

MAIDS: Mining Alarming Incidents from Data Streams
J. Han,* M. Welge (National Center for Supercomputing Applications)
Office of Naval Research

There are many applications that require handling data in the form of data streams. Data streams are dynamic, high in volume, potentially infinite, and require multidimensional analysis. These characteristics pose a challenge for data analysis of data streams. This project is researching and developing the MAIDS system, which mines alarming incidents from data streams, with the following major analysis functions: multiresolution modeling using a tilted time window framework, multidimensional analysis using a stream “data cube” model, online stream classification, online frequent pattern mining, online clustering of data streams, and stream mining visualization. Moreover, we are exploring intrusion detection and other kinds of applications for this technology.

Mining Dynamics of Data Streams in Multidimensional Space
J. Han*
National Science Foundation, IIS-03-8215

Stream data processing and mining represent an important, emerging class of data-intensive applications, characterized by dynamic data flows, only adaptive to single-scan algorithms, but often demanding fast responses. Most stream data resides at the primitive abstraction level, but most interesting patterns may be discovered at certain high levels of abstraction in multidimensional space. This project will develop effective, efficient, and scalable methods for mining the dynamics of data streams in multidimensional space, including the discovery of changes, trends, and evolutions of characteristics, clusters, classification models, and frequent patterns in data streams. Several important applications will be explored, including network intrusion detection, telecommunication and Web data flow analysis, and financial data flow analysis.

Mining Hidden and Evolving Linkages across Multirelational Data
J. Han*
IBM Faculty Award

Industry firms and government agencies have built up huge databases or other information repositories, which contain a large number of semantically interrelated relations, with voluminous structured or semistructured data and heterogeneous definitions. These data repositories can be constantly changing and evolving, bringing in an additional dimension of complexity and heterogeneity to the system. Since data across multiple relations and/or platforms contain rich semantic information, it is interesting and challenging to automatically, effectively, and efficiently perform linkage analysis and structure discovery to find hidden and evolving linkages across multiple relations, as well as in various kinds of data repositories across multiple platforms. Mining hidden and evolving linkages across multirelational and/or multiplatform data is one of the most demanding and challenging tasks in data mining, information retrieval, homeland security, digital government, bioinformatics, Web search and mining, and many other applications.

Mining Sequential and Structured Patterns: Scalability, Flexibility, Extensibility, and Applicability
J. Han*
National Science Foundation, IIS-02-9199

Sequential and structured pattern mining finds frequent subsequences or substructures in large sequence, structured, or semistructured data sets. These are important data mining tasks with broad applications, including analysis of customer purchase sequences, analysis of Web page structures and Web traversal patterns, understanding of disease treatments, scientific experiments, transportation and production processes, discovery of unusual events for intrusion, discovery of DNA sequences and molecule structures, and so on. The project is aimed at developing effective, efficient, and scalable methods for mining such patterns and exploring their important applications.

Mining Unusual Patterns in Data Streams
J. Han*
IBM Faculty Award (2002-2003)

Traditional data mining systems and methods assume that data resides on disks or in main memory and that a data mining process can scan the data sets multiple times to uncover interesting patterns. However, dynamic environments often quickly generate a tremendous amount of stream data so that the volume of data is too huge to be

*Denotes principal investigator.
stored on disks or is too expensive to be fetched and scanned multiple times from disk. Moreover, applications may require real-time mining of unusual patterns in data streams, including finding unusual network or telecommunication traffic, pattern mining in video surveillance, and detecting suspicious online transactions or unexpected terrorist activities. We propose to develop efficient and scalable stream data mining methods for discovery of unusual patterns in data streams.

Structure Discovery and Database Integration by Data Mining
J. Han*
IBM Faculty Award (2003-2004)

Our world is filled with huge amounts of heterogeneous and interconnected data, and it is challenging to automatically, effectively, and efficiently perform knowledge discovery, information exchange, and database integration on various kinds of data repositories across multiple platforms. This project investigates the issues for the discovery and integration of database structures, linkages, and contents, and develops efficient mechanisms. We will especially focus on the automatic discovery of knowledge across multiple relations and the building-up of semantic linkages across multiple databases and information repositories to facilitate information analysis.

Data Management, Storage, and Query Systems for Scientific Applications
M. Winslett,* S. Mitra, A. Termehchy
U.S. Department of Energy, Center for Simulation of Advanced Rockets; National Science Foundation, ITR; U.S. Department of Energy, Scientific Discovery through Advanced Computing

Large-scale scientific applications pose new challenges for data management, including a unique environment and requirements for long-term data storage, unusual requirements for large-scale movement of data across the internet, and a need for very lightweight and data-format-independent facilities for buffering, caching, parallel I/O, indexing, and querying. The Panda and Godiva projects are addressing all of these needs in close collaboration with scientists and engineers from University of Illinois at Urbana-Champaign and beyond.

User-Centered Adaptive Information Retrieval
C. X. Zhai,* X. Shen, B. Tan
National Science Foundation IIS CAREER Award, IIS-0347933

Existing information retrieval systems are inherently nonoptimal because the retrieval decision is primarily based on the current query and the document collection without considering information about the user and search context. For example, a traveler and a programmer may use the same word “java” to search for different information, but the current search systems would return the same results. This project seeks to break this limitation of the existing retrieval methods and formally develop a new retrieval paradigm called user-centered adaptive information retrieval, in which user information and search context are both exploited to improve retrieval performance. We will develop a client-side personalized search agent to optimize search accuracy by utilizing the previous queries, viewed documents, and other information about the user.

Educational Research

Building Communities: Recruiting and Retention of Underrepresented Groups in Computer Science
S. Kamin,* T. Wentling, C. Heeren
National Science Foundation, CNS-0420505

This project endeavors to increase the number of women and minority students entering and the percentage of these students remaining in the undergraduate programs of Computer Science Department. The University of Illinois leads five other central Illinois partners—Computer Science Departments of Parkland Community College, Eastern Illinois University, Illinois State University, Heartland Community College, and Bradley University—in developing programs for women and minority students. These include outreach to high schools in our region and around the state, computer-oriented competitions for high school and college women, teacher training workshops, special orientation programs, and other activities.

Educational Uses of the Tablet PC
S. Kamin,* C. Peiper, B. Capitanu, C. Heeren
Microsoft, Hewlett-Packard

The Tablet PC holds great promise as an educational tool for several reasons. Its light weight allows it to be carried easily to class and its flat format allows it to be used in classes without blocking the student’s view. Because it is shaped like a paper pad, it is easier to read from than a
laptop, so can effectively replace textbooks. Its writable surface allows for taking notes more easily and more quietly than a computer with a keyboard. We are developing a Tablet PC-based system, called eFuzion, for classroom use, either by a professor alone or in a tablet-equipped classroom. eFuzion allows for virtually unlimited interaction among students and professors. It is scriptable, so that instructors can customize their interactions to suit their teaching style and course content and educational researchers can test a variety of usage modalities without excessive development costs.

Graphics and Visualization

Procedural Representation and Visualization Enabling Personalized Computational Fluid Dynamics (CFD)
D. Ebert,* D. Marcum,* K. Gaither, J. C. Hart, P. Rheingans
National Science Foundation, ACI-0121288

Due to the exponential growth in processing power, CFD simulations are generating huge terabyte-scale time-varying flow datasets at a faster pace than scientists can cope with currently, requiring the warehousing of the flood of data for later examination. This project focuses on compact procedural representations of large flow datasets for rapid examination by scientists using ordinary personal computers, which will aid them in finding flow problems, such as instabilities in aircraft, much faster.

Automatic Global Multiscale Surface Parameterization
M. Garland*
University of Illinois

Many algorithms that operate on 2-manifold surfaces are most easily formulated over a planar parametric domain. This requires a parametric mapping of the plane onto the 2-manifold in question. Free-form polygonal meshes are not necessarily equipped with such a parameterization, and constructing a suitable one is a challenging problem. We are focused on developing efficient multiscale (multigrid) methods over irregular triangle meshes embedded in a 3-D Euclidean space. We also address the problem of constructing a global conformal structure over the surface, represented by a holomorphic 1-form. This global structure provides a global parameterization of the surface mesh, and provides a very convenient means of dealing with manifolds of arbitrary genus.

Everyday Shape Modeling
M. Garland*
National Science Foundation, ITR CCR-0086084

There are many tools available for modeling 3-D shapes. However, they are almost universally targeted toward experts and often exhibit steep learning curves. This project aims to produce tools that allow nonexperts to easily work with digital representations of 3-D shapes, just as the typical user can currently work easily with digital images. We emphasize simple interface modalities, such as sketching, that come naturally to most users. We are developing the technologies necessary for users to model shape by example. That is, a user first demonstrates a desired editing operation on a part of the model. The modeling system then automatically extrapolates the modification to the shape as a whole.

Processing Massive Polygon Meshes
M. Garland*
National Science Foundation, CCR-0098170

The past decade has seen the production of ever-larger polygonal datasets that users expect to manipulate and visualize. Extremely accurate laser scanners can produce precise models of real-world objects. Similarly, large-scale scientific simulations, such as computational fluid dynamics, produce huge amounts of data. Complex human artifacts, such as buildings and airplanes, are frequently modeled on computers in full detail. In all these cases, multigigabyte datasets containing billions of individual polygons are used. Our aim is to develop the means to store, process, and transmit extremely complex 3-D data efficiently. Our current work is focused on automatic data reduction, hierarchical data storage, and efficient streaming data representations.

Real-Time Texture Synthesis
M. Garland*
National Science Foundation, ITR CCR-0086084

Virtually all 3-D environments make extensive use of texture images to achieve a convincing level of realism. Large surfaces must frequently be covered with textures simulating a diverse range of materials such as wood, sand, brick, water, grass, paper, and patinated copper. From the design perspective, it is convenient to be able to generate large amounts of surface texture from a single example image. In this project, we are working on the development of near real-time methods that can generate arbitrary amounts of texture on-demand from sample images. We address the problems of generating texture images and of directly texturing 3-D surfaces from the given example.
Simplification and Multiresolution Modeling of Polygonal Surfaces
M. Garland*
University of Illinois

Extremely precise polygonal surface models are now widely available, in large part due to advances in scanning technology. Models of this complexity, perhaps several million polygons, frequently contain far more detail than required for the target application. This project is focused on the design and implementation of efficient algorithms for the automatic simplification of highly detailed polygonal surface models into faithful approximations containing fewer polygons. Using such simplification algorithms, researchers can also construct new multiresolution representations for surfaces that allow the application to treat an object at many different levels of detail.

Multipass Programming for Personal High-Performance Computing
J. C. Hart*
National Science Foundation Information Technology Research, ACI-0113968

By taking advantage of parallelism and stream processing, PC graphics processors (GPUs) have doubled their power to three times faster than the CPU, and the GPU has recently overtaken the CPU in processing power. Our Multipass Programming project seeks to take advantage of this personal supercomputing power by porting general-purpose graphics and scientific algorithms to run on the graphics card instead of the CPU.

Robust LaGrangian Surface Propagation with Topological Control
J. C. Hart,* M. Heath, X. Jiao, J. Sullivan
National Science Foundation, DMS-0310446; Defense Advanced Research Projects Agency

Moving boundary or interface surfaces are an integral part of the modeling and simulation of many physical processes. This project is developing new methods for propagating interface surfaces more efficiently and robustly, and with more control than previously possible, by using a moving surface mesh representation instead of existing volumetric data structure. Working through the University of Illinois Center for Simulation of Advanced Rockets, this work will result in more efficient and more accurate virtual prototyping of rocket motor designs, leading to safer and more economical solid rocket boosters, such as those powering the U.S. space shuttle.

Making 3-D Visibility Practical
S. LaValle,* J. C. Hart,* J. Erickson, F. Durand
National Science Foundation, NSG-0219594

Great strides have been made in understanding and organizing the visibility of objects in a scene, most recently into a data structure called the visibility complex. However, this understanding has so far had little impact on applications due to its complexity and brittleness. This project seeks to make efficient visibility determination easier to implement and more robust, and will allow personal computers to simulate larger, more detailed virtual environments.

Image-based Modeling and Rendering
Y. Yu*
University of Illinois

This research includes image-based modeling and rendering, texture synthesis, detail modeling, and simulation. The work on image-based modeling and rendering tries to extend lighting and scene composition manipulation. Work on texture synthesis leads to algorithms for 3-D textures that have spatially varying height and reflectance. Research on the details focuses on both geometric and appearance models that account for all visual effects introduced by intermediate and microstructure level details. Past research resulted in development of segmentation techniques for organizing points from laser range images into coherent objects. Another research outcome was a well-known technique for simultaneously recovering reflectance models of multiple objects from photographs of the objects in a scene that accounts for both the direct illumination of the objects from light sources as well as the indirect illumination from light reflected by neighboring objects. Research extends to investigation of techniques to recover the appearance of complex materials, such as skin, to make more convincing synthetic pictures of humans.

Human–Computer Interfaces

Computational Tools for the Early Stages of Interactive Systems Design
B. P. Bailey*
University of Illinois

Our research focuses on computer-based tools that better support the early stages of interactive systems design so that higher-quality systems can be built more quickly. Our research has produced DEMAIS, which enables a quick sketch of a design and then the creation of a low-fidelity...
functional prototype from that design. DEMAIS significantly enhances the communication of design ideas when compared to existing tools, and impedes the design process less than high-fidelity tools. We are also researching larger electronic workspaces and two-handed interactions effective for sketching, an interface to enable the exploration of interaction design on paper without losing the benefits of a functional prototype, and more expressive visual sketching languages.

**Interface for Interactive Workspaces**

B. P. Bailey*  
*University of Illinois

The promise of an interactive workspace, a technology-rich workspace that enhances co-located and collaborative work, is to better share electronic information across laptops, large screens, and other computing devices. Users need effective interfaces to quickly and intuitively relocate information and redirect user input across those devices. Our research has produced ARIS, a tool that enables a user to quickly and visually relocate information in that environment. Our research activities include measuring the usability of the tool, identifying new metrics for evaluating interfaces, and empirically comparing ARIS to similar techniques. Our research will dramatically improve how users utilize interactive workspaces to create, share, juxtapose, and annotate information.

**Managing Human Attention**

B. P. Bailey*  
*University of Illinois

As increasingly interactive systems seek to gain a user’s attention more often, they will likely interrupt the user’s tasks. We have conducted controlled experiments to better understand the disruptive effects of interruptions. The results are used to inform the design of an attention manager that allows users to manage attention among competing systems. A measure of mental workload is computed from a user’s pupil size, blink rate, and saccades and is combined with a model of task behavior to predict opportune moments for interruptions. Annoyance, frustration, and anxiety, should decrease and performance and satisfaction should increase for users of desktop applications as well as for operators of safety critical systems.

**Adaptive/Reflective Middleware System**

R. Campbell,* K. Nahrstedt,* R. Kravets,* L. Sha,*  
J. Tanner, P. DeRose  
*Defense Advanced Research Projects Agency Grant, INT NBCH 1030017

**Networking**

**Ad hoc Wireless Communication Between Vehicles**

R. H. Campbell,* S. Myagmar  
*Motorola, Inc.

We propose an ad hoc routing protocol with location service for vehicle-to-vehicle communication. As an example of feasibility, we developed and tested application prototypes of voice chat, location filtering, and roadside information service for moving vehicles. Our protocol takes into account the motion of vehicles on a highway. It broadcasts location updates only when the velocity or direction of a vehicle “space reservation” to avoid transmission collisions.

**IT-Based Collaboration Framework for Preparing against, Responding to, and Recovering from Disasters Involving Critical Physical Infrastructures**

I. Gupta,* F. Pena-Mora,* G. Robinson, N. Contractor, A. Hollingshead  
*National Science Foundation Grant, CMS-0427089

In a new and novel study, scientists are looking to nature—specifically, to ants, bees, and viruses—for ways to improve human collaboration during disaster relief efforts. Supported by a five-year, $2.37 million grant from the National Science Foundation, and supplemented by the

*Denotes principal investigator.
University of Illinois at Urbana-Champaign, the research team is attempting to draw inspiration from the collaboration patterns that honeybees and ants use, and the spread patterns viruses typically take. The ideas the researchers develop will augment current collaboration among first responders to extreme events involving critical physical infrastructures. Epidemiological algorithms can be used in large groups of participants to spread, collect, and search for information. The resulting software systems can scale to networks with hundreds or thousands of first responders and withstand unresponsive participants and poor communication channels.

**Systematic Design of Distributed Protocols—from Methodologies and Toolkits to Systems**  
I. Gupta*

*National Science Foundation CAREER Award, CNS-0448246*

Gupta and his research group will study, invent, and discover systematic “design methodologies” to enable creation of a variety of distributed systems that are scalable and robust under failures and attacks. Newly developed systems will include cooperative web caching, adaptive Grid computing paradigms, peer-to-peer systems, persistent distributed file systems, and disaster response and recovery networks. Protocols for these systems will be created by using novel methodologies such as ones that translate differential equations into equivalent distributed protocols, or those that compose existing distributed protocols in a systematic manner. This project will enable systematic translation of many natural phenomena from non-Computer Science fields, such as biology, into practicable and robust distributed system designs. The project integrates research and educational activities.

**Transparent Data Sharing in Large-Scale, Dynamic Distributed Systems**  
I. Gupta,* G. Antoniu (INRIA), A.-M. Kermarrec

*UIUC-CNRS-INRIA Collaboration Grant*

Distributed environments such as the Grid are large-scale and dynamic, for instance, they involve a large number of participating workstations that are joining and leaving at high rates. This collaborative project seeks to develop novel solutions for transparent and decentralized access to data in dynamic, large-scale, and distributed environments. The project will develop algorithms and strategies for replication, group membership, data consistency, resource discovery, and network size estimation. Many of these ideas are well-understood in fault-tolerant distributed systems research, but have not been explored for Grid environments.

**Data-Centric Sensor Networks**  
J. C. Hou,* L. Sha, P. R. Kumar, N. Li, H. Zhang

*National Science Foundation, Special Projects in Networking, ANI-0221357*

In this research project, we first lay an integrated framework in which a comprehensive solution can be designed that comprises a set of component solutions at each layer to achieve the targeted goals of data-centric sensor networks. Then, we consider under this unified framework, research issues along the following thrusts of research: hierarchical cluster formation and routing; topology control and power management; Quality-of-Service provisioning within/between clusters; MAC design for timely dissemination of delay-sensitive data; and empirical study with the use of Motes.

**Design, Theoretical Validation, and Empirical Evaluation of a Class of Multicast Congestion Control Schemes**  
J. C. Hou,* Y. Gao, Y. Ge

*National Science Foundation, ANI-0073725 (subcontract to Ohio State University)*

In this research project, we explore the use of robust feedback control theory to design and implement a rate-based congestion control framework for multicasts, with the following design objectives: scalability, capability to adjust source sending rates to achieve TCP-friendliness, and (weighted) fairness in an analytically provable manner, capability to handle independent losses of the same packet, capability to deal with dynamic traffic/membership changes, and minimal router support.

**Multiple Time-Scale Traffic for Next-Generation Internets**  
J. C. Hou,* G. He, H. Lim

*National Science Foundation, ITR ANI-00-82861*

In this research project, we address the following two-pronged problem: how to exploit the multiple time-scale property of network protocols to facilitate effective coordination and integration of disjoint network controls for end-to-end Quality-of-Service (QoS), and how to exploit the multiple time-scale nature of Internet workload to achieve workload-sensitive traffic controls. The first problem is comprised of two key issues: sufficiency or separation conditions under two network controls and the effective coupling of protocols when time-scale separation...
is not available. The second program consists of three key issues: short-lived connection management using lightweight optimistic control, long-lived connection management using connection duration prediction and multilayered feedback control, and QoS amplification through workload-sensitive, end-to-end, and per-hop control.

**Next-Generation Network Protocols and Services for Real-Time Systems**  
J. C. Hou,* C. Hu, A. Sobeit  
*Multidisciplinary Research Program of the University Research Initiative, AFOSR F49620-00-1-0330 (subcontract to University of California, Santa Barbara)

In this research project, we categorize network protocols into traffic specification and Quality-of-Service (QoS) translation/negotiation, admission control, unicast/multicast routing, resource reservation and adaptation, congestion and flow control, local traffic control and run-time packet scheduling, fault detection and fast restoration, security, and traffic regulation and QoS monitoring. We address the problems of provisioning QoS and fault tolerance in each category.

**On Providing Quality-of-Service Control for Core-based Multicast Routing**  
J. C. Hou,* J.-K. Lee  
*National Science Foundation, Advanced Networking Infrastructure and Research, ANI-9804993

We investigate the Quality-of-Service (QoS) extension to core-based multicast routing protocols such as Core-Based Tree, Simple Multicast, and Protocol Independent Multicast Sparse Mode. Specifically, we propose a set of enhancements in the member join/leave and state update/refresh procedures to facilitate the deployment of additive (e.g., end-to-end delay bound), multiplicative (e.g., packet loss ratio along a path), and concave (e.g., minimum bandwidth available) QoS. We also implement a proof-of-concept prototype in the FreeBSD UNIX operating system and conduct an empirical study on a lab testbed.

**A Component-Based Software Environment for Simulating and Synthesizing Network Protocols in Large-Scale Networks**  
J. C. Hou,* R. Campbell, L. Kung, H. Kim  
*University of Illinois

In this project, we propose to design, implement, and evaluate a component-based software environment for a wide variety of emerging network architectures and applications. The environment expedites execution and simulates, emulates, and synthesizes network protocols and services in a systematic manner. We follow three research thrusts: We extend JavaSim to include base classes and packages for grid networking technologies. We investigate issues of parallelizing real-time process driven simulation engines and explore the use of fluid models, network calculus models, and rescaling techniques to expedite simulation. In a related project, we build a software-programmable router platform, called CROSS, that is dynamically extensible, configurable, and able to predictably process network flows that require QoS-aware access to multiple resources. We will leverage JavaSim components as building blocks for CROSS/Linux router services, and realize differentiated multicast and secure video proxy systems as CROSS services.

**An Integrated Simulation Environment for Robust, Multiple Time-Scale Traffic Control in Next-Generation Internets**  
J. C. Hou,* D. Chi, H. Kim, L. Kung  
*Network Modeling and Simulation, Defense Advanced Research Projects Agency, Information Processing Technology Office (subcontract to University of California, Berkeley); Cisco University Research Program

In this research project, we develop a component-based, compositional Java network simulation environment, called JavaSim. JavaSim is built upon an innovative autonomous component architecture that closely mimics the IC design architecture and a generalized packet switched network model that defines the generic structure of a node (either an end host or a router) and the generic network components. We also study (in the JavaSim simulation environment) the issues of fluid model-based simulation and large-scale parallel network simulation. JavaSim also provides a script interface to allow integration with different script languages such as Perl, Tcl, or Python.

**A Cross-Layer Approach to Energy Conservation in Mobile Ad Hoc Networks**  
R. Kravets*  
*National Science Foundation, ANIR 0347468

Current approaches to energy conservation in ad hoc networks narrowly focus on optimizations at only one layer, and some only focus on a specific mechanism in that layer. By ignoring the impact within a layer and on other layers, many approaches become ineffective and may even increase energy consumption. This research integrates optimizations across layers in the innovative Pulsar framework, resulting in network-wide energy-
efficient communication. Pulsar captures the relationships between layers and provides energy-efficient communication using intelligent MAC and routing protocols and distributed algorithms to manage high-level network goals.

**Application/System Quality-of-Service (QoS) Interface Capabilities**

K. Nahrstedt,* W. J. Jeon, B. Kalter, J. H. Seo  
*National Aeronautics and Space Administration, NAG 2-1250*

Researchers are investigating application-system Quality-of-Service (QoS) interface capabilities for visual tracking distributed applications. The interface between the application and the underlying QoS-aware resource management system must provide several important functionalities: application QoS application programming interface, translation between the application QoS into the system QoS parameters, integrated reservation coordination policies and protocols to avoid and prevent deadlock situations, adaptation policies and their application enforcement, and others. These functions will reside in the end-system management entity called the QoS Broker, which represents the application/system interface for provision of end-to-end QoS guarantees.

**Hybrid Adaptive Algorithms for End System Middleware**

K. Nahrstedt,* B. Kalter, B. Li  
*Defense Advanced Research Projects Agency, F30602-97-2-0121*

Current distributed multimedia applications demand Quality-of-Service (QoS) from the supporting system. However, within the QoS demands, lower level transport facilities may not constantly provide guaranteed QoS without perturbation. In this scenario, researchers are investigating hybrid adaptive algorithms in the middleware level of end systems to perform QoS adaptation on a critical QoS metric. The research concentrates on analysis of QoS adaptation in dependence of system resource availability changes by applying theories from digital control systems.

**QoS Routing**

K. Nahrstedt,* J. Qian, L. K. Shan  
*Defense Advanced Research Projects Agency, F30602-97-2-0121*

The task of Quality-of-Service (QoS) routing is to find a path in the network that satisfies constraints on such metrics as bandwidth, delay jitter, and cost. This study focuses on QoS routing algorithms and their design within routers. The problem of finding a path with constraints on two or more additive metrics (delay and delay jitter) is NP-complete. This research concentrates on heuristic algorithms and study of the family of distributed and hierarchical routing algorithms to solve the multiconstrained routing problem. The QoS routing solutions are applied to point-to-point as well as multicasting scenarios.

**QoS-Aware Resource Management**

K. Nahrstedt,* K. Kim, A. K. Viswanathan, J. Wang  
*Partnerships for an Advanced Computational Infrastructure*

Operating systems and communication systems need new algorithms, services, and protocols to support processing of audio/visual streams according to Quality-of-Service (QoS) specification. This project concentrates on the CPU brokerage service with advanced reservation, admission, scheduler, and adaptation control for soft real-time and non-real-time tasks. At the communication level, researchers provide IntServ bandwidth brokers in the edge networks and DiffServ brokers within the backbone routers to provide end-to-end guarantees.

**Operating Systems and Security**

**ITR: Active Information Spaces Based on Ubiquitous Computing**

*National Science Foundation, CCF-00-86094*

The project researches a new form of operating system to manage a model of computing called an Active Space. This model integrates physical spaces that contain ubiquitous computers into a computational environment that supports human activity and applications. The physical space, augmented with communicating computer devices, becomes a distributed computing system. Gaia, an operating system for Active Spaces, will accommodate diversity by exploiting standards for interoperability and cooperation. System services track, authenticate, and support mobile users with reconfigurable graphics, multimedia, and Active Space applications. A unifying object bus, component model, and adaptive stream model extends plug and play to distributed mobile computers.

*Denotes principal investigator.
within physical spaces like cities, buildings, and rooms. Active Spaces have the potential for creating multibillion dollar industries. Automated surgery, collaboration, and engaged learning are a few of the compelling examples.

Mobile Sensor-Network Authentication
R. Campbell,* V. Welch,* C. Andrews, P. Naldurg, H. Khurana
Office of Navy Research

Authentication is a critical security requirement for sensor network nodes and provides a high quality of assurance in a hostile deployment scenario, when it is important for a data-gathering source to confidently verify the origin of sensor data. We focus on higher-end sensors that have significantly more processing power and memory than first-generation sensors. We question some of the existing weak cryptographic protocols and investigate the feasibility of using limited public-key encryption to address the sensor origin authentication problem. The challenge of key distribution is addressed by imprinting sensors with public key certificates, as well as the corresponding private keys, before being deployed. A line-of-sight transmission may be used to update the key.

Security and Privacy in Open Systems
M. Winslett,* A. Lee, L. Olson, M. Rosulek
Defense Advanced Research Projects Agency, National Science Foundation Information Technology Research (medium), NSF-Information Technology Research (large)

The need for rapid response to opportunities and threats has become the impetus for a move to computing systems where resources are shared across organizational boundaries: open systems. Example open systems range from supply chain management to the semantic web, grid, and peer-to-peer computing. The TrustBuilder project is addressing the unique security needs of open systems, with a focus on the development of trust negotiation as an approach to authorization and authentication in open systems.

Parallel Processing

Data Parallel Programming
L. V. Kale*
University of Illinois

Highly regular, array-oriented computations constitute a significant majority of computation-intensive scientific and engineering applications. Data parallel languages, such as High Performance Fortran, simplify and support the parallelizations of such applications. This project explores novel techniques for making such languages more efficient and flexible. One of the techniques developed causes different parallel subcomputations to overlap, increasing the tolerance of the performance to communication latencies. A rich set of intrinsics is being developed. The system provides flexible intermodule connectivity, so a high degree of reuse of parallel software becomes possible. Also, data parallel components can be integrated with nondata parallel components at will.

Debugging and Performance Feedback for Parallel Programs
L. V. Kale*
University of Illinois

Debugging parallel programs and improving their performance is a daunting task. Researchers are developing debugging and performance feedback tools that can maintain and exploit refined application-specific data better than is possible with traditional techniques. Such tools can be significantly beneficial in developing and improving parallel programs. This work is carried out using the Charm/Charm++ object parallel programming system. It is being extended to other languages in a multilingual framework. By exploiting “specificity” at language constructs, and by recording specific events, it becomes possible to provide visual feedback on performance and to suggest improvement paths via expert analysis.

Dynamic Load-balancing Strategies
L. V. Kale*
University of Illinois

A small grain of parallelism is essential and natural in executing irregular symbolic computations. The efficiency of a parallel processing system depends on how uniformly these granules of action are distributed to processors. Researchers have developed a dynamic load-balancing scheme that speedily distributes newly created work to the “needy” processors. It employs a corrective redistribution component and saturation control (not moving pieces of work around while everyone has sufficient work). Also, new strategies appropriate for the current generation of multicomputers are being designed. Some of these strategies support prioritized load balancing and control memory requirements simultaneously.
Highly Parallel Discrete Event Simulation
L. V. Kale,* T. Wilmarth  
*University of Illinois

Many complex systems are characterized by the presence of asynchronous events. A flexible manufacturing system, a digital circuit, and vehicular traffic in cities are examples of such systems. Neither analytical solutions nor time-marching simulations are appropriate for modeling such systems; they are modeled by discrete event simulations. The efficiency of many industrial processes is dependent on their speedy modeling. Researchers are engaged in developing a parallel computing-based approach for this challenging problem. The objective is to develop easy-to-use modeling tools and enable their simulation on highly parallel supercomputers and in workstation clusters.

Java Extensions for Parallel Computing
L. V. Kale,* M. Bhandarkar  
*University of Illinois

Java has emerged as a dominant object-oriented language that could replace or augment C++ for building large-scale parallel applications. Several studies show that Java boosts programmer productivity because of its well-conceived design, garbage collection, and standard libraries. For this project, researchers implemented a prototype parallel extension to Java that provides dynamic creation of remote objects with load balancing and object groups. The language constructs are based on those of Charm++. The prototype is implemented using the Converse interoperability framework, which makes it possible to integrate, in a single application, parallel libraries written in Java with modules in other parallel languages.

Parallel and Distributed Object-Oriented Programming
L. V. Kale,* M. Bhandarkar, R. Brunner  
*University of Illinois

This project extends earlier research on Charm, a portable parallel programming language based on message-driven objects. Message-driven execution makes it possible to adaptively overlap computation and communication, even across multiple modules. Charm supports dynamic creation and load balancing of parallel objects and specific information-sharing abstractions. Its branched chare and chare array constructs facilitate interfacing parallel modules and implementation of distributed data structures. Charm is highly suitable for irregular parallel computations. Several applications and libraries are written using Charm. Current research includes support for heterogeneity and client-server environments.

Parallel Execution of Speculative Computations
L. V. Kale*  
*University of Illinois

A large class of interesting computational problems has the following property: if one attempts to solve them in parallel, one often ends up solving subproblems that are not needed or that are not solved in a sequential execution. This leads to anomalous behavior. The speedups may vary from sublinear to superlinear from run to run and may increase or decrease with the addition of processors. This research is aimed at obtaining consistent and monotonically increasing speedups for such computations. Such problems arise in state-space search, branch-and-bound, game-tree search, planning, and theorem proving. Each of them requires a different set of techniques. Successful in obtaining satisfactory results for state-space search, the research team is working on other problems.

Run-Time Framework for Multilingual Interoperability among Parallel Languages
L. V. Kale,* M. Bhandarkar, J. Yelon, R. Brunner  
*University of Illinois

To tackle the difficult problem of parallel software development, many parallel languages are being developed, each with its own unique features and advantages. To benefit from this multitude of languages, one should be able to compose modules written in different languages into a single application program. This is difficult because of different scheduling models assumed by each language run time. This research is aimed at developing Converse, a framework for facilitating such interoperability. Converse also simplifies development of the run-time systems for new languages. Converse includes components supporting flexible threads, message passing, and processor scheduling. Several languages are being implemented using Converse.

CADRE: A National Facility for High-Performance I/O Characterization and Optimization
D. A. Reed,* G. Wang, D. Wells, Y. Zhang  
*National Science Foundation, EDA 99-75248

To catalyze research on I/O system design, analysis, and optimization for scalable, parallel, and distributed systems, this work will create a national facility to disseminate I/O characterization as well as optimization tools and data for quantitative study of I/O systems. The work will extend, document, and distribute a multilevel I/O characterization toolkit with logical and physical I/O instrumentation, statistical and visual data analysis tools, and documentation; instrumented I/O libraries, including

*Denotes principal investigator.
MPI-IO and HDF; instrumented, I/O-intensive applications; documented I/O traces in a portable data metaformat; and I/O trace analyses based on statistical analyses, hidden Markov models, and time series analysis that can be used for constructing configurable I/O benchmarks.

Human–Computer Interactions and Interfaces
Collaboration Support for the Development and Evolution of Complex Systems
D. A. Reed,* S. Kaplan,* H. George, Y. Huang, C. Lu, B. Schaeffer, E. Shaffer, S. Whitmore, S. Wu
Defense Advanced Research Projects Agency, F30602-96-2-0264

Complex systems are developed and evolved by groups, often separated in time and space and using disparate tools and techniques. No circumscribed tool suite can encompass all future needs. Instead, software support and collaboration environments must themselves evolve and grow to meet the needs of collaborative groups. As a solution to this problem, this research is focused on developing an extensible collaboration framework that supports the full range of activities undertaken by current team members, integrates the wide variety of tools and artifacts they use to realize their goals, and supports the evolution of the development team and its processes over time.

Intelligent Information Spaces: A Testbed to Explore and Evaluate Intelligent Devices and Augmented Realities
D. A. Reed,* R. H. Campbell, R. Kravets, M. D. Mickunas, K. Nahrstedt, L. Sha
National Science Foundation, EIA 99-72884

To support information environments where ubiquitous, intelligent devices unobtrusively share data, preferences, and contexts about users and their movement among environments, this project is developing interoperable component architectures for device coordination, seamless object communication for user quality of service, and adaptive user context and modality management. The goal is to define a software architecture capable of enabling a mobile, responsive, and contextual information environment where a broad collection of high-end data display and visualization systems, low-power mobile devices, and “smart” devices with widely varying capabilities are seamlessly integrated using dynamically tailored software components.

Intelligent, Adaptive Performance Analysis
(Intelligent High-Performance Computing on Toys)
D. A. Reed,* P. DeRose, C. Lu, C. Steffen, D. Wells
National Science Foundation, ACI 02-19597

This research explores the utility and performance of low-cost game system clusters for scientific computing and high resolution visualization. Assessment will be conducted using a suite of adaptive performance analysis tools that support both offline and online performance optimization and their application to a suite of scientific and visualization codes. Research will focus on three areas: offline, multilevel performance instrumentation of applications and system software; online, adaptive selection of multiversion code execution; and experimental assessment using large-scale scientific applications and visualization software. Performance analysis software developed via this project will be distributed widely, both in binary and source code forms.

Language-Directed Performance Prediction and Analysis
D. A. Reed,* D. Padua,* R. Aydt, K. Mahesh, Y. Zhang
Defense Advanced Research Projects Agency, N66001-97-C-8532

A multi-institution collaborative project

Achieving a large fraction of peak performance on parallel and metacomputing systems has proven difficult. To address this challenge, researchers are developing an integrated performance modeling, measurement, analysis, and prediction environment that will allow application and system developers to explore the performance implications of software and hardware design choices for extant systems, hypothetical systems, and combinations of the two. This work is based on compiler-supported program annotation, symbolic performance scalability models, integrated performance instrumentation, and comparative analysis of multiple system configurations.

Scalable Performance Analysis Tools
D. A. Reed,* R. A. Aydt, D. Israel, J. Karim, J. Mainzer, B. Schaeffer, J. Wendling
National Computational Science Alliance

A multi-institution collaborative project

As part of the national Partnerships for an Advanced Computational Infrastructure (PACI), this research team is focusing on three interrelated areas of performance analysis for scalable parallel systems: augmentation of current tools for performance analysis of parallel codes;
analysis of the interactions among application I/O patterns, file systems, and I/O hardware configurations; and design and testing of an adaptive resource management infrastructure that uses real-time performance data to interactively and automatically choose and configure run-time resource management policies. The results of this work are being shared throughout the national PACI alliance.

**Parallel Programming Patterns**

M. Snir*

*U.S. Department of Energy, DE-FG02-03ER25560*

We study and classify programming patterns that are prevalent in high-end scientific codes and that describe key activities of programmers that develop high-end scientific codes. We next examine how well these programming patterns are supported by several new parallel programming environments. This work is part of the activities of the Center for Programming models for Scalable Parallel Computing.

**Programming Languages, Formal Systems, and Software Engineering**

**Actor Coordination Abstractions, Semantics, and Implementation**

G. Agha,* C. Varela

*University of Illinois*

This research focuses on the complexity of expressing interaction and coordination in Web-based computing. Researchers are working on providing high-level mechanisms to manage the complexity of scaling up computations over the Web, piggy-backing on the availability of Java byte-code for portability. The project defines several actor-based abstractions (casts, directors, messengers) to effectively harness the power of the World Wide Web as a global computing infrastructure. Groups of actors, or casts, represent an abstraction unit for naming, synchronization, migration, composition, and load balancing. Each cast contains a director, and intercast communication is performed via special actors named messengers.

**Agent Generation and Control**

G. Agha,* N. Jamali, P. Thati

*U.S. Air Force Office of Scientific Research, F49620-97-1-0382*

Agents provide a natural abstraction for using geographically distributed computational and memory resources. Agents are autonomous mobile actors that may be invoked to satisfy specific goals that may require traveling across physical and economic boundaries. Agents and agent ensembles can exhibit resource consumptive or otherwise unsafe behavior, raising security and resource management concerns. Agents must, therefore, be limited by the resources they consume in pursuing a goal. The project is developing concepts necessary to provide linguistic and system support for defining multiagent architectures. A related goal is to extend the mathematical theory of actors to allow reasoning about multiagent systems.

**Customizable Coordination Services for Large-Scale Network Embedded Systems**

G. Agha,* P. Chang, P. Thati, R. Ziaei

*Defense Advanced Research Projects Agency, F49620-97-1-0382*

The focus of this research is on developing application independent services to coordinate large scale network embedded systems. The coordination services will use customization and composition to enable dynamic adaptation in uncertain environments. The approach is to define algorithms that are based on stochastic models of system behavior, which enable the research team to represent the incompleteness in information about the current global system state as well as the unpredictability of the environment. The operational model uses probabilistic transitions rather than simple nondeterministic interleavings of actions, and it explicitly accounts for duration of transitions. The goal is to develop algorithms that provide for coordination in real-time and that guarantee the desired properties with sufficiently high probabilities. Examples include algorithms for approximate consensus (such as approximate synchrony), recovery, and hierarchical coordination. The algorithms will be implemented to provide a code basis for application independent coordination services. The implementation strategy is to build a repository of basic coordination services using reflective middleware. The goal will be to derive more complex algorithms based on simpler core resource management services.
**Parametric Models for Large-Scale Agent Systems**

G. Agha,* N. Jamali, P. Thati, R. Ziaei  
*Defense Advanced Research Projects Agency, F30602-00-2-0586*

A goal of this research is to develop mathematical models to support the analysis and modeling of complex, large-scale agent systems. Instead of simple nondeterminism, the new theory will represent behavior stochastically. Moreover, instead of the current approach of using input-output behavior of individual agents, it will allow the behavior to be parametric in terms of variables that represent aggregated behavior of large numbers of agents. The operational model uses probabilistic transitions over an abstract representation of the current state of the system. The use of statistical techniques on this model for aggregating behaviors opens up the possibility of studying conditions under which either a stable equilibrium or chaotic behavior may occur. Another goal is to develop a radically different logical framework for expressing properties of large-scale agent systems. The framework is inspired by Quantum Logics, which allow the expression of testable properties. This is in contrast to the usual algebraic approach that assumes every sentence (whether testable or not) can be assigned a truth value. Specifically, this research will enable macroscopic properties to be expressed without implying assertions about how they arise.

**Software Architectures for Distributed Systems**

G. Agha,* M. Astley  
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The term middleware describes a set of services for integrating components of a distributed application, such as coordination and communication mechanisms. Recently, middleware services have been developed that support fault-tolerance, security, and other high-level policies. Such services have a fixed semantics, their implementation being influenced by the semantics of the application and the nature of the execution environment. The goal of this research is to provide a modular framework for developing middleware services. The project is formulating theoretical, linguistic, and run-time support for developing the needs of a particular application. Particular attention is paid to placement and mobility issues and vertical integration requirements.

**Specifying and Deriving Mobile Systems**

G. Agha,* P. Thati, R. Ziaei  
*U.S. Army, JHU 8812-48151*

This research is focused on studying formal methods for specifying and verifying distributed software systems. The objective is to use automated deduction tools to reason about certain properties of mobile agents in open distributed systems. More specifically, security issues in authentication protocols and agent design are being studied. The project is formalizing an appropriate semantic framework that captures the fundamental properties of mobile computing and simplifies the task of reasoning. A specification language and logic will be developed based on the semantic framework. Finally, automated reasoning environments will be explored to find a suitable platform to implement the reasoning system.

**Studies in Distributed Database Systems**

G. G. Belford*  
*University of Illinois*

Distributed databases can provide enhanced data availability to support applications such as office automation and computer-aided design and manufacturing. But first, further work is needed on problems such as maintaining the consistency of replicated data in an efficient, reliable manner. This research addresses these and related problems by the development of provably correct, reliable protocols and by the analysis and simulation of competing protocols and algorithms.

**Advanced Collaborative Systems Laboratory (ACSL)**

M. T. Harandi*  
*U.S. Army Construction Engineering Research Laboratory, DACA88-91-D-0005, DACA 88-91-D-0006; Intel Corp.; Sun Microsystems Inc.; Bull; Fujitsu/Open Systems Solutions; Hewlett-Packard Co.*

The Advanced Collaborative Systems Laboratory is a collaborative venture with the U.S. Army Corps of Engineers and various industrial sponsors. The goal of research at ACSL is the development of next-generation environments to address the complex issues associated with understanding and supporting collaborative engineering processes. A particular focus is the development of knowledge-based tools that support collaborative software development processes. This should be viewed as a prototypical area of endeavor rather than a closure of interests. The research has three major thrusts: development of models and technologies for the support of collaborative activities, development and application of knowledge-based theories and methodologies to increase...
the level of support that can be provided to users, and
development of advanced user-interface management
systems.

**Analogical Approaches to Reuse of Software Artifacts**
M. T. Harandi,* S. Yao
*U.S. Army Construction Engineering Research Laboratory, DACA88-94-K-0014

In conjunction with the Advanced Collaborative Systems Laboratory (ACSL)

While software reuse promises improved programmer productivity, greater code quality, and reduced developmental costs, it has been difficult to achieve under past paradigms. This research investigates the hypothesis that software reuse benefits are better realized at higher levels of abstraction than is typically attempted and that automated analogical reasoning, applied to knowledge-based domain-specific models, can greatly facilitate the reuse process. This work is being conducted within the context of the development of intelligent design assistance for the ISLE programming environment.

**Automated Support for Object-Oriented Design Evolution**
M. T. Harandi*  
*U.S. Army Construction Engineering Research Laboratory, DACA88-94-K-0014

In large-scale software development, design occurs in an evolutionary manner. This is particularly true in object-oriented software development. During the design process many objects, relations, and other aspects of the system will change. Each change would necessitate other changes and may make the system inconsistent. It is usually the designers’ responsibility to manage this change process. Managing this process, however, is a tedious and often complicated task. This research is aimed at developing an automated support tool to assist with object change management. Researchers address such issues as types of design change, semantics of change, formalization of change operators, and knowledge required for automated change management.

**Distributed Knowledge Acquisition System**
M. T. Harandi,* B. Park  
*University of Illinois

This project aims to build a distributed knowledge acquisition system by which domain experts can independently contribute to the gradual construction of a communal knowledge base. The knowledge base contains entities, such as subdomains, concepts, and variables, as well as relations between these entities. The system allows experts to enter information concerning a domain-related topic and to determine how this information affects the existing knowledge structures. Researchers are studying the use of such theories in proving, completing, or modifying user-specified knowledge segments. Researchers are also developing a new knowledge representation language and domain modeling tools and techniques.

**Formalization of Code Reuse through Abstract Algorithms**
M. T. Harandi,* J. Caplan  
*National Aeronautics and Space Administration, NAG 1-613

This project intends to study the form and use of a new abstraction method using data structure independent algorithm skeletons called task-oriented abstract algorithms (TOAA). These algorithm skeletons represent the essence of a common task, without the details that apply to special cases. Deciding what data structure to use in an abstract algorithm is part of its specialization and implementation information. Reusable software artifacts are most useful when they carry verification information. The proposed method of research is expected to provide partially verified reusable skeletons and correctness preserving specializations that provide the final proof of an implementation. The verification information includes assertions, data invariants, and restrictions on subtasks or data structure operations.

**Hybrid Reasoning in Multiagent Cooperative Systems**
M. T. Harandi,* C. Tinelli  
*U.S. Army Construction Engineering Research Laboratory, DACA88-94-K-0014

In conjunction with the Advanced Collaborative Systems Laboratory (ACSL)

Distributed problem solving has been widely used to provide intelligent support for cooperative activities. While a distinguished feature of hybrid reasoning systems is the use of multiple specialized subreasoners, they generally assume a centralized model of computation and rely on single-agent logics. Researchers on this project believe that the basic ideas of hybrid reasoning can be successfully extended to both distributed problem solving and multiagent logics. Researchers will be developing a hybrid reasoning framework for problem solving in multiagent cooperative systems.
Intelligent Support for Distributed Problem Solving
M. T. Harandi,* G. Rendon
U.S. Army Construction Engineering Research Laboratory, DACA88-94-K-0014

In conjunction with the Advanced Collaborative Systems Laboratory (ACSL)

This research deals with issues of distributed problem solving. In particular, researchers are looking for mechanisms that provide intelligent support for problem solving. This support could be in the form of reasoning mechanisms for handling interdependencies among tasks and interactions among agents. It could also be in the form of providing scenario analysis for decision making. A goal of this project is to develop a framework for representation of all relevant aspects of a problem-solving process. The framework provides a language composed of three primitives: agents, actions, and artifacts.

Knowledge-Based Programming Assistant
M. T. Harandi*
U.S. Army Construction Engineering Research Laboratory, DACA88-94-K-0014

Part of research being conducted in the Advanced Collaborative Research Laboratory (ACSL)

The knowledge-based programming assistant (KBPA) project has been researching, designing, and constructing the elements of an intelligent programming support system capable of aiding programmers in various facets of program production, such as specification, design, coding, debugging, and testing. In this system, techniques of computer inference, general problem solving, planning, and data management are applied to a rich database of knowledge about different phases of program production. This study focuses on issues of program synthesis and analogical programming.

Run-Time Code Generation for the Masses
S. Kamin,* B. Aktemur, P. Morton, M. Katelman
National Science Foundation, CCR 0306221

The goal of this project is to explore an easy-to-use approach to developing run-time code generators for Java. The technique we employ is “compositional compilation,” which provides power similar to macros (that is, “generative components”), while allowing for run-time code generation, which we believe is essential to making code generation practical. Our previous research resulted in the Jumbo system, which consists of a Java compiler and an API to support run-time code generation. We are studying ways of generating code more efficiently and allowing for safe use of software components. We are also applying the method of compositional compilation to other languages.

The Memory Model for Java
W. W. Pugh* (Univ. of Maryland), S. Adve
University of Maryland; University of Illinois

A multi-institution collaborative project

The memory consistency model for a multithreaded programming language determines the ease of programming and possible hardware and compiler optimizations. The Java programming language is perhaps the first commercially successful language to incorporate threads as first class objects. Unfortunately, the memory model of Java is incompletely and incorrectly specified. An expert group of seven researchers/companies has been established to fix the Java memory model. It has resulted in a new memory model specification for Java that is the first memory model specification to incorporate known hardware and compiler optimizations while preserving the security and safety features of the Java language. This specification will impact all programmers of multithreaded Java programs, Java compiler writers, and hardware designers.

Scalable Formal Methods for Multidimensional Components
G. Rosu,* J. Meseguer*
National Science Foundation, CCR 0234524

This research investigates scalable formal methods and their combinations as a way to reduce the gap between formal methods and software practice. These methods include domain-specific certification and runtime verification and monitoring. Various prototypes are developed: safety policy certifier for units of measurement; coordinate frame safety certifier; optimality state estimation certifier; and runtime verification and monitoring prototypes. These are experimentally evaluated using the NASA-HDCP testbed. This research is expected to lead to advances in software technology and to benefit advanced education. Novel combinations of software synthesis, certification, and monitoring lead to new, powerful, dependable software development methodologies that ensure safe execution with little or no overhead.

*Denotes principal investigator.
Real-Time and Embedded Systems

Adaptive Resource Management in Highly Dynamic Real-Time Systems with Physical Constraints
M. Caccamo*
National Science Foundation, CCR-0237884

This CAREER project is a combined research and educational project in the area of resource management for highly dynamic real-time systems with physical constraints. The research project investigates three avenues. The first is collaborative scheduling: Distributed rate adaptation and collaborative resource reclaiming techniques are explored to mitigate the effects of highly dynamic workloads in a distributed system with tightly-coupled real-time tasks running on different nodes. The second avenue is prioritized medium access control (MAC) with rate-adaptive messages: This research considers how to prioritize medium access to guarantee bounded delay, and how to implement distributed rate adaptation. The third avenue is template design: Off-line template design will be explored for managing multiple physical constraints, such as energy and thermal bounds in real-time CPU and network resource scheduling.

Defect-Tolerant System Integration and Evolution
L. Sha*
U.S. Office of Naval Research, Sha 2063

Large software systems are developed by integrating software components. Unfortunately, many complex software components often contain defects. On the other hand, the technology exists to develop modest-size software components with a high degree of confidence. Flight control software is an example. This research focuses on algorithms and architectures that can leverage simple high-assurance components to ensure the integrity of large distributed real-time systems in spite of faults in complex software components.

Dependable and Secured Embedded Systems
L. Sha,* V. Adve, M. Spong
National Science Foundation, CNS 0209202

Faults and attacks during upgrades can be classified into three categories: application level control logic faults or attacks; code, data, thread, or process access faults or attacks; and resource depletion faults or attacks. To protect against them, our work will focus on integrated compiler static analysis and runtime checks to enforce the resource usage limits and to protect code, data, thread, and processes; and advanced safety controllers that can protect against coordinated control logic faults or attacks. Together with real-time scheduling technology, they form a foundation upon which applications can be upgraded without shutting down normal operation. Furthermore, the system stability can be maintained in spite of insider attacks masquerading as upgrades.

Quality of Surveillance and Control in Network Centric Warfare
L. Sha,* J. C. Hou,* M. Caccamo, W.-P. Chen, P. R. Kumar, R. Iyer, R. Zheng
Office of Naval Research, Multidisciplinary Research Program of University Research Initiative

In this project, we aim to develop a sound scientific foundation and technologies to allocate computing, sensing, and communication resources in a way that will enhance the quality of surveillance and control for the Department of Defense’s vision of network centric cooperative engagement. We are working with the DoD community to develop model problems that embody the fundamental scientific and engineering challenges faced by DoD systems, including network of multifunction radars, distributed sensor network, and advanced avionics systems. We are working to solve these model problems, demonstrate the solutions, and transition the technologies to major DoD programs through technology transition partners.

Scientific Computing

Curriculum Development in Computational Materials Science and Nanoscale Science and Engineering
E. de Sturler,* D. Ceperley, D. Johnson, R. Martin, T. Martinez, U. Ravaiolo
National Science Foundation, EEC-0088101

This project encompasses development of course materials (lecture notes, demos, practical assignments, numerical experiments) on Krylov subspace methods for linear systems and eigenvalue problems, nonlinear problems, multigrid methods, and fast multipole methods for summer school (summer 2001 and summer 2004) and general curriculum in the College of Engineering.
Fast Linear Solvers for Large Sequences of Slowly Varying Linear Systems
E. de Sturler,* P. Geubelle, R. Dodds, M. Parks, C. Siefert, M. Kilmer (Tufts University)
U.S. Department of Energy, B341494; University of Illinois Computational Science and Engineering Program (fellowship M. Parks)

This project aims at the efficient solution of large sequences of slowly changing linear systems arising in time-dependent and nonlinear finite element analysis, such as crack propagation and analysis of fatigue. Further applications involve nonlinear optimization in diffuse optical tomography and other optimization problems. More generally, this project also involves the analysis and development of very robust and efficient (parallel) linear solvers and preconditioners for very large, sparse problems. Such research is of paramount importance to address the huge systems and sequences of systems that result from the problems addressed in the ASCI project.

Iterative Methods and Matrix Function Approximation in Material Science Simulations
E. de Sturler,* D. Johnson
National Science Foundation, Focused Research Group Grant, DMR-0325939

This research is focused on study of a variety of techniques related to iterative methods for linear systems for problems arising in material science. An important topic is formed by cheap methods to compute selected coefficients of the inverses of matrices.

Multigrid and Krylov Subspace Solvers for Parallel Simulations with Dynamic Adaptive Mesh Refinements
E. de Sturler,* Z. Chen, S. Wang
NASA Computational Technologies Project Cooperative Agreement, NCC5-615

Dynamic adaptive mesh refinement is a key technology in solving problems that require a large variation of spatial resolution in different parts of the computational domain and rapid changes in the required resolution. Such dynamically changing meshes pose several hard problems for iterative solvers, both of Krylov subspace and multigrid type. We consider improvements to both types of solvers for simulations using dynamic adaptive mesh refinements. For Krylov subspace methods, one of the main problems is to devise preconditioners that remain efficient after the redistribution of grid blocks and effectively deal with long range interaction. For multigrid methods, two problems are strong anisotropy and jumps in the coefficients. The traditional methods to deal with these situations in multigrid solvers cannot easily be used on adaptively refined meshes.

Preconditioners for Generalized Saddle Point Problems
E. de Sturler,* A. Beaudoin, Robert Dodds, C. Siefert, L. Zhu, M. Parks
U.S. Department of Energy, B341494; University of Illinois Computational Science and Engineering Program (Fellowship M. Parks)

Saddle point problems and generalized saddle point problems pervade computational science and engineering. Among other areas, these problems arise in constrained optimization and in systems of partial differential equations with conservation laws. The linear systems arising from these problems lead to very poor convergence for iterative solvers. As a consequence, research in effective preconditioners is of paramount importance. An interesting application of such preconditioners is in the parallel domain decomposition method FETI, which turns variational problems in solid and fluid mechanics into constrained optimization problems. The FETI method is one of the most popular parallel domain decomposition methods with very good numerical and parallel scalability.

Center for Simulation of Advanced Rockets
M. T. Heath,* E. de Sturler, X. Jiao, W. Cochran, C. Siefert
U.S. Department of Energy, B523819

The center carries out a wide variety of research in combustion, fluid dynamics, structural analysis, and computer science. Research in numerical computation focuses on solvers for large linear systems and on data transfer between disparate meshes. Work on linear solvers includes development of direct and iterative methods for symmetric and nonsymmetric linear systems and eigenvalue problems. Specific emphases include grid-based solvers, subspace reuse in Krylov iterative solvers, and preconditioners for indefinite systems. Also under development are algorithms for numerically accurate and physically conservative data transfer at component interfaces based on a common refinement of mismatched surface meshes.

*Denotes principal investigator.
Multidimensional Computation of Electronic Properties of Semiconductor Microstructures of High-Performance Heterojunction Devices
National Science Foundation, EET-87-19100

The goal of this research is to design numerical programs for the simulation of multidimensional quantum wells. The numerical model consists of Poisson’s equation coupled with Schrodinger’s equation. Poisson’s equation is solved as an elliptic boundary value problem, while Schrodinger’s equation defines an eigenvalue problem. The model is nonlinear and requires repeated solution of such eigenvalue problems. Researchers compare the performance of Lanczos procedures with subspace iteration and examine the use of inverse iteration. Consistency of the two problems is obtained in an outer iteration that will be accelerated with a conjugate gradient procedure.

Inclusion of Overshoot Effects in the Drift-Diffusion Semiconductor Model
National Center for Computational Electronics; National Science Foundation, EET 88-09023

Researchers cooperate on the development of a numerical program in which overshoot effects are included in the drift-diffusion model. The model is extended by the introduction of mobility functions for which field dependence is computed by Monte Carlo simulation. The Scharfetter-Gummel discretization is adapted so that it can be applied to the modified model.

National Computational Infrastructure for Lattice Gauge Theory
D. A. Reed,* C. Mendes, Y. Zhang
U.S. Department of Energy, DEFC02-01ER41205

This initiative is developing the software and hardware infrastructure necessary to support large-scale numerical simulations of quantum chromodynamics (QCD). As part of this effort, this group is assessing the performance of software APIs, measuring application performance, and evaluating new software approaches for community QCD codes.

Performance Evaluation Research Center
D. A. Reed,* C. Mendes, Y. Zhang
U.S. Department of Energy, DAR 0517 ANTIC

This research group is one of the participants developing performance analysis and optimization techniques for high-end computer systems and applications. By developing a software infrastructure for monitoring and collecting performance data, this research group is contributing to the development of benchmarks, models, analytical techniques, and tools for the evaluation, optimization, and utilization of memory hierarchy in high performance computer systems.

NIH Resource for Macromolecular Modeling and Bioinformatics
K. Schulten* (Physics), G. Budescu (Beckman Instit.), L. V. Kale, R. Skeel, J. DeSouza, D. Hardy, S. Kumar, M. Potnuru, W. Wang, G. Zhang, and others
National Institutes of Health, P41RR05969

This project involves the development of computational technology for modeling of large macromolecular systems in realistic environments and its deployment in the biomedical community. The computer science part of the effort is directed toward the parallel molecular simulation program NAMD and the web-enabled collaborative environment BioCore. Research topics include parallelization techniques for scaling to thousands of processors and fast methods for electrostatic calculations including polarization effects.

Numerical Methods for Molecular Dynamics
R. Skeel,* E. Cyr
National Science Foundation, DMS-0204442

The goal of this research is the analysis and development of propagators and especially integrators for molecular simulations. The emphasis is on the study of integrators for the kinetics of biomolecules with application to methods for conformational dynamics.
Journal Articles

Algorithms and Theory


Erickson, J. and Har-Peled, S. **Optimally cutting a surface into a disk.** *Discrete and Computational Geometry, 31*:1, 37-59 (Jan. 2004).


Artificial Intelligence: Machine Learning, Vision, and Robotics

Agarwal, S., Mawan, A., and Roth, D. **Learning a sparse representation for object detection.** *Institute of Electrical and Electronics Engineers Transactions on Pattern Analysis and Machine Intelligence, 20*, 1475-1490 (Nov. 2004).


Computer Architecture and Compilers


Databases and Information Systems


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Dong, G. Z., Han, J. W., Lam, J. M. W., Pei, J. A., Wang, K., and Zou, W. Mining constrained gradients in large databases. Institute of Electrical and Electronics Engineers Transactions on Knowledge and Data Engineering, 16:8, 922-938 (Aug. 2004).

Han, J. W., Pei, J., Yin, Y. W., and Mao, R. Y. Mining frequent patterns without candidate generation: A frequent-pattern tree approach. Data Mining and Knowledge Discovery, 8:1, 53-87 (Jan. 2004).

Han, J., Pei, J., and Yan, X. From sequential pattern mining to structured pattern mining. Journal of Computer Science and Technology, 19:3, 257-279 (May 2004).


Pei, J., Dong, G., Zou, W., and Han, J. *Mining condensed frequent pattern bases*. Knowledge and Information Systems, 6:5, 570-594 (Sep. 2004).

Pei, J., Han, J. W., Mortazavi-Asl, B., Wang, J. Y., Pinto, H., Chen, Q. M., Dayal, U., and Hsu, M. C. *Mining sequential patterns by pattern-growth: The PrefixSpan approach*. Institute of Electrical and Electronics Engineers Transactions on Knowledge and Data Engineering, 16:11, 1424-1440 (Nov. 2004).

Pei, J., Han, J., and Lakshmanan, L. V. S. *Pushing convertible constraints in frequent itemset mining*. Data Mining and Knowledge Discovery, 8:3, 227-252 (May 2004).

Pei, J., Han, J., Mortazavi-Asl, B., Pinto, H., Chen, Q., Dayal, U., and Hsu, M.-C. *Mining sequential patterns efficiently by pattern-growth methods*. Institute of Electrical and Electronics Engineers Transactions on Knowledge and Data Engineering, 16:10, 1424-1440 (Nov. 2004).


Yu, H., Han, J., and Chang, K. C.-C. *PEBL: Web page classification without negative examples*. Institute for Electrical and Electronics Engineers Transactions on Knowledge and Data Engineering, 16:1, 70-81 (Jan. 2004).


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**Graphics and Visualization**


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**Networking**


### Operating Systems and Security


### Parallel Processing


### Programming Languages, Formal Systems, and Software Engineering


### Real-Time and Embedded Systems

Baliga, G., Graham, S., Sha, L., and Kumar, P. R. **Service continuity in networked control using etherware.** *Institute of Electrical and Electronics Engineers Distributed Systems Online, 5:*9, 2 (Sep. 2004).


### Scientific Computing


Tran, N. and Reed, D. A. **Automatic ARIMA time series modeling for adaptive I/O prefetching.** *Institute of Electrical and Electronics Engineers Transactions on Parallel and Distributed Systems,* 15:4, 362-377 (Apr. 2004).


### Book Chapters

**Artificial Intelligence: Machine Learning, Vision, and Robotics**


**Databases and Information Systems**


**Networking**


**Programming Languages, Formal Systems, and Software Engineering**


**Real-Time and Embedded Systems**


**Papers Presented at Conferences and Symposia**

**Algorithms and Theory**


Artificial Intelligence: Machine Learning, Vision, and Robotics


Li, X., Roth, D., and Small, K. The role of semantic information in learning question classifiers. 1st International Joint Conference on Natural Language Processing (Sanya City, Hainan Island, China, Mar. 2004).


Computer Architecture and Compilers


Gopalakrishnan, S. Managing communication in integrated modular architectures. 18th International Parallel and Distributed Processing Symposium (Santa Fe, NM, Apr. 2004). Proceedings, 18th International Parallel and Distributed Processing Symposium 1775-1778 (2004).


Databases and Information Systems

Aggarwal, C., Han, J., Wang, J., and Yu, P. S. On-demand classification of data streams. 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference (Seattle, WA, Aug. 2004). Proceedings, 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference 503-508 (2004).


Cheng, H., Yan, X., and Han, J. **IncSpan: Incremental mining of sequential patterns in large databases.** 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference (Seattle, WA, Aug. 2004). Proceedings, 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference 527-532 (2004).


He, B., Chang, K. C., and Han, J. **Discovering complex matchings across web query interfaces: A correlation mining approach.** 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference (Seattle, WA, Aug. 2004). Proceedings, 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference 148-157 (2004).

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Kim, W.-Y., Lee, Y.-K., and Han, J. CCMine: Efficient mining of confidence-closed correlated patterns. 8th Pacific-Asia Conference on Knowledge Discovery and Data Mining (Sydney, Australia, May 2004). Proceedings, 8th Pacific-Asia Conference on Knowledge Discovery and Data Mining, Lecture Notes in Computer Science, Vol. 3056, 569-579 (2004).


Li, X., Han, J., and Gonzalez, H. High-dimensional OLAP: A minimal cubing approach. 30th International Conference on Very Large Data Bases (Toronto, ON, Aug. 2004). Proceedings, 30th International Conference on Very Large Data Bases 528-539 (2004).

Li, Y., Han, J., and Yang, J. Clustering moving objects. 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference (Seattle, WA, Aug. 2004). Proceedings, 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference 617-622 (2004).


Shao, Z., Han, J., and Xin, D. MM-Cubing: Computing iceberg cubes by factorizing the lattice space. 16th International Conference on Scientific and Statistical Database Management (Santorini Island, Greece, Jun. 2004). Proceedings, 16th International Conference on Scientific and Statistical Database Management 213-222 (2004).


Wu, A., Garland, M., and Han, J. Mining scale-free networks using geodesic clustering. 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference (Seattle, WA, Aug. 2004). Proceedings, 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference 719-724 (2004).


Zhai, C., Velivelli, A., and Yu, B. **A cross-collection mixture model for comparative text mining.** 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference (Seattle, WA, Aug. 2004). Proceedings, 10th Association for Computing Machinery Special Interest Group on Knowledge Discovery and Data Mining International Conference 743-748 (2004).


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**Graphics and Visualization**


Lim, J. and Kriegman, D. **Tracking humans using prior and learned representations of shape and appearance.** 6th Institute of Electrical and Electronics Engineers International Conference on Automatic Face and Gesture Recognition (Seoul, South Korea, May 2004). Proceedings, 6th Institute of Electrical and Electronics Engineers International Conference on Automatic Face and Gesture Recognition 869-874 (2004).


**Human–Computer Interfaces**

Karahalios, K. **FashionFone.** Identity Workshop, Computer-Supported Cooperative Work Conference (Chicago, IL, Sep. 2004).


**Networking**


Cui, Y., Xue, Y., and Nahrstedt, K. Max-min overlay multicast: Allocation and tree construction. 12th Institute of Electrical and Electronics Engineers International Workshop on Quality of Service (Montréal, QC, Jun. 2004). Proceedings, 12th Institute of Electrical and Electronics Engineers International Workshop on Quality of Service 221-231 (2004).


Ong, C. S., Xue, Y., and Nahrstedt, K. A middleware for service adaptation in differentiated 802.11 wireless networks. 12th Institute of Electrical and Electronics Engineers International Conference on Networks (Singapore, Nov. 2004).


Sobeih, A., Hou, J., and Viswanathan, M. **Check and simulate: A case for incorporating model checking in network simulation.** 2nd Association for Computing Machinery/Institute of Electrical and Electronics Engineers International Conference on Formal Methods and Models for Codesign (San Diego, CA, Jun. 2004).


Yang, Y. and Kravets, R. **Distributed QoS guarantees for realtime traffic in ad hoc networks.** 1st Annual Institute of Electrical and Electronics Engineers Communications Society Conference on Sensor and Ad Hoc Communications and Networks (Santa Clara, CA, Oct. 2004). Proceedings, 1st Annual Institute of Electrical and Electronics Engineers Communications Society Conference on Sensor and Ad Hoc Communications and Networks 118-127 (2004).


**Operating Systems and Security**


### Parallel Processing


Rashmi, J., Lawlor, O. S., and Kale, L. V. Debugging support for Charm++. 18th International Parallel and Distributed Processing Symposium (Santa Fe, NM, Apr. 2004). Proceedings, 18th International Parallel and Distributed Processing Symposium 264 (2004).


Programming Languages, Formal Systems, and Software Engineering


Jang, M.-W., Momen, A. A., and Agha, G. ATSpace: A middle agent to support application-oriented matchmaking and brokering services. Institute of Electrical and Electronics Engineers/Women’s International Center/Association for Computing Machinery International Conference on Intelligent Agent Technology (Beijing, China, Sep. 2004). Proceedings, Institute of Electrical and Electronics Engineers/Women’s International Center/Association for Computing Machinery International Conference on Intelligent Agent Technology 393-396 (2004).


Thati, P. and Viswanathan, M. **Verification of asynchronous systems with unbounded and unordered message buffers.** 3rd Workshop on Automated Verification of Infinite State Systems (Barcelona, Spain, Apr. 2004).

Tosic, P. and Agha, G. **Concurrency vs. sequential interleavings in 1-D threshold cellular automata.** 18th International Parallel and Distributed Processing Symposium: 6th Workshop on Advances in Parallel and Distributed Computational Models (Santa Fe, NM, Apr. 2004). Proceedings, 18th International Parallel and Distributed Processing Symposium 2539-2546 (2004).


**Real-Time and Embedded Systems**


**Scientific Computing**


**Theses**

**Algorithms and Theory**


**Artificial Intelligence: Machine Learning, Vision, and Robotics**


Computer Architecture and Compilers


Databases and Information Systems


Li, X. High-dimensional online analytical processing: A minimal cubing approach. M.S. thesis, J. Han, advisor (2004).


Graphics and Visualization


Human–Computer Interfaces


Networking


Operating Systems and Security


Programming Languages, Formal Systems, and Software Engineering


Real-Time and Embedded Systems


Scientific Computing


Awards and Honors

Sarita Adve
Research Initiation Award, National Science Foundation (NSF), 1994-1997
Faculty Early Career Development Program (CAREER) Award, NSF, 1995-1998
Associate Editor, ACM Transactions on Modeling and Computer Simulation, 1997-
Faculty Partnership Award, IBM Corporation, 1997-1999
Research Fellowship, Alfred P. Sloan Foundation, 1998-2000
Coauthor, one of forty-one papers chosen for an anthology of selected papers from the first twenty-five International Symposia on Computer Architecture (Sohi, editor), ACM Press, 1998
University Scholar, University of Illinois, 2004

Vikram Adve
Best Paper Award, 15th Workshop on Parallel and Distributed Simulation, May 2001

C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 2002
Associate Editor, ACM Transactions on Programming Languages and Systems, 2003-
Best Paper Award, Programming Language Design and Implementation, 2005

Gul A. Agha
Young Investigator Award, U.S. Office of Naval Research, 1989
Incentive for Excellence Award, Digital Equipment Corporation Faculty Program, 1990
Fellow, University of Illinois Center for Advanced Study, 1992-1993
International Lecturer, Association for Computing Machinery (ACM), 1991-2000
Editor, ACM Computer Surveys, 1995-1999
Associate Editor-in-Chief, IEEE Parallel and Distributed Technology: Systems and Applications, 1992-1994
Editor, Theory and Practice of Object Systems, 1993-1999
Golden Core Member, Institute of Electrical and Electronics Engineers (IEEE) Computer Society, 1999
Meritorious Service Award, IEEE Computer Society, 1999
Editor-in-Chief, ACM Computing Surveys, 2000-
Fellow, IEEE Computer Society, 2002
Member, European Academy of Sciences, 2003
Arthur Schofstall Distinguished Lecturer, Rensselaer Polytechnic Institute, 2003

Eyal Amir
Arthur L. Samuel Award for Best Thesis, Stanford University Computer Science Department, 2002

Brian P. Bailey
Research Contribution Award, University of Minnesota Department of Computer Science, 2001
Fellow, National Center for Supercomputing Applications, 2004

Geneva G. Belford, Emeritus
Distinguished Visitor, Institute of Electrical and Electronics Engineers Computer Society, 1982-1985
Halliburton Engineering Education Leadership Award, University of Illinois College of Engineering, 1986
Award for Outstanding Faculty Member, Dad’s Association, University of Illinois, 1991
Graduate College Outstanding Mentor Award, 2005

Stephen Bond
Fellow, La Jolla Interfaces in Science, 2000
Marco Caccamo
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2003

Roy H. Campbell
Senior Visiting Research Fellowship at University of Newcastle upon Tyne, Science and Engineering Research Council of Great Britain, 1981-1983
Information Technology Committee, Illinois Terrorism Task Force, 2002-2003
Sohaib and Sara Abbasi Professor in Computer Science, University of Illinois, 2004-

Kevin C.-C. Chang
Best Paper selection, 26th International Conference on Very Large Data Bases, 2000
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2002
Faculty Fellows Award, National Center for Supercomputing Applications, 2003
IBM Faculty Award, 2004

Gerald DeJong
Faculty Assistant Grant, Exxon Mobil Corporation, 1982
Arnold O. Beckman Research Award, University of Illinois Research Board, 1984
Faculty Recognition Grant, Alcoa Foundation, 1989
Fellow, American Association for Artificial Intelligence, 1992
International Scientist of the Year, International Biographical Centre, 2001

AnHai Doan
William Chan Memorial Dissertation Award, University of Washington, 2003
Distinguished Doctoral Dissertation Award, Association for Computing Machinery, 2003
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2004
Outstanding Alumnus Award, University of Wisconsin, 2004

Jeffrey G. Erickson
Mathematical Sciences Postdoctoral Research Fellowship, National Science Foundation (NSF), 1996-1998
Research Fellowship, Alfred P. Sloan Foundation, 1999-2001

Everitt Award for Teaching Excellence, University of Illinois College of Engineering, 2001
C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 2001
Faculty Early Career Development Program (CAREER) Award, NSF, 2001-2006
Willett Faculty Scholar, University of Illinois College of Engineering, 2002-2005

David Forsyth
National Science Foundation Research Initiation Award, 1992
National Science Foundation Young Investigator Award, 1992
Marr Prize, Best Paper at 1993 International Conference on Computer Vision, 1993
Okawa Foundation Fellowship, 2003

Carl A. Gunter
Best Paper Award, Fourth International Conference on Requirements Engineering, 2000
Editor, Journal of Computer Security, November 2004

Elsa Gunter
Best Paper Award, Fourth International Conference on Requirements Engineering, 2000
European Association of Software Science and Technology Award for the Best Software Science Paper, European Joint Conferences on Theory and Practice of Software, 2001

Indranil Gupta
Faculty Early Career Development Program (CAREER) Award, NSF, 2005

Jiawei Han
Distinguished Paper Award (Co-recipient), 1st International Symposium on Artificial Intelligence, 1988
Excellent Paper Award (Co-recipient), 8th Annual Conference of Japan Society of Artificial Intelligence, 1994
Associate Editor, Data Mining and Knowledge Discover (DAMI), 1997-
Associate Editor, Journal of Intelligent Information Systems (JIIIS), 1997-
Endowed University Professor, Simon Fraser University, 1999-2004
Outstanding Contribution Award, IEEE International Conference on Data Mining, 2002
Board of Directors, ACM SIGKDD, 2001-
IBM Faculty Award, 2002, 2003
Senior Member, Institute of Electrical and Electronics Engineers, 2003
Fellow, Association for Computing Machinery, 2003
Technical Achievement Award, IEEE Computer Society, 2004

Mehdi T. Harandi
Best Paper Award, 3rd International Workshop on Computer-Aided Software Engineering, 1989
Senior Member, Institute of Electrical and Electronics Engineers, 1990
Best Paper Award, 5th Conference on Knowledge-based Software Assistant, 1990
Editor, Journal of Automated Software Engineering, 1992-
Recognition of Service Award, Association for Computing Machinery, 1997

John C. Hart
Research Initiation Award, National Science Foundation, 1993-1996
Associate Editor, ACM Transactions on Graphics, 2000-
Editor-in-Chief, ACM Transactions on Graphics, 2003-

Michael T. Heath
Eugene P. Wigner Postdoctoral Fellow, Oak Ridge National Laboratory, 1978-1980
Editor, SIAM News, 1988-
Editor, SIAM Journal on Scientific Computing, 1990-1995
Editor, International Journal of High-Performance Computing Applications, 1993-
Editor, SIAM Review, 1994-2002
Everitt Award for Teaching Excellence, University of Illinois College of Engineering, 1998
Fellow, Association for Computing Machinery (ACM), 2000
Recognition of Service Award, ACM, 2001
Member, European Academy of Sciences, 2002
Fulton Watson Copp Chair in Computer Science, 2003-
Engineering Council Award for Excellence in Advising, University of Illinois College of Engineering, 2003
Editor, SIAM Fundamentals of Algorithms, 2003-
Member, European Academy of Sciences, 2003

Jennifer C. J. Hou
Women in Science Initiative Award, University of Wisconsin, 1993-1995
Wisconsin/Hilldale Undergraduate/Faculty Research Fellowship, University of Wisconsin College of Engineering, 1995
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 1996-2001
Senior Member, Institution of Electrical and Electronics Engineers (IEEE), 1999-
Lumley Research Award, The Ohio State University, 2001
General co-chair, IEEE 7th Real-Time Technology and Application Symposium, June 2001
Cisco University Research Program Award, 2002-2003
Editor, Computer Network Journal, 2002-
Editor, IEEE Transactions on Wireless Communications, 2002-
Editor, ACM Baltzer Wireless Networks WINET, 2002-
Editor, IEEE Transaction on Parallel and Distributed Systems, 2003-
Editor, IEEE Wireless Communications Magazine, 2003-

Laxmikant V. Kale
NCR Award of Excellence, 1989
C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 1990
Gordon Bell Award, Supercomputing Conference 2002, 2002
Best Poster Award, Supercomputing Conference 2002, 2002
Editorial Board, SIAM Book Series: Computational Science and Engineering, 2004-

Samuel N. Kamin
Editorial Board, ACM Transactions on Programming Languages and Systems, 1993-1999
Stanley H. Pierce Faculty Award, University of Illinois College of Engineering, 2001
Charter Member, International Federation for Information Processing Working Group 2.11 (Program Generation), 2004
Campus Award for Excellence in Advising Undergraduate Students, University of Illinois, 2005

Karrie Karahalios
IBM Fellowship, 2000, 2001

Robin Kravets
Faculty Early Career Development Program (CAREER) Award, National Science Foundation (NSF), 2004
Steven M. LaValle
Finalist for Best Journal Paper of the Year Award, IEEE Transactions on Robotics and Automation, 1998
Alternative Winner: Presidential Early Career Award (PECASE), Directorate for Computer and Information Science, National Science Foundation, 2000
C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 2003-2004

Jose Meseguer
Postdoctoral Research Fellow, Spanish Ministry of Universities and Science, 1977-1979
Research Fellow, U.S.-Spain Joint Committee for Scientific Cooperation, 1979-1981
Associate Editor, Theory and Practice of Object Systems, 1994-2000
Editorial Board, University of Madrid Mathematics Journal, 1995-
Member, International Federation for Information Processing (IFIP) Working Group 14.3 (Foundations of Systems Specification)
Member, IFIP Working Group WG1.6 (Term Rewriting)
Member, Gesellschaft für Informatik Working Group 0.1.7 (Specification and Semantics)

Saburo Muroga, Emeritus
Honorary Member, Information Processing Society of Japan
Fellow, Institute of Electrical and Electronics Engineers (IEEE)
Distinguished Visitor, IEEE, 1988-1990
Contribution Award, Information Processing Society of Japan, 1991
Honorary Member, Information Processing Society of Japan, 1998
The Order of the Sacred Treasure, Gold Rays with Neck Ribbon, Emperor of Japan, 2004

Klara Nahrstedt
Weierstrass Prize, Weierstrass Institute of Mathematics, Berlin, 1985
Faculty Early Career Development Program (CAREER) Award, National Science Foundation (NSF), 1996
NASA Space Act Award, NSF, 1996
Editorial Board, IEEE Multimedia Newsletter, 1996
Xerox Award for Junior Faculty Research, University of Illinois College of Engineering, 1998
C. W. Gear Faculty Award, University of Illinois Department of Computer Science, 1999
Best Tutorial Paper Award, Institute of Electrical and Electronics Engineers (IEEE), for “An Overview of Quality of Service Routing for Next-Generation High-Speed Networks: Problems and Solutions,” 1999
Campus Award for Innovation in Undergraduate Instruction Using Educational Technologies, University of Illinois, 2000
Associate Editor, ACM Computer Communications Reviews, 2000-
Editor-in-Chief, ACM Multimedia Systems Journal, 2001-
Ralph M. and Catherine V. Fisher Professorship, University of Illinois College of Engineering, 2002-

David A. Padua
Distinguished Visitor, Institute of Electrical and Electronics Engineers (IEEE) Computer Society, 1990-1993
Xerox Award for Faculty Research, University of Illinois College of Engineering, 1992
Editorial Board, Journal of Parallel and Distributed Computing, 1993-
Best Paper Award, International Conference on Supercomputing, 1995
Golden Core Member, IEEE Computer Society, 1997
Editorial Board, Wiley Encyclopedia of Electrical and Electronics Engineering, 1998
Editorial Board, International Journal of Parallel Programming, 1998-
Editorial Board, Electronic Journal of the Latin-American Center for Information Studies, 1998-
Fellow, IEEE, 2000

Lenny Pitt
Research Initiation Award, National Science Foundation, 1988
C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 1992
Everitt Award for Teaching Excellence, University of Illinois College of Engineering, 1999
University Distinguished Teacher/Scholar, University of Illinois, 2004

Jean A. Ponce
Xerox Award for Faculty Research, University of Illinois College of Engineering, 1993, 1998
Area Editor, Computer Vision and Image Understanding, 1994-
Beckman Associate, University of Illinois Center for Advanced Study, 1994-1995
Critical Research Initiative Planning Award, University of Illinois, 1996
Senior Member, Institute of Electrical and Electronics Engineers (IEEE), 1997-2003
Associate Editor, IEEE Transactions on Robotics Research, 1998-2002
Editor-in-Chief, International Journal of Computer Vision, 2002-
Fellow, IEEE, 2003

Grigore Rosu
Irina Gorun-Bercovici Memorial Prize, Society of Mathematicians from Romania, 1997
Best Software Science Paper (ETAPS 2002), European Association for the Study of Sciences and Technology, 2002
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2005
C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 2004

Dan Roth
Derek Bok Excellence in Teaching Award, Harvard University, 1993
Best Paper, 16th International Joint Conference on Artificial Intelligence, 1999
IBM Faculty Equipment Award, 1999
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2000
C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 2000
Editorial Board, Computational Linguistics, 2000-2003
Innovative Applications of AI Award, American Association of Artificial Intelligence, 2001
Xerox Award for Junior Faculty Research, University of Illinois College of Engineering, 2001
Editorial Board, Machine Learning Journal, 2001-2004

Honorable Mention: Campus Award for Excellence in Guiding Undergraduate Research, University of Illinois, 2002
Willett Faculty Scholar, University of Illinois Department of Computer Science, 2002-2005
Editorial Board, Computational Intelligence, 2003-
Editorial Board, ACM Transactions on Asian Languages: Information Processing, 2003-2005
Action Editor, Machine Learning Journal, 2004-
Xerox Award for Faculty Research, Xerox Foundation, 2005

Lui Sha
Fellow, Institute of Electrical and Electronics Engineers
Associate Editor, International Journal of Real-Time Systems, 1992-
Area Editor, IEEE Computer, 1993-1995
GE Scholar, University of Illinois Academy for Excellence in Engineering Education, 1999
Co-Chair, IEEE Real-Time and Embedded Technology and Applications Symposium, 2001
Associate Editor, IEEE Transactions on Parallel and Distributed Systems, 2001-2002

Robert D. Skeel, Emeritus
Editor-in-Chief, SIAM Journal on Scientific Computing, January 1997

Marc Snir
Outstanding Innovation Award for work on Hierarchical Memory Model, IBM Corporation, 1989
Editorial Board, Parallel Processing Letters, 1992-
Member, IBM Academy of Technology, 1993
Outstanding Innovation Award for work on Parallel System Architecture and Software Structure, IBM Corporation, 1994
Fellow, Institute of Electrical and Electronics Engineers, 1996
Fellow, Association for Computing Machinery, 1999
Editorial Board, Computing Surveys, 2002-
Michael Faiman and Saburo Muroga Professor of Computer Science, 2001-
Board of Directors, Computing Research Association, 2003-2006
Eric de Sturler
Leslie Fox Prize, Institute of Mathematics and Its Applications, 1997
Invited Plenary Lecture, 15th Householder Symposium in Numerical Linear Algebra, 2002
Editor, SIAM Journal on Numerical Analysis, 2003-2006
Program Director, SIAM Activity Group on Supercomputing, 2003-2006
Editor, International Journal of Computational Science and Engineering, 2004
Co-chair, SIAM Conference on Computational Science and Engineering, 2005
(Invited) Plenary lecture, 16th Householder Symposium in Numerical Linear Algebra, 2005

Josep Torrellas
Research Initiation Award, National Science Foundation (NSF), 1993-1996
Young Investigator Award, NSF, 1994-1999
C. W. Gear Outstanding Junior Faculty Award, University of Illinois Department of Computer Science, 1997
IBM Partnership Award, 1997-1999
Xerox Award for Outstanding Faculty Research, University of Illinois College of Engineering, 1997, 2000
Vice-Chairman, Institute of Electrical and Electronics Engineers (IEEE) Technical Committee on Computer Architecture (TCCA), 2000
Editorial Board, IEEE Computer Architecture Letters, 2001-
Willett Faculty Scholar, University of Illinois Department of Computer Science, 2002-2005
Associate Editor, ACM Transactions on Architecture and Code Optimization, 2003-
Fellow, IEEE, 2004

Mehesh Viswanathan
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2005

Marianne S. Winslett
Presidential Young Investigator Award, National Science Foundation, 1989
Xerox Award for Junior Faculty Research, University of Illinois College of Engineering, 1990
Associate Editor (Funding News and On-Line Services), ACM SIGMOD Record, 1991-
University Scholar, University of Illinois, 1992
Associate Editor, Journal of Intelligent Information Systems, 1992-
Associate Editor, ACM Transactions on Database Systems, 1994-

Associate Editor, IEEE Transactions on Knowledge and Data Management, 1994-1998
Xerox Award for Senior Faculty Research, University of Illinois College of Engineering, 1997
Stanley H. Pierce Award, University of Illinois College of Engineering, 1999
Board Accredited Editor, ACM SIGMOD Digital Review, 1999-
Associate Editor (Distinguished Profiles in Databases), ACM SIGMOD Record, 2001-
Faculty Fellows Program, National Center for Supercomputing Applications, 2004-2005

Yizhou Yu
Microsoft Fellowship, 1998
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2002

Cheng Xiang Zhai
Presidential Early Career Award for Scientists and Engineers (PECASE), National Science Foundation, 2004

Yuanyuan Zhou
Dupont Fellowship, University of Virginia, 1992
IBM Shared University Research (SUR) Award, 2003
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2004
IBM Faculty Award, 2004
W. Anita Borg Early Career Award, Computing Research Association, 2005

Craig Zilles
National Science Foundation Fellowship, 1996
Intel Graduate Fellowship, 2000
Wisconsin Distinguished Graduate Research Fellowship, 2001-2002
Faculty Early Career Development Program (CAREER) Award, National Science Foundation, 2004