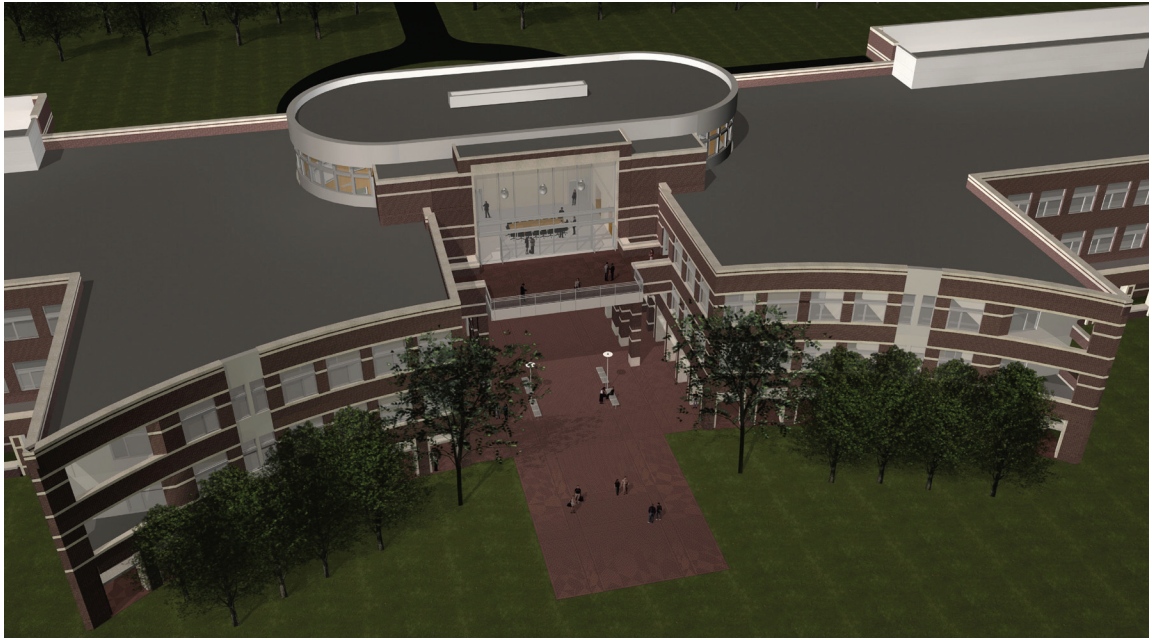# COMPUTER SCIENCE RESEARCH BROCHURE


SPRING 2004

An architectural rendering of the new Computer Science and Electrical and Computer Engineering building, to be completed in the fall of 2005

Welcome to the Computer Science Department at North Carolina State University. The Spring 2004 Research Brochure highlights some of our recent progress in faculty hiring, sponsored research, the graduate program, and student and faculty achievements.

Research Faculty. The Computer Science Department has grown to include 40 tenure and tenure-track research faculty. We welcomed six new faculty members this year: Dr. Vincent Freeh from the University of Notre Dame, Dr. Steffen Heber from the University of Heidelberg, Germany, Dr. Jaewoo Kang from the University of Wisconsin-Madison, and Dr. Xiaosong Ma, Dr. Jun Xu, and Dr. Ting Yu from the University of Illinois-Urbana Champaign. We hope to recruit at least two additional faculty members for 2004, with an emphasis on formal methods and software engineering.
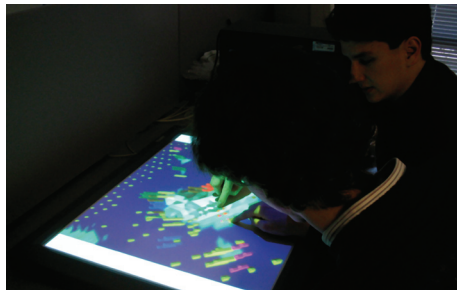
Students collaborate on a Mitsubishi Diamond-touch, a touchscreen display capable of tracking input and interaction for up to eight participants

Dr. Wushow Chou retired in May 2003, following 27 years of research and service. He remains affiliated with the department as a Professor Emeritus. On a sadder note, Dr. K. C. Tai passed away in October, 2002. A memorial fund has been established in Dr. Tai's honor. Interested parties can contact the Computer Science Department for more information.

Sponsored Research. Sponsored research grants within the department currently total $15 million, an increase of $3 million from 2002. Granting agencies include traditional venues like the National Science Foundation, DARPA, the Army Research Office, NASA, and the Department of Energy, as well as local industry and research centers. We expect to achieve an intermediate goal of $20 million within the next three years.

Graduate Program. The department's graduate program currently includes 93 Ph.D and 247 M.S, M.S in Computer Networking, and M.CS students. We received 723 applications for admission to the graduate program in 2003, with 112 new students accepting our offer to join the department.

Student and Faculty Awards. Students and faculty achieved a number of significant awards during the past academic year. The undergraduate team of Nathan Green, Jeremy Maness, Buck Webb, and J. R. Wilson placed third in the worldwide IEEE Computer Society International Design Competition. Our students were the on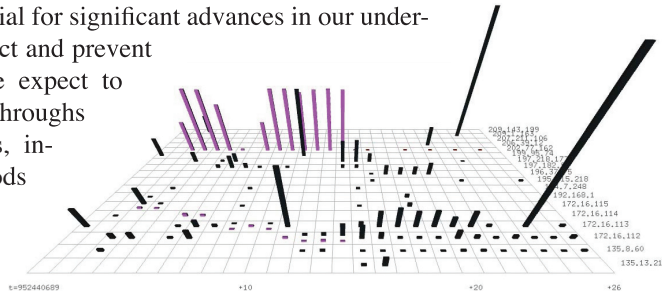ly U.S. team to reach the world finals. Dr. Frank Mueller received a National Science Foundation CAREER Award, NSF's most prestigious award for new faculty members. Dr. George Rouskas received the North Carolina State University Alumni Outstanding Research Award for 2003, one of the university's highest research honors. Dr. Donald Bitzer received an Emmy Award from the National Academy of Television Arts and Sciences for co-inventing plasma display technology in the early 1960s. This technology is used in the plasma flat-panels now being sold as large format, high-definition televisions.

Dr. Donald Bitzer (left) displays his Emmy Award with University Chancellor Dr. Maryanne Fox and Dean of Engineering Dr. Nino Masnari

Dr. Alan L. Tharp
Professor and Department Head

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Research Profiles

ITR: Integrating Intrusion Detection with Intelligent Visualization and Interaction Strategies, Dr. Peng Ning, Dr. Christopher G. Healey, Dr. Robert St. Amant. NSF ($415,099, 2002-2005)

The overall objective of this project is to develop new intrusion detection techniques by integrating intrusion detection with visualization and intelligent interaction strategies. Research in this project offers the potential for significant advances in our understanding of how to detect and prevent network intrusions. We expect to make important breakthroughs on a number of fronts, including (1) new methods to automatically identify sophisticated intrusion attempts, (2) new techniques that harness a human observer's unique analysis talents to augment and extend an auto-

An example visualization of tcpdump traffic during an IPSweep *attack: time along horizontal axis, source IP subnet along vertical axis, color for protocol (TCP, UDP, or ICMP), and height for packet count*

mated IDS's ability to respond to new or unexpected attacks, and (3) new approaches that allow automated detection algorithms to continually improve by learning from their users. Moreover, the multidisciplinary approach we are using offers the significant benefit of making the problem-solving processes of intrusion detection accessible and available to non-experts.

ITWF: Collaboration Through Agile Software Development Practices: A Means for Improvement in Quality and Retention of IT Workers, Dr. Laurie Williams, Dr. Mladen A. Vouk, Dr. Sarah B. Berenson, Dr. Winser E. Alexander. NSF ($687,859, 2003-2006)

North Carolina State University, North Carolina A&T University and Meredith College have entered into a three-year study of the collaborative aspects of agile software development methodologies. The project's objective is to perform extensive, longitudinal experimentation in advanced undergraduate software engineering college classes at the three institutions to examine student success and retention in the educational and training pipelines when the classes utilize an agile software development model. The project will also involve the development of agile software development materials for software engineering classes.

CAREER: Exploiting Binary Rewriting to Analyze and Alleviate Memory Bottlenecks for Scientific Applications, Dr. Frank Mueller. NSF ($400,000, 2003-2008)

Today, high-performance clusters of shared-memory multiprocessors (SMPs) are employed to cope with large data sets for scientific applications. On these SMPs, hybrid programming models combing message passing and shared memory are often less efficient than pure message passing although the former fits SMP architectures more closely. The objective of this work is to determine the sources of inefficiencies in utilizing memory hierarchies of SMPs and to optimize memory behavior. The novelty lies in the reliance on dynamic binary rewriting, i.e., performance analysis and tuning are performed on the application while it executes. The technical challenges are to (1) develop a framework

for dynamic binary rewriting, (2) determine coherence traffic resulting in misses for non-deterministic orders of executions in the presence of parallelism, (3) identify memory bottlenecks, (4) determine data dependencies between data references for hotspots for binaries, (5) study the potential for memory-improving program transformations on the executing binary and 6) evaluate the merits of optimizations for large-scale benchmarks among others. The key intellectual merit is in providing additional, dynamic optimizations for long-running applications. The broader impact of this work lies in its contribution to counter the increasing gap between processor and main memory speeds by fully exploiting software optimizations.

CAREER: Plan-Based Integration of Control and Coherence in Intelligent Exploratory Environments, Dr. R. Michael Young. NSF ($465,695, 2001-2006)

Exploratory environments – virtual worlds in which users interact with a simulation of a physical or abstract space to form, pursue and achieve their goals – have shown great success in applications ranging from education and training to entertainment to social interaction. A principal limitation of these systems, however, is that users' activities within them are typically greatly over- or under-constrained. To address this problem, the PI will develop new plan-based models for the structure of user interactions within exploratory environments. Planning techniques will be used to create novel activity within the environment that encompasses both the system-controlled characters, the environment and the actions of the user. The PI will build on his prior work in plan generation and plan-related communication to develop an architecture for creating, monitoring and controlling interaction in intelligent exploratory environments. This architecture will integrate: planning algorithms that create plans for interaction

A virtual walkthrough of the Monterey Bay Aquarium, modeled using the Unreal Tournament game engine

in virtual worlds whose structure is readily understandable by users; discourse generation algorithms that effectively communicate the currently unfolding plan-based activity; and execution monitoring algorithms that mediate the execution of actions between the user interface and the virtual world, intervening in appropriate ways when actions that the user intends to perform deviate from the system's current plan structure. If successful, the work will greatly increase our ability to produce engaging, novel and effective virtual environments in which users' domain and task-oriented learning are enhanced across a range of applications and contexts.

Senior Faculty Profiles

Dr. Carla D. Savage
Professor of Computer Science

Dr. Carla D. Savage did her undergraduate work Mathematics at Case Western Reserve University, graduating with a B.S. in Mathematics in 1973. She received her Ph.D. in Mathematics in 1977 from the University of Illinois at Urbana-Champaign, with one of the first dissertations on parallel graph algorithms. She spent a year as an IBM postdoctoral fellow in the Computer Science Department at the University of Texas, Austin before taking a faculty position in the Department of Computer Science at North Carolina State University in 1978.

Dr. Savage worked in the area of parallel algorithms and architectures until 1988 when, inspired by talks of Donald Knuth and Herbert Wilf at the SIAM Discrete Math Conference, she became interested in combinatorial Gray codes. Since then, her research has focused on the structure of combinatorial objects and various schemes for listing and counting them, with particular emphasis on Gray code variants and their relationship to problems in graph theory, group theory, and discrete mathematics. Her survey of the area was published by SIAM Review in 1997. She has given many talks at conferences and universities and published papers on topics such as parallel algorithms, systolic arrays, Gray codes, Hamilton cycles, generating and enumerating integer partitions, graph theory, Cayley graphs, the notorious middle two levels problem (mentioned in Peter Winkler's new book, Mathematical Puzzles), and Venn diagrams. Her work has been supported by grants from the National Science Foundation and the National Security Agency.

Recently, in collaboration with an NCSU student, Chip Killian, and Jerrold Griggs from the University of South Carolina, Dr. Savage settled an open question by showing that it is possible to draw symmetric Venn diagrams for *n* sets whenever *n* is prime. Current research interests are in the areas of algorithms, discrete mathematics, combinatorics, and graph theory, in particular, algorithmic problems in optical networks and computational aspects of combinatorics.

Dr. Harry G. Perros
Professor of Computer Science
(on-board his boat Aegean)

Dr. Harry G. Perros is a Professor of Computer Science, an Alumni Distinguished Graduate Professor, and the Program Coordinator of the Master of Science degree in Computer Networks at North Carolina State University. He received the B.Sc. degree in Mathematics in 1970 from Athens University, Greece, the M.Sc. degree in Operational Research with Computing from Leeds University, England, in 1971, and the Ph.D. degree in Operations Research from Trinity College Dublin, Ireland, in 1975. He has held visiting faculty positions at INRIA, Rocquencourt, France (1979), NORTEL, Research Triangle Park, North Carolina (1988-89 and 1995-96) and University of Paris, France (1995-96, 2000, and 2002).

Dr. Perros has published extensively in the area of performance modelling of computer and communication systems, and has organized several national and international conferences. He has also published two print books: *Queueing Networks with Blocking: Exact and Approximate Solutions*, Oxford Press 1994, *An Introduction to ATM Networks*, Wiley 2001, and an e-book *Computer Simulation Techniques – The Definitive Introduction*, 2002. He is currently completing a textbook entitled *Connection-Oriented Networks*, scheduled to be published in the Spring of 2005 by Wiley.

In 1995, Dr. Perros founded the IFIP Working Group 6.3 on the *Performance of Communication Systems*, and was the chairman from 1995 to 2002. From 2004, he is the chairman of the IFIP Working Group 6.10 on *Optical Networks*. He is also a member of IFIP Working Groups 6.2 and 7.3, an IEEE Senior Member, and an associate Editor for the *Performance Evaluation* Journal and the *Telecommunications Systems* Journal. His current research interests are in the areas of optical networks.

Annie I. Antón, Associate Professor
PhD, Georgia Institute of Technology, 1997
Software engineering, requirements engineering, information privacy and security

Dennis R. Bahler, Associate Professor
PhD, University of Virginia, 1987
Artificial intelligence, machine learning, hybrid neural-symbolic computing

Donald Bitzer
Distinguished University Research Professor
PhD, University of Illinois, 1960
High-speed networks, satellite/land communications, bioinformatics, computer-based education

Franc Brglez, Research Professor
PhD, University of Colorado, 1970
Distributed/collaborative workflows, databases, graph-based algorithms, signal processing

Rada Y. Chirkova, Assistant Professor
PhD, Stanford University, 2002
Databases, computational logic

Edward W. Davis, Professor
PhD, University of Illinois, 1972
Computer architecture, parallel processing

Jon Doyle
SAS Professor of Computer Science
PhD, Massachusetts Institute of Technology, 1980
Artificial intelligence, mathematical foundations of reasoning, rationality, knowledge discovery

Rudra Dutta, Assistant Professor
PhD, North Carolina State University, 2001
Traffic grooming, fault tolerance, optical networks, ad-hoc wireless networking

Robert Fornaro, Professor
PhD, Pennsylvania State University, 1969
Concurrent programming in computer graphics, robotics, signal processing, operating systems

Vincent Freeh, Assistant Professor
PhD, University of Arizona, 1996
Operating systems, compilers, programming languages, distributed and parallel computing

Robert E. Funderlic, Professor
PhD, University of Tennessee, 1970
Scientific and parallel computing, numerical methods

Edward Gehringer, Associate Professor
PhD, Purdue University, 1979
Object-oriented software, parallel processing

Khaled Harfoush, Assistant Professor
PhD, Boston University, 2002
End-to-end network diagnosis, topologies, routing protocols, ad-hoc and peer-to-peer networks

Christopher G. Healey, Associate Professor
PhD, University of British Columbia, Canada, 1996
Visualization, computer graphics, perception

Steffen Heber, Assistant Professor
PhD, University of Heidleberg, Germany, 2001
Computational biology, bioinformatics

Thomas L. Honeycutt, Associate Professor
PhD, North Carolina State University, 1969
MIS, modeling and simulation, computer literacy

S. Purushothaman Iyer, Professor
PhD, University of Utah, 1986
Formal methods for distributed and embedded systems, programming languages, concurrency theory

Jaewoo Kang, Assistant Professor
PhD, University of Wisconsin, 2003
Data mining, query optimization, data integration

James C. Lester, Associate Professor
PhD, University of Texas, 1994
Artificial intelligence, multimedia, knowledge-based learning environments, computational linguistics

Xiaosong Ma, Assistant Professor
PhD, University of Illinois, 2003
High performance computing, parallel IO, storage systems, scientific data management

David F. McAllister, Professor
PhD, UNC Chapel Hill, 1972
Computer graphics, speech processing

NEW FACULTY PROFILES

Dr. Vincent Freeh

Dr. Vincent Freeh joined the department in January 2003. He received a B.Sc, M.Sc, and Ph.D from the University of Arizona in 1983, 1989, and 1996. Dr. Freeh's research interests include operating systems, compilers, and programming languages, with a particular interest in their relationship to distributed and parallel computing. Dr. Freeh's recent research also involves power-aware computing.
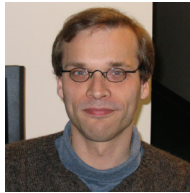

Dr. Steffen Heber

Dr. Steffen Heber joined the department in August 2003. He received a Diploma in mathematics from the University of Heidelberg, Germany in 1995, a Staatsexamen in mathematics and biology in 1998, and a Ph.D in bioinformatics from the University of Heidelberg, Germany in 2001. Dr. Heber's research interests include computational biology, bioinformatics, and combinatorial and statistical problems in biology like gene order comparison, physical mapping, EST assembly, and alternative splicing.


Dr. Jaewoo Kang

Dr. Jaewoo Kang joined the department in August 2003. He received a B.Sc from Korea University, Seoul in 1994, an M.Sc from the University of Colorado at Boulder in 1996, and a Ph.D from the University of Wisconsin-Madison in 2003. Dr. Kang's research interests focus on building large-scale internet information system that can answer complex queries over billions of heterogeneous internet data sources. This includes research in data integration, model management, query optimization, semi-structured data management, text mining, and statistical natural language processing.
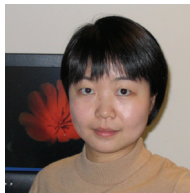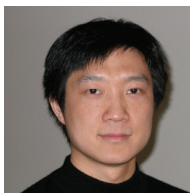

Dr. Xiaosong Ma

Dr. Xiaosong Ma joined the department in August 2003. She received a B.Sc from Peking University, China in 1997 and a Ph.D from the University of Illinois-Urbana Champaign in 2003. Dr. Ma's research interests include high performance computing, parallel I/O, storage systems, and scientific data management.
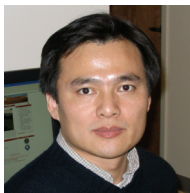
Dr. Jun Xu

Dr. Jun Xu joined the department in August 2003. He received a B.Sc from Peking University, China in 1996, an M.Sc from the University of Pittsburgh in 1998, and a Ph.D from the University of Illinois-Urbana Champaign in 2003. Dr. Xu's research interests include computer system security and reliability, operating system and compiler support for defeating security attacks, fault injection-based system security and reliability evaluation, distributed system for security and reliability, and measurement-based system security and reliability analysis.

Dr. Ting Yu

Dr. Ting Yu joined the department in August 2003. He received a B.Sc from Peking University, China in 1997, an M.Sc from the University of Minnesota in 1998, and a Ph.D from the University of Illinois-Urbana Champaign in 2003. Dr. Yu's research interests include trust management and privacy preservation in open systems, and database management systems.

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