New Research Offers Security For Virtualization, Cloud Computing

Researchers from NC State have developed new techniques and software that may be the key to resolving data privacy and security concerns, therefore boosting public confidence in virtualization and cloud computing and adoption of the new technology.

"What we've done represents a significant advance in security for cloud computing and other virtualization applications," says Dr. Xuxian Jiang, an assistant professor of computer science and co-author of the study who recently won a prestigious NSF CAREER Award. "Anyone interested in the virtualization sector will be very interested in our work."

One of the major threats to virtualization – and cloud computing – is malicious software that enables computer viruses or other malware that have compromised one customer's system to spread to the underlying hypervisor and, ultimately, to the systems of other customers.

But Jiang and his Ph.D. student Zhi Wang have now developed software, called HyperSafe, that leverages existing hardware features to secure hypervisors against such attacks. "We can guarantee the integrity of the underlying hypervisor by protecting it from being compromised by any malware downloaded by an individual user," Jiang says. "By doing so, we can ensure the hypervisor's isolation."

2009–2010

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www.csc.ncsu.edu

Research Highlights

The NC State University Department of Computer Science is one of the oldest and largest computer science departments in the nation, and research is central to the success of the department. The department's research productivity continues to grow with annual research expenditures in the range of $9 to $10 million, and we now have an all time high of almost $36 million in active research grants. This ranks us well within the top 20 for sponsored research funding among computer science departments in colleges of engineering. Faculty research interests range from theory and algorithms, bioinformatics, high-performance and power-aware systems, to advanced analytics research, to artificial intelligence, serious games, graphics and visualization, networks, security, software engineering, and computer-based education. Please see the list of select representative research projects that appear on page three of this newsletter.

In the 2009-2010 academic year, faculty as a group published 46 refereed journal papers, 176 refereed conference and workshop papers, five books and nine book chapters and other edited works. They also produced over 80 other publications, tutorials, editorials, news articles, or media appearances. Over the academic year, faculty gave over 200 professional talks related to their research and educational activities. Seventeen of our faculty serve as editors, and on editorial boards of leading professional publications (33 functions), and as members and officers in the most prestigious professional societies and organizations in their areas of specialty.

Undergraduate enrollment increased in the fall of 2009 to 630 students, and the percentage of females increased slightly, which can be attributed in part to an increased focus on outreach efforts. In 2009-2010, we awarded 102 BS degrees, including the first in the Computer Science Game Development Concentration.

Research Faculty

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

Kemafor Anyanwu, Assistant Professor
PhD, University of Georgia, 2007
Semantic computing: semantic Web, databases, data
mining, information retrieval, services computing

Dennis R. Bahler, Associate Professor
PhD, University of Virginia, 1987
AI: constraint processing, machine learning, hybrid
neural-symbolic computing

Donald Bitzer, Distinguished University Research
Professor, PhD, University of Illinois, 1960
Convolutional codes, signal processing for biological
systems, computer-based education

Franc Brglez, Research Professor
PhD, University of Colorado, 1970
Distributed and collaborative workflows, databases,
and groupware for the Internet

Rada Y. Chirkova, Associate Professor
PhD, Stanford University, 2002
Database performance, query-processing efficiency
by designing and materializing views

Jon Doyle, SAS Professor of Computer Science
PhD, Massachusetts Institute of Technology, 1980
Artificial Intelligence, mathematical and philosophical
foundations, rational agents, decision making

Rudra Dutta, Associate Professor
PhD, North Carolina State University, 2001
Network design: optical, wireless sensor and mesh
networks; future Internet design

Robert Fornaro, Professor
PhD, The Pennsylvania State University, 1969
Networks and applications of real-time embedded
computer systems, wireless sensor systems

Vincent Freeh, Associate Professor
PhD, University of Arizona, 1996
Operating sys., compilers, programming languages—
distributed & parallel computing, embedded systems

Edward Gehringer, Associate Professor
PhD, Purdue University, 1979
Hardware support for memory management, object-
oriented software systems—performance studies

Xiaohui (Helen) Gu, Assistant Professor
PhD, University of Illinois, 2004
Distributed systems, operating systems, computer
networks

Khaled Harfoush, Associate Professor
PhD, Boston University, 2002
Computer networking, Internet measurements, peer-
to-peer systems, routing protocols

Christopher G. Healey, Associate Professor
PhD, University of British Columbia, Canada, 1996
Visualization & computer graphics: methods for rapidly,
accurately, effectively visualizing lg. complex datasets

Steffen Heber, Associate Professor
PhD, Universität Heidleberg, Germany, 2001
Algorithms to compare and analyze gene order permu-
tations, animation dev. for bioinformatics education

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

Xuxian Jiang, Assistant Professor
PhD, Purdue University, 2006
Virtual machines and security

Highlights (cont.)

Demand for our undergraduates continues to be very strong, and the average annual starting salary for our undergraduates increased this year to over $57,000. The top employers for this year's students are Fidelity Investments, IBM, NetApp, Cisco and SAS Institute.

Our graduate program continues to grow with an overall enrollment of over 520 students. Applications for admission to the graduate program for fall 2010 are up 18% over last year. Applications for the PhD program alone are up 25% over fall 2008. In 2009-2010 we awarded 126 masters (25 with thesis), and 26 PhD degrees, a rate in line with that in the top 30 computer science departments in the nation.

In 2009-2010 our faculty received a number of prestigious awards and honors: Dr. Harry Perros became the department's 5th IEEE Fellow; Dr. Xuxian Jiang became the department's 20th NSF CAREER Award winner; Dr. Annie Antón was named a Distinguished Scientist by the Association for Computing Machinery (ACM); Dr. Tao Xie was named a Sigma Xi Outstanding Young Researcher, and was appointed to the ACM History Committee as the ACM SIGSOFT History Liaison; Dr. Donald Bitzer, Distinguished University Professor at NC State, was one of the inaugural inductees into the UIUC Engineering Hall of Fame, and he was honored as inventor of PLATO, and co-inventing the flat-panel gas plasma display, at the Computer History Museum (Silicon valley, CA); Dr. R. Michael Young was named a 2010 GlaxoSmithKline (GSK) Faculty Fellow, and was named Research Director for 2009 for the Triangle Game Initiative; Ms. Margaret Heil, lecturer and associate director for the Computer Science Senior Design Center, was named an NC State Outstanding Teacher for 2009-2010; Dr. George Rouskas was named an IEEE Communications Society Distinguished Lecturer for 2010 and 2011; Nine faculty members: Drs. Kemafor Anyanwu, Rada Chirkova, Patrick Dreher, Helen Gu, Christopher Healey, Xiaosong Ma, Mladen Vouk, Laurie Williams, and Tao Xie, received 2009 IBM Faculty Awards totaling $267,000; Drs. Edward Gehringer and Xiaohui (Helen) Gu received Google Research Awards totaling over $85,500; and Dr. Nagiza Samatova co-mentored a team of high school students (Yekaterina "Katie" Shpanskaya and Neil Shah) who won second place in the Siemens Competition in Math, Science and Technology.

Our students received numerous awards as well: graduate students Zhenhuan Gong and Ben Smith were awarded prestigious 2010 IBM Ph.D. Fellowship Awards; second year doctoral student Jennifer Robison was recognized with the Best Student Paper Award at the International Conference on Affective Computing & Intelligent Interaction (ACII-2009); Andy Meneely, a doctoral candidate, won first place in the poster and presentation portion of the ACM Student Research Competition at the 41st ACM Technical Symposium on Computer Science Education (SIGCSE 2010); a team made up of Kelsey Hawkins, Drew Boyuka and Stuart Robinson won first place at the UNC site in the ACM "Battle of the Brains" competition; and senior Brittany Strachan was named to the ACC Women's Basketball All-Academic Team.

The department experienced several faculty additions during the year. We welcomed Drs. Emerson Murphy-Hill, and David Roberts, assistant professors, in August, 2010, and Dr. Michael Rappa, Distinguished University Professor in March, 2010. In August 2009, we welcomed Dr. Sarah Heckman, a three-time graduate of NC State, and the department's first teaching assistant professor. We also welcomed Ms. Suzanne Balik, lecturer, in August, 2009, and Ms. ToniAnn Marini, undergraduate lab coordinator and lecturer, in January, 2010. We now have about 40 tenure/tenure-track faculty, 10 lecturers and adjuncts, and about 31 research, development, information technology and administrative staff.

I would like to take this opportunity to thank all our students, faculty and staff for making 2009-2010 a success; and our alumni, corporate friends and partners for their continued support.

Mladen Vouk
Professor and Department Head

Selected Research Projects

Complete list with abstracts is at http://www.csc.ncsu.edu/research/

TC: Large: Collaborative Research: Trustworthy Virtual Cloud Computing, **Peng Ning, Xuxian Jiang, Mladen Vouk. $1,523,685 by National Science Foundation**.

IC-CRIME: Interdisciplinary Cyber-Enabled Crime Reconstruction Through Innovative Methodology and Engagement, **David Hinks (Lead-Textiles)**, **R. Michael Young, Timothy Buie. $1,400,000 by National Science Foundation.**

High-Performance Data Analytics with Demonstrations to DOE-Mission Applications, **Nagiza Samatova. $1,120,002 by Oak Ridge National Laboratories & UT-Battelle, LLC**.

Computer-aided Human Centric Cyber Situation Awareness, **Peng Ning, R. Michael Young. $979,463 by Pennsylvania State University**.

NetSE: Large: Collaborative Research: Platys: From Position to Place in Next Generation Networks, **Injong Rhee, Munindar Singh. $706,167 by National Science Foundation**.

Quality of Information-Aware Networks for Tactical Applications (QUANTA), **Munindar Singh. $669,029 by Penn State University (Army Research Laboratory**.

II: NEW: ARC: A Root Cluster for Systems Research into Scalable Computing, **Frank Mueller, Vincent Freeh, Xiaohui (Helen) Gu, Xuxian Jiang, Xiaosong Ma. $549,999 by National Science Foundation**.

Collaborative Research: Automatic Extraction of Parallel I/O Benchmarks From HEC Applications, **Xiaosong Ma, Frank Mueller. $499,999 by National Science Foundation**.

HCC: Small: Plan-Based Models of Narrative Structure For Virtual Environments, **R. Michael Young. $497,860 by National Science Foundation**.

GENI IMF: Integrated Measurement Framework and Tools for Cross Layer Experimentation, **Rudra Dutta, George Rouskas. $479,259 by Global Environment for Network Innovations (National Science Foundation)**.

III:Small: MOSAIC - Semantic Querying Techniques for Supporting Problem Solving Tasks on the Structured Web, **Kemafor Anyanwu-Ogan. $477,713 by National Science Foundation**.

HCC-Small:Modeling Student Affect in Game-Based Learning Environments, **James Lester. $464,422 by the National Science Foundation**.

CAREER: Towards Exterminating Stealthy Rootkits – A Systematic Immunization Approach, **Xuxian Jiang. $424,166 by the National Science Foundation**.

CSR: Small: Online System Anomaly Prediction and Diagnosis for Large-Scale Hosting Infrastructures, **Xiaohui (Helen) Gu. $405,000 by National Science Foundation**.

Collaborative Research: CPATH II: Incorporating Communication Outcomes into the Computer Science Curriculum, **Mladen Vouk, Michael Carter (co-PI) Grad. $353,881 by National Science Foundation**.

CSR:Small:Collaborative Research: Hybrid Opportunistic Computing For Green Clouds, **Xiaosong Ma, Xiaohui (Helen) Gu (co-PI). $320,000 by National Science Foundation**.

Role of Alternative Splicing in Arabidopsis Immune Response, **Steffen Heber, Paola Veronese (CALS). $299,420 by National Science Foundation**.

Use of Affordable Open Source Systems by Rural/Small-Practice Health Professionals, **Laurie Williams, Mladen Vouk. $298,712 by Agency for Healthcare Research and Quality – NIH**.

SoD: Collaborative Research: Transparency and Legal Compliance in Software Systems, **Annie Antón. $270,407 by the National Science Foundation**.

SHF:Small:Collaborative Research: Constraint-Based Generation of Database States for Testing Database Applications, **Tao Xie. $249,880 by National Science Foundation**.

Production and Assessment of Student-authored Wiki Textbooks, **Edward Gehringer. $110,518 by National Science Foundation**.

Network Visualization and Optimization through Accurate Traffic Characterization, **Harry Perros (co-PI), Mihail Devetsikiotis. $38,400 by Center for Advanced Computing & Communication (CACC)**.

Research Faculty (cont.)

James C. Lester, Professor
PhD, University of Texas, 1994
Artificial intelligence, intelligent user interfaces, intelligent tutoring systems, computational linguistics

Xiaosong Ma, Associate Professor (joint appointment with ORNL), PhD, University of Illinois, 2003
High performance computing, parallel I/O, storage systems, scientific data management

Brad Mott, Research Scientist
PhD, NC State University, 2006
Artificial intelligence, game-based learning environments, computational models of interactive narrative

Frank Mueller, Professor
PhD, Florida State University, 1994
Compilers and code optimization, concurrent and distributed, real-time and embedded systems

Emerson Murphy-Hill, Assistant Professor
PhD, Portland State University, 2009
Software engineering, esp. the intersection of human-computer interaction and software engineering.

Peng Ning, Professor
PhD, George Mason University, 2001
Computer and network security: new techniques for building trustworthy systems and wireless security

Harry Perros, Alumni Distinguished Graduate Professor, PhD, Trinity College, Ireland, 1975
Performance analysis of optical networks, performance monitoring of grids, queueing networks

Michael Rappa, Distinguished University Professor, PhD, Univ. of Minnesota, 1987
Analytics, e-commerce, open courseware, open educational content, technology management

Douglas S. Reeves, Professor
PhD, The Pennsylvania State University, 1987
Internet protocols, multimedia computing and networking, information security, computer org.

Injong Rhee, Professor
PhD, UNC Chapel Hill, 1994
Computer/wireless/sensor networks, multimedia networking, distributed systems, operating systems

David Roberts, Assistant Professor
PhD, College of Computing, Georgia Tech, 2010
Machine learning and artifical intelligence and their application to interactive technological experiences

Robert D. Rodman, Professor
PhD, University of California, Los Angeles, 1973
Computational forensic linguistics, applying AI to error recovery in speech recognition

George N. Rouskas, Professor
PhD, Georgia Institute of Technology, 1994
Network architectures and protocols, optical networks, grid computing, scheduling

Nagiza Samatova, Associate Professor (joint apt. w/ORNL), PhD, Russian Acad. of Sci. (CCAS), 1993
Graph theory & algorithms, bioinformatics, systems biology, data management, data integration

Carla D. Savage, Professor
PhD, University of Illinois, 1977
Combinatorics, combinatorial algorithms, network algorithms, graph theory, discrete mathematics

Munindar P. Singh, Professor
PhD, University of Texas, 1993
Multiagent systems, intelligent agents, service oriented computing, agent languages and protocols

Robert St. Amant, Associate Professor
PhD, University of Massachusetts, Amherst, 1996
Human-computer interaction, artificial intelligence, intelligent user interfaces, statistical expert systems

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Senior Faculty Profiles

Dr. Annie Antón, professor of Computer Science and recognized expert in privacy policy, received her PhD, MS and BS from the College of Computing at the Georgia Institute of Technology. Her research focuses on methods and tools to support the specification of complete, correct behavior of software systems used in environments that pose risks of loss as a consequence of failures and misuse, including web-based and e-commerce systems in which the security of personal and private information is particularly vulnerable. Antón is the founder and director of ThePrivacyPlace.org, co-founder and co-director of the NC State's E-Commerce Studio, and co-founder of the Symposium on Requirements Engineering for Information Security. In 2002, she coordinated NC State's successful application for a National Security Agency Center of Academic Excellence designation in Information Assurance Education. She is an associate editor for IEEE Transactions on Software Engineering, the cognitive issues subject area editor for the Requirements Engineering Journal, and a member of the International Board of Referees for Computers & Security. She serves on several boards including DHS Data Privacy and Integrity Advisory Committee, an Intel Advisory Board, CRA Board of Directors, Distinguished External Advisory Board for the TRUST Research Center, Electronic Privacy Information Center Advisory Board, Future of Privacy Forum Advisory Board, IDA/DARPA Information Science and Technology (ISAT) study group, US ACM Public Policy Council Executive Committee, and Georgia Tech Alumni Association Board of Trustees.

Dr. Robert D. Rodman, professor of Computer Science and respected authority on computational linguistics, received his PhD in linguistics, and his MA and BA in mathematics, from UCLA. His research interests in computational linguistics includes voice recognition, lip synchronization for visual speech synthesis, emotion recognition, speaker verification and speaker identification with emphasis on forensic applications. He is coauthor of the best selling introductory textbook *An Introduction to Language*, presently in its ninth edition and having sold more than one million copies worldwide. While at NC State, Dr. Rodman has published two additional books, edited three books and produced about 70 research articles for journals and conference proceedings. In the course of his research he has collaborated with scholars from China, Finland, Greece, Korea, Iran, Singapore and the UK. Dr. Rodman is a founding member of the North Carolina Japan Center, has an extensive consulting practice, concentrating on forensic linguistics, and has testified as an expert witness on numerous occasions. He is a member of the Academy of American Forensic Sciences and the Forensic Expert Witness Association, and serves as an associate editor of the journal *Speech Technology*. Dr. Rodman received a Teleclass Recognition Award from the North Carolina Microelectronics Center for his contributions to distance education, and was honored by the Oxford English Dictionary for coining a new term *Montague grammar* in one of his research publications. Dr. Rodman writes radio scripts for short, 'user friendly' science programs, and has published two mystery novels that employ some of the scientific knowledge he has accumulated in their plots and characters.

New Faculty Profiles
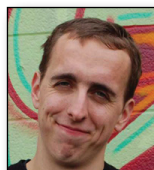
Dr. Emerson Murphy-Hill joined the faculty as an assistant professor in August, 2010. He received his BS in Computer Science from Evergreen State College in 2004, and completed his PhD at Portland State Univ. in 2009. He was previously a postdoc research fellow in the Software Practices Lab at the University of British Columbia. His area of expertise is software engineering, especially the intersection of human-computer interaction and software engineering.

Dr. Michael Rappa , a Distinguished University Professor, joined the department in March, 2010. Dr. Rappa received his PhD from the University of Minnesota in 1987. He is founder and director of the Institute for Advanced Analytics (IAA) at NC State. In partnership with SAS Institute, he led the development of NC State's Master of Science in Analytics, the first such degree program of its kind in the nation.

Dr. David Roberts joined the faculty as an assistant professor in August, 2010. Dr. Roberts received his BA from Colgate University in 2003, and completed his PhD at the School of Interactive Computing at Georgia Tech in 2010. His current research interests are in the area of machine learning and artificial intelligence and their applications to the design of interactive technological experiences such as computer games, interactive dramas, or training scenarios.