

Computer Science

Research Projects 2007-08

SoD: Collaborative Research: Transparency and Legal Compliance in Software Systems

Annie Antón
the National Science Foundation
 \$270,407
 08/1/2007- 07/31/2009

Healthcare information systems are becoming ubiquitous and thus increasingly subject to attack, misuse and abuse. Mechanisms are needed to help analysts disambiguate regulations so that they may be clearly specified as software requirements. In addition, regulations are increasingly requiring organizations to comply with the law and account for their actions. We propose a requirements management framework that enables executives, business managers, software developers and auditors to distribute legal obligations across business units and/or personnel with different roles and technical capabilities.

ITR: Encoding Rights, Permissions, and Obligations: Privacy Policy Specification and Compliance

Annie Antón; Julie Earp; Lynda Aiman-Smith; David Baumer
the National Science Foundation
 \$932,000
 09/15/2003- 02/28/2010

This research focuses on how society uses, values, and protects citizens' personal information. From the perspective of system design, software engineers need methods and tools to enable them to design systems that reflect those values and protect personal information, accordingly. This research examines how privacy considerations and value systems influence the design, deployment and consequences of IT. The goal is to develop concepts, tools and techniques that help IT professionals and policy makers bring policies and system requirements into better alignment. An action-oriented set of conceptual tools, including guidelines and privacy-relevant policy templates will be constructed and validated.

Collaborative Research: A Comprehensive Policy-Driven Framework for Online Privacy Protection: Integrating IT, Human, Legal and Economic Perspectives

Annie Antón; Ting Yu; David Baumer; Michael Rappa
the National Science Foundation
 \$534,000
 09/15/2004- 08/31/2009

Privacy is increasingly a major concern that prevents the exploitation of the Internet's full potential. Consumers are concerned about the trustworthiness of the websites to which they entrust their sensitive information. Although significant industry efforts are seeking to better protect sensitive information online, existing solutions are still fragmented and far from satisfactory. Specifically, existing languages for specifying privacy policies lack a formal and unambiguous semantics are limited in expressive power and lack enforcement as well as auditing support. Moreover, existing privacy management tools aimed at increasing end-

users' control over their privacy are limited in capability or difficult to use.

Triangle Computer Science Distinguished Lecturer Series

Franc Brglez
Army Research Office
 \$43,320
 09/1/2007- 08/31/2010

Since 1995, the Triangle Computer Science Distinguished Lecturer Series (TCS DLS) has been hosting influential university researchers and industry leaders from computer-related fields as speakers at the three universities within the Research Triangle Area. The lecturer series, sponsored by the Army Research Office (ARO), is organized and administered by the Computer Science departments at Duke University, NC State University, and the University of North Carolina at Chapel Hill. This proposal argues for continuation, for an additional 3 years, of this highly successful lecturer series.

CAREER: Adaptive Automated Design of Stored Derived Data

Rada Chirkova
the National Science Foundation
 \$489,810
 08/1/2005- 07/31/2010

The goal of this project is to develop an extensible framework for designing and using derived data in answering database queries efficiently. The outcomes of the project are expected to be general and independent of a specific data model (e.g., relational or XML), while giving guarantees with respect to query-performance improvement. The approach consists of developing and evaluating mathematical models and algorithms for common types of queries on relational and XML data. Expected outcomes of the project include automated tuning of data-access characteristics in a variety of applications, thus enhancing the quality of user interactions with data-intensive systems.

Formal Models of Belief Change in Cultural Context

Jon Doyle
 MIT
 \$83,377
 12/1/2008- 05/30/2010

This project aims to better understand the process by which one can change the beliefs and preferences of populations in different cultures. We propose to develop formal models of belief change in individuals and populations. We will use the ongoing MURI effort on "Computational Models for Belief Revision, Group Decisions, and Cultural Shifts" as a starting point, but will focus on developing models that exploit formal notions of entrenchment, habit, and mental inertia.

MAESTRO: Multicore Runtime System

Vince Freeh
UNC-Chapel Hill (US Department of Defense)
 \$50,213
 08/16/2008- 08/15/2009

Core counts will increase in the next several years to tens of cores per processor; however, memory bandwidth will increase but only for blocks of data. Consequently, existing

applications will have to be significantly modified to take advantage of multiple cores. This research program, collaboration between NCSU and RENCI, creates an adaptive, parallel runtime system for efficiently executing applications on processors with numerous cores.

Runtime/Operating System Synergy to Exploit Simultaneous Multithreading

Vincent Freeh; Frank Mueller
the National Science Foundation
 \$380,000
 08/ 1/2004- 07/31/2008

This proposal focuses on a synergistic approach combining runtime and operating system support to fully exploit the capabilities of SMTs. To meet this objective, it studies three different approaches. First, it investigates the benefits of using a helper thread alongside the primary thread, by building a reference implementation of an SMT-aware Message Passing Interface library. Second, it investigates the benefits of dynamic mode switching between single-thread and multi-threaded configurations. Third, it modifies the operating system creating an SMT-aware scheduler. The benefits are demonstrated for a variety of applications, including large-scale benchmarks and other nationally relevant parallel codes.

NOAA Interdisciplinary Scientific Environmental Technology (ISET) Cooperative Research and Education Center

Vince Freeate University via the National Oceanic & Atmospheric Administration
 \$978,528
 09/ 1/2006- 08/31/2011

NOAA awarded \$12.5 Million to fund the Interdisciplinary Scientific Environmental Technology (ISET) Cooperative Research and Education Center. NC A&T State University is the lead institution. The team includes a diverse network of scientists, and engineers from A&T, NC State University, University of Minnesota, University of North Carolina at Pembroke, City University of New York, University of Alaska Southeast, California State University-Fresno, Fisk University as well as industrial, state and federal government partners. NC State University is the lead university for the research thrust on the analysis of global observing systems that includes numerical and physical research and analysis of hurricanes.

CAREER: New Directions in Managing Structured Peer-to-Peer Networks

Khaled Harfoush
the National Science Foundation
 \$408,894
 03/15/2004- 02/28/2010

In the research component of my career development program, I focus on strategies for addressing the challenges and opportunities that face the deployment of structured P2P systems. In particular, I introduce new schemes to locate resources and strategies to serve them. I also introduce new schemes for topology interference, integration, and organization in order to optimize content distribution. The proposed educational aspect of my career development program focuses on (1) enhancing our department's networking curriculum, (2) extending opportunities for

women, under-represented minorities, and undergraduates in research, (3) encouraging students to participate in the computer science community outside the university.

Level-of-Detail Visualization of Network Environments

Chris Healey
CACC
 \$40,000
 01/ 1/2008- 12/31/2009

This proposal describes a project to use scientific visualization to display, monitor, and analyze network-based data. Interest in flexible methods to visualize network environments has grown in recent years, particularly with the recent emphasis on network and data security and reliability. Previous work was conducted primarily with Cisco System, with presentations to MCNC. We have partnered with CACC members to identify network-related problems that will benefit from advanced visual representations.

Enhancing Bioinformatics Education

Steffen Heber
the North Carolina Biotechnology Center
 \$80,146
 05/16/2008- 05/15/2009

Due to its interdisciplinary nature and rapid pace, Bioinformatics is a challenging task for students and teachers. Despite many excellent text books and tutorials, there are hardly any supplementary educational tools such as visualizations, animations, or simulation games available. We will address this lack of resources by developing a library of animations for Bioinformatics algorithms and applications, organizing a symposium about Bioinformatics Education with focus on educational tools, and developing an online Bioinformatics education resource portal.

IPA Agreement between NCSU and US Army Research Office for Dr. SP Iyer

SP Iyer
the US Army Research Office
 \$175,158
 02/11/2008- 12/31/2008

Dr. Iyer will direct and manage the extramural basic research program in the Systems & Control subfield of Information Science at the Army Research Office.

Forensic Analysis of Medical Devices

SP Iyer
the National Science Foundation
 \$20,000
 08/ 1/2006- 07/31/2008

Automation in medical devices has led to the use of software as an integral part of these devices. Given the safety critical nature of these devices it is important to take efforts that such software is free of defects. However, in the event of an accident it becomes important to determine the cause of the error -- an activity that is termed {lem forensic analysis}. We propose to work on formal methods based tools that can be used to understand and identify the source of an error. This project will be carried out at NCSU and at FDA.

CT-ISG: Understanding Botnet C&C Communication Protocols

Xuxian Jiang
the National Science Foundation
 \$400,000
 08/28/2008- 08/31/2011

Botnets are recognized as one of the most serious threats to today's Internet. To combat them, one key step is to effectively understand how the botnet members communicate with each other. Unfortunately, the trend of adopting various obfuscation schemes (e.g., encryption) in recent bots greatly impedes our understanding. The main thrust of this research is the investigation of several interrelated key techniques to overcome the above challenges and significantly enrich the understanding of botnet command and control.

CT-ISG: Enabling Detection of Elusive Malware by Going Out of the Box with Semantically Reconstructed View (OBSERV)

Xuxian Jiang
the National Science Foundation
 \$202,595
 08/13/2008- 07/31/2010

There is an alarming trend elusive malware is armed with techniques that detect, evade, and subvert malware detection facilities of the victim. OBSERV enables two exciting malware defense opportunities: (1) detection by view comparison, (2) real-time detection and stoppage of kernel-level root kits. The broader impact is two-fold: (1) Enhance the trustworthiness and effectiveness of widely deployed anti-malware systems. OBSERV is expected to be viewed favorably by the anti-virus software industry because of its support for existing off-the-shelf anti-virus software. (2) Results will lead to the development of education materials for undergraduate and graduate courses and for professional training sessions.

Process Coloring: An Information Flow-Preserving Approach to Malware Investigation

Xuxian Jiang
Purdue University
 \$50,000
 08/ 1/2008- 06/ 7/2009

Cyber infrastructures are facing increasingly stealthy and sophisticated malware threats. Current methods for detection and investigation do not fully exploit the use of information flows tracked at the operating system level. We argue that OS-level information flow is currently an under-utilized tool for malware investigation. In this project, we propose to use operating system information flows to propagate malware break-in provenance information and will demonstrate that provenance preservation can help achieve more efficient and effective malware investigation. We will also show that this technique can be used to produce live alerts for malware that existing tools are unable to provide.

Secure Open Systems Initiative

Dennis Kekas; Peng Ning; Mladen Vouk; Rudra Dutta
Army Research Office
 \$2,247,000
 04/ 3/2008- 04/ 2/2009

This program will establish a national Secure Open Systems Institute (SOSI), located on North Carolina State's premier Centennial Campus that will be a global center for Open

Source security research and development. The goals are twofold. First, SOSI will significantly contribute to strengthening mission critical information technology infrastructures vital to the Department of Defense, state and nation. Second, SOSI will accelerate the creation and growth of high tech industries in North Carolina and beyond by providing a centralized repository of research results, testing tools and qualification services.

HCC-Small: Modeling Student Affect in Game-Based Learning Environments

James Lester
the National Science Foundation
 \$4,644,422
 08/ 1/2008- 07/31/2011

It has long been recognized that affect is central to cognition and learning. Affect plays a particularly important role in the rich interactions offered by game-based learning environments. Devising computational models of affect recognition and affect expression could significantly increase the efficacy of interactive learning environments. In this project, we propose an inductive approach to affect modeling that induces models of affect recognition and affect expression from students' physiological signals and from event streams generated by game-based learning environments. The resulting models will be empirically evaluated with respect to their accuracy, efficiency, and contribution to student learning gains and motivation.

Major: The Narrative Theatre - A Creativity Enhancement Environment

James Lester; Hiller Spires
the National Science Foundation
 \$804,868
 05/ 1/2008- 04/30/2011

Multiple representations are central to the creative process. The objective of the project is to design and empirically evaluate an interactive creativity environment that supports the automatic mapping of one representation to another that is fundamentally different but complementary. In particular, the proposed work will focus on the design, implementation, and evaluation of the Narrative Theatre, an interactive narrative-centered creativity environment. Rigorous comparative studies using both quantitative and qualitative methods will explore the hypothesis that the multiple representations supported by the Narrative Theatre will significantly enhance the creative process in measurable ways.

Bayesian Pedagogical Agents for Dynamic High-Performance Inquiry-Based Science Learning Environments

James Lester; Hiller Spires; John Nietfeld
the National Science Foundation
 \$605,436
 01/ 1/2007- 12/31/2009

Pedagogical agents are embodied software agents that have emerged as a promising vehicle for promoting effective learning. The proposed work has two complementary technology and learning thrusts. First, it will develop a full suite of Bayesian pedagogical agent technologies that leverage probabilistic models of inference to systematically reason about the multitude of factors that bear on tutorial decision making in dynamic high-performance inquiry-based science learning environments. Second, it will provide a compre-

hensive account of the cognitive processes and results of interacting with Bayesian pedagogical agents in inquiry-based science learning by conducting extensive empirical studies of learning processes and outcomes.

R&D: Developing Science Problem Solving Skills and Engagement Through Intelligent Game-Based Learning Environments

James Lester; Hiller Spires; John Nietfeld; James Minogue
the National Science Foundation
 \$2,523,295
 08/ 1/2008- 07/31/2011

Despite the great promise offered by game-based learning environments for elementary science education, realizing its potential poses significant technological challenges. In this project we will develop a full suite of intelligent game-based learning environment technologies for elementary science education. To promote effective science learning, we will create intelligent game-based learning environment technologies that leverage the rich interactive 3D game environments provided by commercial game engines and the inferential capabilities of intelligent tutoring systems. We will also provide a comprehensive empirical account of the cognitive processes and results of elementary students interacting with intelligent game-based learning environments for science education.

CAREER: Transparent, Interactive Desktop Parallel Computing for Scientific Data Processing

Xiaosong Ma
the National Science Foundation
 \$400,000
 03/ 1/2006- 02/28/2011

While individual workstations in scientific research environments have become more powerful, they cannot meet the needs of today's interactive data processing tasks. Meanwhile, idle desktop resources are not efficiently utilized. This project aims at harnessing the collective idle resources within institutional boundaries to speed up computation- or data-intensive tasks routinely executed on desktop machines. We will build a novel desktop parallel computing framework, which will integrate distributed computing and storage resources to create an execution platform similar to that provided by a parallel computer, while maintaining the comfort and responsiveness of desktop sequential computing and the autonomy of resource donors.

ORNL Subcontract to CS/NCSU: Transparent Data Recovery For Parallel File Systems (II)

Xiaosong Ma
Oak Ridge National Laboratories-UT-Battelle, LLC
 \$11,660
 06/ 2/2008- 08/30/2008

Dr. Xiaosong Ma and her students will attack the problem of transparent data recovery to improve the reliability of large parallel file systems. With this proposed technique, job input data will be automatically staged into a supercomputer, while a modified system to perform just-in-time patching to make sure the staged data are available when the corresponding job is scheduled.

Joint Faculty Appointment

Xiaosong Ma
UT-Battelle, LLC
 \$253,484
 09/21/2003- 08/15/2008

Xiaosong Ma's joint work with NCSU and Oak Ridge National Laboratories (ORNL) will bridge the gap between the two organizations in a practical manner to cooperatively research parallel I/O in conjunction with the Genomes to Life (GTL) and Scientific Data management projects within the Computer Science and Mathematics Division at ORNL.

Runtime Data Management for Data-Intensive Scientific Applications

Xiaosong Ma
the US Department of Energy
 \$299,992
 08/15/2005- 08/14/2008

Many applications currently used on daily basis by scientists fail to take advantage of state-of-the-art computer systems. This problem is more severe for many data-intensive applications, such as bioinformatics and visualization codes, whose parallelization are more recent and less studied in parallel architectures' design, compared to traditional simulations. We propose to address the above problems by investigating efficient runtime data management for data-intensive applications. We plan to build novel technologies for generic, automatic parallel execution plan optimization and enhancing parallel scientific data libraries by hiding I/O costs.

Collaborative Research: Application-Adaptive I/O Stack For Data-Intensive Scientific Computing

Xiaosong Ma; Vincent Freeh; John Blondin
the National Science Foundation
 \$266,002
 09/15/2006- 08/31/2009

In this proposal, we address the I/O stack performance problem with adaptive optimizations at multiple layers of the HEC I/O stack (from high-level scientific data libraries to secondary storage devices and archiving systems), and propose effective communication schemes to integrate such optimizations across layers. Our proposed PATIO (Parallel AdapTive I/O) framework will coordinate storage resources ranging from processors to tape archiving systems.

Comparative and Web-Enabled Virtual Screening

Xiaosong Ma (Co-PI); Jacqueline Hughes-Oliver (PI); Moody Chu; Gary Howell; Morteza Khaledi
the National Institutes of Health
 \$1,111,110
 09/23/2005- 07/31/2008

The long-term objective of this project is to develop computational algorithms and software to gain theoretical and empirical insights in the use of chemical diversity for determining quantitative structure-activity relationships (QSARs). In addition to addressing scientific and technical goals with respect to QSAR modeling, planning-period tasks will include specific activities to bring together the researchers and to facilitate inter-disciplinary communication. Specific Aim 1 is to develop and enhance collaborations between three broad disciplines: statistics, computer science, and chemistry.

Reliability, Availability and Serviceability (RAS) for Petascale High-End Computing and Beyond

Frank Mueller
the US Department of Energy
\$150,000
06/ 1/2008- 05/31/2011

The objective of this work is to systematically model and study large-scale reliability, to develop novel, scalable mechanisms in support of proactive FT and to significantly enhance reactive FT. The proposed work promises contributions in modeling reliability, monitoring system health and devising novel reactive as well as proactive schemes to tolerate faults. Overall, this work is targeted at alleviating limitations of current reactive FT schemes. It contributes to fault modeling and health monitoring, it significantly advances transparent checkpointing techniques, and it combines them with novel proactive approaches.

BLCR Support for Job Pause, Live Migration and Incremental Checkpointing

Frank Mueller
Lawrence Berkeley National Laboratory
\$60,000
02/ 1/2009- 01/31/2010

The objective of this work is to provide functionality for the Berkeley Lab Checkpoint/Restart (BLCR) Linux module to support advanced fault-tolerant capabilities, which are of specific value in the context of large-scale computational science codes running on high-end clusters. We have developed a set of techniques to reduce this checkpoint/restart overhead. We propose to integrate a job pause mechanism, live migration support and an incremental checkpointing mechanism into the latest BLCR version.

ERC for Future Renewable Electric Energy Distribution and Management (FREEDM) Systems

Frank Mueller
the National Science Foundation
\$41,024
09/ 1/2008- 08/31/2009

Dr. Alex Huang received an award from NSF for the ERC at NCSU. The primary objective of this work is to define the system management requirements for the Distributed Grid Intelligence (DGI) within the Intelligent Energy/Fault Management (IEM/IFM). Requirements are determined from and generated with System Theory, Modeling and Control (SMC) thrust for control algorithms, Reliable and Secured Communication (RSC) subthrust for communications, and with computer science and engineering knowledge of system management of distributed resources. The results of the project are implementations of coordination algorithms for DGI within the testbed and requirements for the overall project and demonstration thrust.

CSR--EHS: Collaborative Research: Hybrid Timing Analysis via Multi-Mode Execution

Frank Mueller
the National Science Foundation
\$140,000
08/ 1/2007- 07/31/2009

Real-time embedded systems require known bounds on the worst-case execution time (WCET) of tasks. Static timing analysis provides such bounds, yet cannot keep pace with

architectural innovations and hardware performance variation due to chip fabrication scaling. Instead of simulating execution, this work promotes actual execution in hardware to bound WCETs. This renders tedious hardware modeling unnecessary while guaranteeing correct behavior regardless of complexity or variation of hardware. The approach will be evaluated by FPGA synthesis to assess its feasibility and to validate a prototype. Advanced architectural features are studied in co-design space exploration to combine predictability and tight WCET bounds.

Mining Text using GPU Clusters

Frank Mueller
Oak Ridge National Laboratories - UT-Battelle LLC
\$17,003
10/24/2008- 07/30/2009

The proposed work covers development of optimized text search algorithms for GPUs and novel program paradigms for massive data processing requirements in GPUs. This work will leverage and build on previous research on: - customizing text search for the Nvidia CUDA programming platform for GPUs and - high-level prototyping of data-parallel programming models. We propose to demonstrate the feasibility of a flow-based abstraction for data-dependent iterative problems on a local CUDA cluster. Text mining will be in the center of our experiments that are to assess the suitability of massive data-centric iterative algorithms for this text search application domain.

CAREER: Exploiting Binary Rewriting to Analyze and Alleviate Memory Bottlenecks for Scientific Applications

Frank Mueller
the National Science Foundation
\$400,000
06/ 1/2003- 05/31/2009

Today, high-performance clusters of shared-memory multi-processors (SMPs) are employed to cope with large data sets for scientific applications. On these SMPs, hybrid programming models combining message passing and shared memory are often less efficient than pure message passing although the former fits SMP architectures more closely. For more information on this project check Dr. Mueller's Web Page

MOLAR: Modular Linux and Adaptive Runtime Support for HEC OS/R Research

Frank Mueller
the US Department of Energy
\$93,708
02/ 1/2005- 01/31/2009

This project addresses issues of adaptive, reliable, and efficient operating and runtime system solutions for ultra-scale high-end scientific computing with the following goals: (1) Create a modular and configurable Linux system based on application/runtime requirements. (2) Build runtime systems that leverage OS modularity and configurability to improve efficiency, reliability, scalability, ease-of-use. (3) Advance computer reliability, availability and serviceability management systems to work cooperatively. (4) Explore use of advanced monitoring and adaptation to improve application performance and predictability of system interruptions. Our focus is on developing scalable algorithms for high-availability without single points of failure and without single points of control.

ITR: Collaborative Research: SPARTA: Static Parametric Timing Analysis to Support Dynamic Decisions in Embedded Systems

Frank Mueller
the National Science Foundation
 \$130,000
 09/ 1/2003- 08/31/2008

Embedded systems with temporal constraints rely on timely scheduling and a prior knowledge of worst-case execution times. Static timing analysis derives safe bounds of WCETs but its applicability has been limited to hard real-time systems and small code snippets. This proposal addresses these limitations of timing analysis for embedded systems. It contributes a novel approach to program analysis through parametric techniques of static timing analysis and provides innovative methods for exploiting them.

Collaborative Research: Effective Detection and Alleviation of Scalability Problems

Frank Mueller; Jerzy Bernholc
the National Science Foundation
 \$231,652
 09/ 1/2004- 08/31/2009

The focus of this project is to develop tool support to provide the ability for scientific programmers to inquire about scalability problems and correlate this information back to source code. Furthermore, we believe that tools should be able to suggest and evaluate optimizing transformations to alleviate these problems. This would constitute a significant improvement over current performance analysis practice. The key intellectual merit is in providing an automatic framework for detecting scalability problems and correlating them back to source code. We will experiment with our framework on the ASCI codes, which is intended to stress high-performance clusters.

CT-M: Collaborative Research: A Resilient Real-Time System For a Secure and Reconfigurable Power Grid

Peng Ning
the National Science Foundation
 \$50,000
 09/ 1/2008- 08/31/2011

Energy infrastructure is a critical underpinning of modern society that any compromise or sabotage of its secure and reliable operation will have a prominent impact on people's daily lives and national economy. Past failures such as the massive northeastern power blackout of August 2003 have revealed serious defects in both system-level management and device-level designs. This project proposes a hardware-in-the-loop reconfigurable system with embedded intelligence and resilient coordination schemes to tackle the vulnerabilities of the power grid. Part of the collaborative project, the research efforts at NCSU will focus on the threats to existing state estimation algorithms and their defenses.

SEED: Developing Instructional Laboratories for Computer Security Education

Peng Ning
Syracuse University
 \$20,000
 01/ 1/2008- 12/31/2010

This project is to test and evaluate selected lab exercises developed by Dr. Wenliang Du at Syracuse University. Starting from Year 2, he will select 2-3 labs (on average) each year and use them in the course he teaches. After students finish each lab, Dr. Ning will ask students to fill out a survey questionnaire provided by the PI. The surveys will be sent back to Dr. Du, along with Dr. Ning's evaluation on students' performance.

NeTS-NOSS: Secure, Robust and DoS-Resilient Code Dissemination in Wireless Sensor Networks

Peng Ning
the National Science Foundation
 \$269,902
 08/ 1/2007- 07/31/2010

Sensor networks are ideal candidates for a wide range of applications, such as monitoring of critical infrastructures, data acquisition in hazardous environments, and military operations. It is usually necessary to reprogram sensor nodes after they are deployed through wireless links. In this project, we will investigate secure, robust, and DoS-resilient remote program of sensor nodes through wireless links. We expect to develop three groups of fundamental techniques as a result, including secure and proactively robust encoding of binary code images, DoS-resilient mechanisms for authenticating binary images, and efficient and effective techniques for remote sensor programming in hybrid sensor networks.

CAREER: Towards Trustworthy and Resilient Sensor Networks

Peng Ning
the National Science Foundation
 \$400,000
 07/ 1/2005- 06/30/2010

Sensor networks are ideal candidates for a wide range of applications such as critical infrastructure protection. It is necessary to guarantee the trustworthiness and resilience of sensor networks as well as the sensing applications. The objective of this project is to develop practical techniques for building trustworthy and resilient sensor networks as well as instructional materials that facilitate the education of these techniques. The research activities are focused on practical broadcast authentication, trustworthy and resilient clock synchronization, and light-weight and collaborative intrusion detection in sensor networks, seeking effective integration of cryptographic techniques, application semantics, and other knowledge or constraints.

Collaborative Research: CT-T: A Resilient Real-Time System For a Secure and Reconfigurable Power Grid

Peng Ning
the National Science Foundation
 \$28,500
 09/ 1/2007- 08/31/2008

Energy infrastructure is a critical underpinning of modern society that any compromise or sabotage of its secure and reliable operation will have a prominent impact on people's daily lives and the national economy. Past failures such as the massive northeastern power blackout of August 2003 have revealed serious defects in both system-level management and device-level designs. This project proposes a hardware-in-the-loop reconfigurable system with embedded

intelligence and resilient coordination schemes to tackle the vulnerabilities of the power grid. The proposed system will be fully evaluated in terms of real-time responsibility, fault resiliency, and ability for local collaboration in emergent/catastrophic events.

Efficient and Resilient Key Management for Wireless Sensor Networks

Peng Ning
Syracuse University
\$173,165
05/1/2005- 07/30/2008

Security of sensor networks is a critical issue, especially when the sensor networks are deployed in hostile environments for mission critical applications. This project aims at developing efficient and resilient key management techniques for wireless sensor networks, including novel key pre-distribution techniques, effective use of knowledge extracted from practical sensor deployment models as well as application semantics, effective integration of public key and secret key, and specific techniques for key management in hybrid sensor networks consisting of a small number of resourceful nodes and a potentially large number of resource constrained, regular sensor nodes.

Cyber-TA: NCSU: Large-Scale Privacy-Preserving Collaborative Intrusion Analysis

Peng Ning
SRI International
\$80,107
07/1/2006- 07/14/2008

We will focus on one thrust of research in the Cyber-TA initiative. We will explore practical schemes for Internet-scale collaborative sharing of sensitive information security log content, while providing extensive guarantees for contributor anonymity. Cyber-TA will enable much greater content sharing of even the most sensitive system and security log content, allowing contributors to release “rich-content” (anonymized) alert information that can enable new directions in ultra-largest-scale repository correlation.

CT-ISG: The Origin of the Code: Automated Identification of Common Characteristics in Malware

Doug Reeves
the National Science Foundation
\$268,510
09/1/2008- 08/31/2011

There are many ways that computers attached to the Internet can be infected by malicious software. We have developed a method for identifying infectious software, before it succeeds, that is fast and very general. Essentially every method of detection relies upon human intelligence to guide the search for uniquely identifying properties of infectious software. We propose to instead use techniques of data mining that will automatically search for and evaluate such properties. Our method looks for the unvarying, common properties of such software. The benefit will be automated defenses that adapt rapidly to changing threats, including previously-unknown, or “zero-day”, threats.

CT-ER: Metamorphic Worm Detection

Douglas Reeves
the National Science Foundation
\$137,057
08/15/2006- 01/31/2009

Internet Worms are software that propagate from computer to computer across the network, without intervention by or knowledge of users, for the purpose of compromising the defenses of those machines against unauthorized access or use. Worms have the property that they can spread very quickly to the vulnerable population of hosts, sometimes in only seconds, to achieve worldwide penetration. This speed allows them to bypass conventional methods of positive identification and human response.

NeTS-NOSS: Exploring the Design Space of Sensor Networks Using Route-Aware MAC Protocols

Injong Rhee; Robert Fornaro
the National Science Foundation
\$584,999
01/1/2005- 12/31/2008

As applications for wireless sensor networks are extremely diverse, sensor network designers will benefit immensely from (sensor) network protocols that can provide a wide spectrum of design choices, especially for very low energy budget applications. In this proposal, the PIs plan to develop a suite of new MAC protocols for sensor network applications based on a new approach, called Route-aware Media Access Control (RASMACH) that can greatly diversify design choices for application designers. A comprehensive evaluation of the developed protocols and their performance models is planned that involves design and implementation of a wildlife tracking system.

NeTS-NR: Traffic Quantization: A Formal Framework for Quality of Service (QoS) and Scalability in Packet-Switched Networks

George Rouskas
the National Science Foundation
\$357,314
09/1/2004- 08/31/2009

Traffic quantization is a new approach to supporting per-flow functionality in packet-switched networks in an efficient and scalable manner. We propose the concept of tiered service to alleviate the complexity associated with supporting per-flow QoS: a quantized network offers a small set of service tiers, and each flow is mapped to the tier that guarantees its QoS. Research will consist of four components: develop novel quantized implementations of weighted fair queuing (WFQ); develop Linux implementations of quantized WFQ to validate the theoretical results; extend the quantization approach to multiple traffic parameters; and investigate efficient constraint-based routing algorithms for quantized traffic.

CPATH CB: Computing Across Curricula

George Rouskas; Lisa Bullard; Jeffrey Joines; Lawrence Silverberg; Eric Wiebe
the National Science Foundation
\$274,749
07/1/2007- 06/30/2010

The focus of this project is to streamline pathways through which students receive an education that equips them with the computing tools necessary for them to serve as future

computing leaders of society. To this end, we will assemble a community of individuals, each of whom is invested in their own unique way to revitalizing the undergraduate computing education. The community will involve faculty representatives from several academic departments and delegates from industry partner organizations, and will open up meaningful channels for dialogue to flow from industry to the university, leading to a more diverse, flexible workforce of computing professionals.

Collaborative Research: NeTS-FIND: The SILO Architecture For Services Integration, Control, and Optimization For the Future Internet

George Rouskas; Rudra Dutta
the National Science Foundation
 \$220,000
 09/15/2006- 08/31/2008

The objective of this project is to formulate a formal framework for a non-layered internetworking architecture in which complex protocols are composed from elemental functional blocks in a configurable manner, and to demonstrate its potential by developing proof-of-concept prototypes. We propose a new internetworking architecture that represents a significant departure from current philosophy. The proposed architecture is flexible and extensible so as to foster innovation and accommodate change, it supports network convergence, it allows for the integration of security features at any point in the networking stack, and it is positioned to take advantage of hardware-based performance-enhancing techniques.

Edge Reconfigurable Optical Networks (ERONs) for High Performance Applications

George Rouskas; Douglas Reeves; Gigi Karmous-Edwards
 DARPA
 \$250,279
 04/ 2/2008- 12/15/2008

Many scientific applications require the coordination of resources residing at several dispersed sites. To enable these applications, lightpaths across multidomain networks must be scheduled on short timescales. Today, setting up lightpaths on demand is impossible due to a lack of infrastructure capabilities. To bridge the gap between current practice and the future vision of access to dynamically switched lightpaths, we propose the medium term solution of edge-reconfigurable optical networks (ERONs). The objective of an ERON is to enable the sharing of expensive high bandwidth network resources among multiple users and applications that require occasional yet scheduled access to these resources.

Joint Faculty Agreement For Nagiza Samatova

Nagiza Samatova
Oak Ridge National Laboratories - UT Battelle, LLC
 \$238,125
 08/ 9/2007- 08/ 8/2010

Dr. Nagiza Samatova's joint work with NC State University and Oak Ridge National Laboratory (ORNL) will provide the interface between the two organizations aiming to collaboratively address computational challenges in the Scientific Data Management, Data-Intensive Computing for Understanding Complex Biological Systems, Knowledge Integration for the Shewanella Federation, and the Large-

Scale Analysis of Biological Networks with Applications to Bioenergy Production.

High-Performance Data Analytics with Demonstrations to DOE-Mission Applications

Nagiza Samatova
Oak Ridge National Laboratories & UT-Battelle, LLC
 \$920,002
 10/ 4/2007- 08/31/2009

Terascale computing and high-throughput experiments enable studies of complex natural phenomena, on a scale not possible just a few years ago. With this opportunity, comes a new problem - the massive quantities of complex so data produced. However, answers to fundamental science questions remain largely hidden in these data. The goal of this work is to provide a scalable high performance data analytics technologies to help application scientists extract knowledge from these raw data. Towards this goal, this project will research and develop methodologies for addressing key bottlenecks, and provide proof-of-principle demonstrations on the DOE applications.

Workshop on Mathematics for Petascale Data

Nagiza Samatova
the National Science Foundation
 \$20,000
 05/15/2008- 04/30/2009

The goal of this workshop is to engage mathematical scientists and applications researchers to define a research agenda for developing the next-generation mathematical techniques needed to meet the challenges posed by petascale data sets. Specific objectives are to: * understand the needs of various scientific domains, * delineate appropriate mathematical approaches and techniques, * determine the current state-of-the-art in these approaches and techniques, and * identify the gaps that must be addressed to enable the effective analysis of large, complex data sets in the next five to ten years.

NeTS-NBD: Measurement-Based Mobility Modeling for MANETs

Mihail Sichitiu (ECE); Injong Rhee
the National Science Foundation
 \$484,827
 08/15/2006- 07/31/2009

Mobile ad-hoc networks (MANETs) have been the focus of significant research activity in the past decade. Thousands of algorithms and protocols for MANETs have been proposed, evaluated and compared. One of the defining characteristics of MANETs is their mobility. We propose to develop and evaluate a hybrid mobility model that is relatively easy to generate and, at the same time, produces realistic mobility traces that in turn, result in meaningful simulation results for MANET simulations. The proposed model has the desirable characteristics that it is customizable to match any scenario, while allowing the users to vary key parameters.

Policy-Based Governance for the OOI Cyber Infrastructure

Munindar Singh
the University of California-San Diego
 \$163,386
 05/ 3/2007- 09/30/2009

This project will develop policy-based service governance modules for the Oceanographic Observatories Initiative (OOI) Cyber infrastructure. The main objectives of the proposed project include (1) formulating the key conceptual model underlying the patterns of governance; (2) formalizing “best practices” patterns familiar to the scientific community and seeding the cyber infrastructure with them; (3) understanding user requirements for tools that support creating and editing patterns of governance.

Toward Cognitive Habile Agents

Robert St. Amant
the National Science Foundation
\$375,266
01/ 1/2006- 12/31/2009

Tool use is an agent’s manipulation of objects in the environment to transform the interaction between the environment and the agent’s sensors or actuators such that its goals are more efficiently achieved. We propose four core capabilities for a habile agent: the ability to generalize existing effectiveness to those provided by a tool under the agent’s control; the ability to perform detailed internal simulations based on hypothetical application of tool-using abilities; the use of symmetry in recognizing opportunities for tool use; and the use of a general image-schematic representation to control tool-using behavior.

Scientific Data Management Center for Enabling Technologies

Mladen Vouk
the U.S. Department of Energy
\$885,000
11/15/2006- 11/14/2011

With the increasing volume and complexity of data produced by ultra-scale simulations and high-throughput experiments, understanding the science is largely hampered by the lack of comprehensive, end-to-end data management solutions ranging from initial data acquisition to final analysis and visualization. The SciDAC-1 Scientific Data Management (SDM) Center succeeded in bringing an initial set of advanced data management technologies to DOE application scientists in astrophysics, climate, fusion, and biology. Building on our early successes, we will improve the SDM framework to address the needs of ultra-scale science.

Markers of STEM Success (MOSS): An Eleven-Year Longitudinal Study of High Achieving Young Women’s Interests, Experiences, and Preparation for STEM Careers

Mladen Vouk (Co-PI); Sarah Berenson (PI); Joan Michael; Roger Woodard; Susan Bracken
the National Science Foundation
\$511,512
10/ 1/2006- 09/30/2009

Over the past seven years, we have collected data on 250 high achieving young women, ages 11-20 for an intervention project and an ITWF project. High achieving is defined as those girls selected/electing to take Algebra I in middle grades, putting them on track to take calculus in high school. The proposed research provides an opportunity to extend and redirect the current database for a new study. By 2009 we expect to have 100 longitudinal records to inform post-

undergraduate analysis, 200 longitudinal records to inform the undergraduate analysis, and 300 longitudinal records to inform the high school analysis.

Virtual Computing Environment Services for NC Community College System

Mladen Vouk (Co-PI); Eric Sills (PI); Frank Peeler; Henry Schaffer; Sara Stein
the NC Department of Community Colleges
\$892,200
12/ 1/2007- 12/31/2010

NC State’s Virtual Computing Environment (VCE) is a computing environment in use at NC State, which is very attractive to the NC Community College System (NCCCS). It is expected to help them deliver educational services in a manner both superior to and with less resource expenditure than their current computer labs. After investigating the VCE the NCCCS put it into their plans. They then requested and received a Legislative appropriation to fund a production pilot using NC State’s resources. The services provided under this agreement by NC State will support pilots at a number of NC Community College campuses.

CAREER: Managing Complexity: Fidelity Control For Optimal Usability in 3D Graphics Systems

Benjamin Watson
the National Science Foundation
\$59,153
08/ 1/2006- 01/31/2009

Drastic improvements in the speed of 3D graphics rendering hardware have been accompanied by even more drastic increases in the size of displayed models. Researchers trying to display these models have been forced to reduce display speed and interactivity or reduce the fidelity of the displayed views of their models. What are the best methods for preserving visual fidelity as model complexity is automatically reduced? What is the most effective way of striking the display speed vs. visual fidelity compromise? Our research will take examine these questions, resulting in prototype systems and investigations of their effectiveness with user studies.

REU Site: Design Tech: Sparking Research in Interactive Visual Design

Benjamin Watson; Christopher Healey; R. Michael Young; Patrick Fitzgerald
the National Science Foundation
\$268,763
03/ 1/2006- 02/28/2010

Participants of this interactive designed technology hothouse for undergraduate researchers and designers will work with computer science and design faculty and industry on projects spanning artificial intelligence, graphics, and visualization as well as visual and interactive design. Sample projects include: advanced AI for interactive narratives and games; including camera control, and story planning and level design; automated tours through virtual and visualized environments; visualizing streaming news feeds using swarming sprites, and interactive, ambient display walls; PDA-based art installations, and real-world navigation tools. Students will gain the cross-disciplinary and cross-cultural teamwork and communications skills so important in designed technology research and industry.

CAREER: The Test-Driven Development of Secure and Reliable Software Applications

Laurie Williams
the National Science Foundation
 \$413,764
 04/ 1/2004- 03/31/2010

Our nation's critical infrastructure demands that our current and future IT professionals have the knowledge, tools, and techniques to produce reliable and trustworthy software. The objective of this research is to extend, validate, and disseminate a software development practice to aid in the prevention of computer-related disasters. The practice is based upon test-driven development (TDD), a software development technique with tight verification and validation feedback loops. The proposed work extends the TDD practice and provides a supportive open-source tool for explicitly situating security and reliability as primary attributes considered in these tight feedback loops.

CT-ER: On the Use of Security Metrics to Identify and Rank the Risk of Vulnerability- and Exploit-Prone Components

Laurie Williams
the National Science Foundation
 \$193,563
 08/ 1/2007- 07/31/2009

We propose to build, evolve, and validate a statistical prediction model whereby security-related ASA alerts from one or more tools and other software metrics are used to predict the actual overall security of a system. Our research involves collecting and analyzing a significant amount of data on software programs including security-related ASA alerts and actual security vulnerabilities and exploits, based upon inspections, testing failures, field failures, and reported exploits.

On the Use of Security Metrics to Predict Vulnerability-and-Attack-Prone Software Components

Laurie Williams
 CACC
 \$40,000
 01/ 1/2008- 12/31/2008

The work outlined in this proposal focuses on the use of security metrics to prioritize risk-based software engineering for security. Specifically, the objective of this proposal is to build a predictive model based upon security metrics obtained from code artifacts, inspections, and testing to highlight vulnerability-prone and attack-prone components for the risk-based prioritization of re-design, inspection, and testing efforts. The model will be built and validated through detailed analysis of industrial code and data of CACC members: automated static analysis alerts, other static metrics to be determined, inspection records, testing records, and customer-reported problems.

Extending Extreme Programming

Laurie Williams; Mladen Vouk
 CACC-NSA
 \$254,134
 09/15/2003- 12/31/2008

The Extreme Programming methodology was designed for relatively small teams of collocated programmers working on non-critical, small-medium, object-oriented projects. Little empirical assessment has been done on the methodology, though a sizable amount of anecdotal evidence supports the use of the methodology under these conditions. We are proposing collaborative research with the NSA and Galois in which we will empirically assess the efficacy of Extreme Programming practices in a high-confidence, secure, functional programming project. Additionally, we will work on integrating formal methods, reliability, and security testing into the set of Extreme Programming practices.

BPC-AE: The STARS Alliance: A Southeastern Partnership for Diverse Participation in Computing

Laurie Williams; Mladen Vouk; Sarah Berenson
 UNC-Charlotte (NSF)
 \$188,492
 02/ 1/2008- 01/31/2011

The proposed project is an extension of the BPC-A STARS Alliance. Our goal continues to be to broaden participation in computing (BPC) through the STARS Alliance, a Southeastern partnership to implement, institutionalize and disseminate effective practices for recruiting, bridging, retaining and graduating women, under-represented minorities and persons with disabilities into computing disciplines. With this proposal, additional academic institutions will join the STARS Alliance. NC State will continue to work with our own Student Leadership Corps, and with our demonstration and evaluation tasks, and it will act as the initial mentor for the new regional institutions.

BPC-A: The STARS Alliance: A Southeastern Partnership for Diverse Participation in Computing

Laurie Williams; Mladen Vouk; Sarah Berenson
 UNC-Charlotte (NSF)
 \$303,219
 03/ 1/2006- 02/28/2010

Our goal is to broaden participation in computing by developing a Southeastern partnership to implement, institutionalize and disseminate effective practices for recruiting, bridging, retaining and graduating women, under-represented minorities and persons with disabilities into computing disciplines. The Alliance will implement a comprehensive set of activities to provide high-quality opportunities to a large audience of post secondary students, including a Student Leadership Corps, pair programming, a Web portal, and Marketing and Careers Campaign, summer REUS, and a STARS Celebration Conference and Exchange.

Collaboration through Agile Software Development Practices: A Means for Improvement in Quality and Retention of IT Workers

Laurie Williams; Mladen Vouk; Jason Osborne; Winsler Alexander; and Sarah Berenson
 the National Science Foundation
 \$812,587
 06/15/2003- 06/30/2009

This ITWF award to NCSU, NCA&T, and Meredith College will support a three-year study of the collaborative aspects of agile software development methodologies. We believe the collaboration and the social component inherent in these methodologies is appealing to people whose learning and training models are socially oriented, such as some minor-

ity groups, women, and men. 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 pipeline when the classes utilize an agile software development model.

Mining Program Source Code for Improving Software Quality

Tao Xie
the Army Research Office
 \$300,000
 09/ 8/2008- 08/30/2011

Improving software quality is becoming an important yet challenging task in software development, especially for those mission-critical or safety-critical software systems. Many software defects related to correctness, security, and robustness are caused by the incorrect usage of system or application programming interfaces (APIs). We propose to develop new approaches for mining API properties for static verification from the API client call sites in existing code repositories, and then detect violations of these mined API properties to find defects in code repositories.

Collaborative Research: SoD-TEAM: Designing Tests For Evolving Software Systems

Tao Xie
the National Science Foundation
 \$245,000
 01/ 1/2008- 12/31/2010

Existing techniques for the design of tests typically target at designing tests for testing the current version of a software system. Designing tests for evolving software has rarely been explored but is of great importance in advancing science of design. The goal of this research is to address the test-suite augmentation problem by defining novel techniques for: (1) determining whether an existing regression test suite adequately exercises the changes between two versions of a software product; and (2) providing automated support for designing and developing test cases that target the software changes not adequately exercised by the existing tests.

CT-ISG: Collaborative Research: A New Approach to Testing and Verification of Security Policies

Tao Xie
the National Science Foundation
 \$219,275
 08/ 1/2007- 07/31/2010

Security policies such as access control and firewall policies are one of the most fundamental and widely used privacy and security mechanisms. Assuring the correctness of security policies has been a critical and yet challenging task. In this proposal, we propose to develop a uniform representation of security policies across application domains such as XACML access control policies and firewall policies, and a set of novel techniques for testing and verification of both static and stateful policies based on the uniform representation.

CSR---SMA: Improving Software System Reliability via Mining Properties for Software Verification

Tao Xie
the National Science Foundation
 \$20,000
 08/ 1/2007- 07/31/2008

Most correctness, security, and robustness violations of software systems are caused by the incorrect usage of application-specific APIs. But API details and the implicit usage properties are often not documented by the developers. Manually specifying a large number of properties or behaviors for static verification is often inaccurate or incomplete, apart from being cumbersome and prohibitively expensive. In this project, we develop a set of practical techniques and tools for inferring properties centered around single API call and properties related to multiple API calls, and improving the inference results through automatic test generation and dynamic analysis.

Creating Effective Task Descriptions from Action Plans

R. Michael Young
the National Science Foundation
 \$315,000
 08/15/2004- 07/31/2008

Artificial intelligence planning systems are being put to use to determine the activities of a wide range of intelligent interactive systems. The ability for these kinds of systems to explain their plans to human users is essential for the systems' successful adoption and use. We are investigating the generation of natural language descriptions of plan data structures. This work will develop a cognitive and computational model of task context and its role in the generation of action descriptions.

HI-FIVES: Using Web-Based Gaming to Improve Student Comprehension of Information Technology in Science

R. Michael Young (Co-PI); Leonard Annetta (PI); Deborah Mangum; Thomas Miller
the National Science Foundation
 \$1,197,270
 09/ 1/2005- 08/31/2008

Researchers in science education, computer science, distance education, and the NC Department of Public Instruction are partnering with the Kenan Fellows Program to harness the untapped potential of inexpensive, online multi-user competitive simulation software in improving the science achievement and IT skills of NC's grade 6-12 students. Over three years, teacher participants will learn how to use this technology to increase student science achievement and motivation to enter IT-related science careers. Intellectual merits of the project entail rigorous assessment and evaluation of how these environments most effectively improve the IT skills and science content mastery of students.

CAREER: Trust and Privacy Management for Online Social Networks

Ting Yu
the National Science Foundation
 \$450,000
 08/ 1/2008- 07/31/2013

Online social networks not only greatly expand the scale of people's social connections, but also have the potential to become an open computing platform, where new types of services can be quickly offered and propagated through existing social structures. Mechanisms for trust management of privacy protection are integral to the future success of online social networks. We develop theoretical and practical techniques for management of trust and privacy for social networks. Innovative expected results include a formal trust model and trust policy languages for social networks, privacy preserving feedback management, and graph anonymization techniques for the sharing of social network data.

CT-ISG: Collaborative Research: A Framework for the Modeling and Management of Obligations in Security Policies

Ting Yu
the National Science Foundation
\$180,000
08/ 1/2007- 07/31/2010

The correct and reliable operation of an information system relies not only on users' capabilities, but oftentimes on users' obligations. The management of obligations in security policies imposes significant challenges since obligations bear different properties from access control. This project develops a comprehensive framework for the management of obligations, including obligation modeling, specification, analysis, monitoring and discharges. Though the framework is formal in nature, and is designed on purpose to be general, the evaluation of its usefulness and effectiveness is firmly grounded on real applications, in particular, in the context of cross-domain data sharing systems and privacy policy enforcement systems.

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