NITRD

FY 2009

Networking and Information Technology Research and Development

Supplement to the President's Budget

February 2008

SUPPLEMENT TO THE PRESIDENT'S BUDGET
FOR FISCAL YEAR 2009

THE
NETWORKING AND INFORMATION TECHNOLOGY
RESEARCH AND DEVELOPMENT
PROGRAM

A Report by the
Subcommittee on Networking and Information Technology
Research and Development

Committee on Technology
National Science and Technology Council

February 2008

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20502

MEMBERS OF CONGRESS:

I am pleased to forward with this letter the annual report on the interagency Networking and Information Technology Research and Development (NITRD) Program. This Supplement to the President's Budget for Fiscal Year 2009 describes research and development activities in advanced networking, software, high-end computing and computational science, cyber security, and other leading-edge information technologies funded by the 13 Federal agencies that participate in the NITRD Program.

Capabilities and tools generated through NITRD investments accelerate advances across the spectrum of science, engineering, and technology fields, supporting key national security and scientific missions of the Federal Government and enhancing the Nation's economic competitiveness. The President's Fiscal Year 2009 Budget provides a 6 percent increase for the NITRD Program overall, reflecting the vital contributions of networking and information technology to sustaining U.S. leadership in science and technology, consistent with the objectives of President Bush's American Competitiveness Initiative.

The active collaboration and coordination among the NITRD agencies in the planning and execution of their research programs leverages the Federal investment in these critical technologies, enabling the Program to have a greater impact than agencies alone could achieve. You will find many examples of such coordination in this timely report.

Sincerely,

John H. Marburger, III
Director

Table of Contents

Introduction and Overview 1

High End Computing Infrastructure and Applications (HEC I&A) 2

High End Computing Research and Development (HEC R&D) 4

HEC Update: Agencies Continue Implementation of *Federal Plan for High-End Computing* 6

Cyber Security and Information Assurance (CSIA) 7

Human Computer Interaction and Information Management (HCI&IM) 10

Large Scale Networking (LSN) 12

High Confidence Software and Systems (HCSS) 14

Social, Economic, and Workforce Implications of Information Technology (IT) and IT Workforce Development (SEW) 17

Software Design and Productivity (SDP) 19

Agency NITRD Budgets by Program Component Area (PCA) 21

NITRD Program Budget Analysis 22

NITRD Subcommittee Roster and Interagency Working Group (IWG), Coordinating Group (CG), and Team Chairs 26

Participation in the NITRD Program 27

Glossary.......... 28

Acknowledgements 31

National Coordination Office for Networking and Information Technology Research and Development 32

Copyright Information 32

To Request Additional Copies 32

Buy American Report 32

Introduction and Overview

This Supplement to the President's Fiscal Year (FY) 2009 Budget provides a technical summary of the budget request for the Networking and Information Technology Research and Development (NITRD) Program, as required by the High-Performance Computing Act of 1991 (P.L. 102-194) and the Next Generation Internet Research Act of 1998 (P.L. 105-305). The multiagency NITRD Program, now in its 17th year, provides a framework and mechanisms for coordination among Federal agencies that support R&D in networking and information technology. Considered a model of effective interagency collaboration, the Program is one of the few such activities in the Federal government. The NITRD Program is an Administration interagency R&D budget priority for FY 2009.

The NITRD Supplement describes the FY 2009 networking and information technology R&D plans and current technical and coordination activities of the 13 Federal agencies in the NITRD budget crosscut as well as other agencies that are not formal members of the Program but participate in NITRD activities. In the NITRD Program, the term "agency" may refer to a department, a major departmental subdivision, or a research office or laboratory.

The President's 2009 budget request for the NITRD Program is \$3.548 billion, an increase of \$0.207 billion, approximately 6 percent, over the 2008 NITRD budget estimate of \$3.341 billion. Major contributors to this change are NITRD Program budget increases at NSF, DARPA, DOE, and NIST, partially offset by decreases at DoD (OSD and DoD Service research organizations), NSA, and NASA. Details of the NITRD budget, including 2008 estimates and 2009 requests by agency and by Program Component Areas (PCA), are presented in the budget table on page 21 and discussed in the budget analysis beginning on page 22.

NITRD activities and plans are coordinated in eight PCAs: high-end computing infrastructure and applications (HEC I&A); high-end computing research and development (HEC R&D); cyber security and information assurance (CSIA); human computer interaction and information management (HCI&IM); large-scale networking (LSN); high-confidence software and systems (HCSS); social, economic, and workforce implications of IT and IT workforce development (SEW); and software design and productivity (SDP). Agency program managers in each PCA meet monthly in an Interagency Working Group (IWG) or a Coordinating Group (CG) to exchange information and coordinate research plans and activities such as workshops and solicitations. Overall NITRD Program coordination is carried out by the Subcommittee on Networking and Information Technology Research and Development, under the aegis of the Committee on Technology of the National Science and Technology Council (NSTC).

For each NITRD PCA, this Supplement presents, in brief, the interagency strategic priorities underlying the FY 2009 budget request, programmatic highlights of the request, ongoing and anticipated interagency planning and coordination activities, and additional technical activities, by agency. Agencies engaged in various R&D and coordination topic areas are listed in NITRD budget order unless there is a lead agency (listed first) for the activity; agencies listed after the word "with" are in-kind contributors to the activity rather than funders or performers. Some large-scale activities may be cited in more than one PCA because they involve R&D efforts in a variety of technologies. In such cases, agencies report the portion of program funding in each relevant PCA.

Abbreviations and acronyms are used throughout the Supplement to maintain brevity. A glossary, beginning on page 28, is provided for reference.

Assessment of the NITRD Program by the President's Council of Advisors on Science and Technology
In August 2007, the President's Council of Advisors on Science and Technology (PCAST) concluded a two-year review of the NITRD Program conducted by the PCAST Subcommittee on Networking and Information Technology. The PCAST assessment, described in a 62-page report entitled *Leadership Under Challenge: Information Technology R&D in a Competitive World,* marked the first full review of the Program since 1999.

The NITRD community is currently evaluating the implications for the Program of PCAST's substantive and wide-ranging findings and recommendations. This evaluation is being undertaken as an integral part of the NITRD Program's strategic planning process.

High End Computing (HEC) Infrastructure and Applications (I&A)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, DOE/SC, NASA, NIST, DOE/NNSA, NOAA, EPA

HEC I&A agencies coordinate Federal activities to provide advanced computing systems, applications software, data management, and HEC R&D infrastructure to meet agency mission needs and to keep the United States at the forefront of 21st-century science, engineering, and technology. HEC capabilities enable researchers in academia, Federal laboratories, and industry to model and simulate complex processes in biology, chemistry, climate and weather, environmental sciences, materials science, nanoscale science and technology, physics, and other areas to address Federal agency mission needs.

President's 2009 Request

Strategic Priorities Underlying This Request

Ongoing investment in Federal HEC facilities and advanced applications supports Federal agencies' science, engineering, and national security missions and helps sustain U.S. scientific leadership. Priorities include:

Leadership-class systems: Continue acquisition of highest-capability systems for cutting-edge scientific research and national security applications

Production-quality HEC resources: Invest in capacity platforms to expand Federal computing resources for critical agency needs and for the science and engineering communities

Advanced applications: Develop data- and compute-intensive applications for current and new HEC platforms

Highlights of Request

Acquisition of prototype leadership-class and production R&D systems

NSF: Continue multiyear acquisitions of the Track 1 petascale system and other midrange Track 2 systems to capitalize on the growing importance of cyberinfrastructure for advanced scientific discovery and education; Track-2 system (504 TF) at the Texas Advanced Computing Center becomes operational

OSD (HPCMP): Upgrade HEC platforms at multiple supercomputing centers

NIH: Selected acquisition of cluster and midrange compute-intensive systems

DOE/SC: Upgrade LCF system at ORNL to 1 PF (early FY 2009); expand ANL's LCF resources by upgrading BlueGene/P to 250-500 TF (late FY 2008); NERSC 104-TF XT4 in full production and integrated into a common high-performance file system

NASA: Continue annual investments in supercomputing systems to track Moore's Law (4X capacity every 3 years) and meet NASA's rapidly growing requirements for large-scale numerical modeling and simulation

DOE/NNSA: Acquire new production system to replace ASC Purple; continue operation of RoadRunner base system; deploy and operate TLCC07 capacity clusters; initiate operation of Sequoia Initial Delivery (ID) system

Applications

NSF: Multidisciplinary Cyber-enabled Discovery & Innovation (CDI) program, including petascale applications that focus on understanding complexity in natural, built, and social systems and increasingly data-intensive applications; software for applications that need to integrate computation and data acquisition in heterogeneous, dynamic computing environments

OSD (HPCMP): CREATE program to develop highly scalable application codes (aircraft, ships, antennae)

NIH: R&D for biomedical applications, such as the new NIH-wide Blueprint for Neuroscience Research activity

DOE/SC: Petascale multiphysics applications; integrated reviews of SciDAC2 projects; INCITE competition for access to LCF resources by outside researchers; mathematics for analysis of extremely large data sets; multiscale mathematics

NASA: Increase core computing capability and capacity, including visualization and storage

NIST: Mathematical modeling, computational simulation, and high-end visualization for measurement science applications

DOE/NNSA: Code validation and verification (V&V) and uncertainty quantification for predictive simulations

NOAA: Accelerate improvements in model-based computing of hurricane track and intensity forecast guidance

EPA: Applications in computational toxicology (aggregated resource repository, Virtual Liver model for predictions of dose-response), air quality (enhance code quality while maintaining modularity, portability)

HEC infrastructure

NSF: Develop numerical algorithms and innovative software implementations that push the boundaries of cyberinfrastructure, computational science and engineering, and computing on the TeraGrid

OSD: Consolidate operations of supercomputing centers under single technical services contract; implement common cross-center services

NIH: Invest in grid computing infrastructure and tools for major R&D projects (e.g., BIRN, CaBIG, BISTI)

DOE/SC: Continue emphasis on unified approach to software, languages, and tools support to reduce barriers to effective use of complex HEC resources by application developers and users

NASA: Strategically grow, manage integrated HEC infrastructure; broaden HEC application and knowledge base

NIST: Development and analysis of fundamental mathematical algorithms and software; parallel and distributed algorithms; interoperable MPI; high-end visualization tools

DOE/NNSA: Deploy ASC common operating environment

NOAA: Explore ways to coordinate Federal HEC resources "on demand" (surge computing) for critical events

EPA: Continue building GEOSS systems for data, information exchange, including work with NASA and NOAA on real-time movement of large data sets through Remote Information Sensing Gateway

Planning and Coordination Supporting Request

Access to leadership-class computing: Coordination to make highest-capability HEC resources available to the broad research community – NSF, DOE/SC, NASA, NIST, DOE/NNSA, NOAA

System reviews, benchmarking: Collaborative efforts to evaluate HEC system performance – NSF, OSD, DOE/SC, NSA, NASA, DOE/NNSA, NOAA

Acquisition procedures and analysis: Information sharing, streamlining of processes, and collaborative analysis of total cost of ownership – NSF, OSD, DOE/SC, NASA, DOE/NNSA, NOAA, EPA

Multiscale modeling in biomedical, biological, and behavioral systems: Interagency collaboration to advance modeling of complex living systems (e.g., MIDAS Project) – NSF, NIH

Infrastructure for climate and weather modeling: Development of interoperable interfaces, software tools, and data standards – NSF (NCAR), OSD, DOE/SC, NASA, NOAA, EPA

Surge Computing: Discussing how to implement this capability – NOAA, NSF, OSD, DOE/SC

Computational toxicology: Integration of HEC technologies with molecular biology to improve methods for risk assessment of chemicals – OSD, NIH, DOE/SC, EPA, FDA

Additional 2008 and 2009 Activities by Agency

NSF: Expand TeraGrid to include new systems; develop cyberinfrastructure software (e.g., for debugging, fault tolerance, performance tuning, middleware, data handling); operational support for TeraGrid

OSD (HPCMP): Provide HEC services for DoD R&D and test communities (e.g., platforms, computational science software support); support six computational science institutes focused on DoD priority areas (air armament, health force protection, weather prediction, ground sensors, space situational awareness, rotorcraft)

NIH: Support international networks for biomedical data and software sharing (caBIG, BIRN); NIH Roadmap National Centers for Biomedical Computing (NCBCs); Cancer Imaging and Computational Centers; P41 computational centers; NLM information and analysis servers; bioinformatics resource centers for emerging and re-emerging infectious disease; proteomics and protein structure initiatives; systems biology centers

DOE/SC: Manage LCF facilities at ORNL and ANL; support computation-intensive and data-intensive applications; new generation of petascale tools; optimization and risk analysis in complex systems

NASA: Provide access to National Leadership Computing System (NCLS) to external researchers (through FY 2008); expand applications of visual supercomputing using hyperwalls and concurrent visualization; develop multitiered computing architecture

NIST: Virtual measurement systems, including uncertainty quantification, design of computational experiments, V&V, calibration; Virtual Measurement Laboratory

DOE/NNSA: Continue providing production-level systems and software environments to the weapons program and undergoing computing-related transformational activities under the Nuclear Weapons Complex Initiative

NOAA: Complete upgrade of new integrated R&D HEC system (2.1-fold increase over current system); integrate management, allocation of HEC resources; develop, transition advanced science/technologies into operations

EPA: Continue developing HEC applications for human health, ecology, pollution control, decision sciences; focus on large-scale data management and understanding, algorithm R&D

High End Computing (HEC) Research and Development (R&D)

NITRD Agencies: NSF, DARPA, OSD and DoD Service research organizations, DOE/SC, NSA, NASA, NIST, DOE/NNSA, NOAA

HEC R&D agencies conduct and coordinate hardware and software R&D to enable the effective use of high-end systems to meet Federal agency mission needs, to address many of society's most challenging problems, and to strengthen the Nation's leadership in science, engineering, and technology. Research areas of interest include hardware (e.g., microarchitecture, memory subsystems, interconnect, packaging, I/O, and storage), software (e.g., operating systems, languages and compilers, development environments, algorithms), and systems technology (e.g., system architecture, programming models).

President's 2009 Request

Strategic Priorities Underlying This Request

Next-generation HEC systems: Develop new scientific frameworks and system architectures to take computing power and communications "beyond Moore's Law"; innovative systems that combine increased speed, economic viability, high productivity, and robustness to meet Federal agency needs for HEC systems that manage ultra-large volumes of data and run multiscale, multidisciplinary science and engineering simulations

Extreme-scale computation: Integrate computer science and applied mathematics foundations to address computation at the petascale level

New hardware and software directions: Explore novel concepts and approaches for solving technical challenges such as power use, thermal management, file system I/O latency, highly parallel system architectures, and programming language and development environments that can increase the usability of large-scale multiprocessor, including hybrid, systems

Productivity: Continue collaborative development of new metrics of system performance, including benchmarking, lessons learned for acquisition, total ownership costs of HEC systems; integrate resources for improved productivity

Prototypes: Develop, test, and evaluate prototype HEC systems and software to reduce industry and end-user risk and to increase competitiveness

Talent pool: Replenish the workforce with highly skilled researchers who can develop future-generation HEC systems and software

Highlights of Request

High-Productivity Computing Systems (HPCS) Phase III: Design, fabricate, integrate, and demonstrate full-scale prototypes by 2010 for a new generation of petascale, economically viable computing systems to provide leap-ahead advances in performance, robustness, and programmability; develop parallel programming languages and tools to increase user productivity and enable efficient implementation of performance-critical applications – DARPA, DOE/SC, NSA

Next-generation architectures and programming: R&D in highly parallel systems architectures (silicon-based as well as radically new device-based technologies), parallel programming languages and programming environments, programming models, compilers, file systems and I/O, system software and tools; Forum to Address Scalable Technology for runtime and Operating Systems (FAST-OS) – NSF, DARPA, DOE/SC, DOE/NNSA

Petascale computing: R&D in petascale operating, runtime, and file systems; tools, programming models, performance modeling, low-power approaches, software for computation- and data-intensive applications; software effectiveness metric; mathematics and computer science (scalable algorithms, optimization of complex systems, control theory, risk assessment) – NSF, DARPA, DOE/SC, DOE/NNSA

Advanced computing systems: R&D to improve power efficiency, chip-to-chip I/O, interconnects, productivity, resilience, and file system I/O – DARPA, NSA

System on a chip: Pursue system-on-a-chip technology, self-monitoring of system processors' health and state; provide PCA technology for a new generation of onboard, embedded processing capabilities – DARPA

Quantum computing: Quantum information theory; architectures and algorithms; modeling of quantum memory, quantum gates – NSF, DARPA, NSA, NIST

Resources for scientific research: Computational concepts, methods, and tools for discovery; centers, institutes, and partnerships for predictive science, applied math/computer science challenges of scientific computing at extreme scale, joint mathematics/computer science institutes – NSF, DARPA, DOE/SC, DOE/NNSA

Computational Research and Engineering Acquisition Tools and Environments (CREATE): Computer science foundations to enhance development of highly scalable application codes – OSD (HPCMP)

Software environments: Develop modeling architecture based on Earth System Modeling Framework (ESMF)
– NOAA with NSF (NCAR), DoD, DOE/SC, NASA

Planning and Coordination Supporting Request

Planning

Technical and planning workshops: Third Storage and I/O Workshop to coordinate HEC-URA effort; Federal Application Benchmark Workshop to plan multiagency benchmarking activity; New Architecture (multithread, cell) Application Workshop; Petascale Tools Workshop; Memory for High-Performance Computing Workshop – NSF, DARPA, OSD, DOE/SC, NSA, NASA, DOE/NNSA

Open-source software: Enable HEC users to read, modify, and redistribute source code, fostering more efficient development and collaboration to improve software quality – NSF, DOE/SC, NASA, DOE/NNSA

Proposal reviews: Multiple HEC agencies

Systems architecture

HEC hardware and software: Facilitate access to and share knowledge gained and lessons learned from HEC hardware and software development efforts – NSF, OSD, DOE/SC, NASA, NIST, DOE/NNSA, NOAA

HPCS: Support architecture development – DARPA, DOE/SC, NSA

BlueGene/Q: Assess alternatives for future-generation BlueGene architecture – DOE/NNSA, DOE/SC

Quantum information science: Study information, communication, and computation based on devices governed by the principles of quantum physics – NSF, DARPA, DOE/SC, NSA, NIST

Systems software development

HEC tools: Coordinate research in operating/runtime systems, languages, compilers, libraries – NSF, DARPA, DOE/SC, NSA, DOE/NNSA

HEC metrics: Coordinate research on effective metrics for application development and execution on high-end systems – NSF, DARPA, DOE/SC, with OSD, NSA, NASA, DOE/NNSA

Benchmarking and performance modeling: Collaborate on developing performance measurement test cases with applications commonly used by Federal HEC community for use in system procurements, evaluation of Federal HEC system productivity – OSD, with NSF, DARPA, DOE/SC, NSA, NASA, DOE/NNSA

File systems and I/O: Coordinate R&D funding based on a national research agenda and update agenda on a recurring basis – NSF, DARPA, OSD, DOE/SC, NSA, NASA, DOE/NNSA

Additional 2008 and 2009 Activities by Agency

NSF: Science and Engineering Beyond Moore's Law (SEBML) emphasis on revolutionary new hardware technologies, related programming models, languages, and tools with promise for computing systems of the future; multidisciplinary CDI emphasis on computational concepts, methods, models, algorithms, and tools to advance science and engineering; complex software and tools for HEC environments; software development and technologies for cyberinfrastructure; modeling and simulation of complex systems; numerical algorithms and software implementations that push the boundaries of computing infrastructure; grid computing

DARPA: Develop a new class of processing approaches, algorithms, and architectures to efficiently enable implementation of cognitive information processing (micro-architecture concepts, framework, and multilevel programming models and implementations for goal-based, resource-constrained cognitive applications)

OSD (HPCMP): HEC systems and software R&D in support of DoD mission priorities; modeling and simulation

DOE/SC: Joint mathematics/computer science institutes for petascale algorithms; data analysis and management, interoperability; software development environments; support for leading-edge application development to accelerate acceptance of new high-risk, high-payoff algorithms and software

NSA: Complete Eldorado project, with systems available in 2008; Center for Exceptional Computing (hosts visiting scholars); initiate the Integrated High End Computing program

DOE/NNSA: Focus on code validation and verification, uncertainty quantification for predictive simulation

Update: NITRD Agencies Continue Implementation of *Federal Plan for High-End Computing*

Since the May 2004 release of the *Federal Plan for High-End Computing* by the White House Office of Science and Technology Policy (OSTP), the NITRD HEC agencies together have implemented many key recommendations of the *Federal Plan* and are providing ongoing support for these new efforts.

The HEC agencies collaborate through the HEC Interagency Working Group (HEC IWG), which coordinates high-end computing policy, strategies, and programs across NITRD member and participating agencies. Recent highlights of NITRD agencies' implementation of the *Federal Plan* include the following:

High-End Computing University Research Activity (HEC-URA): Begun in 2004 by NSF, DARPA, DOE/SC, and NSA, this research effort in operating systems, languages, compilers, libraries, software tools, and development environments has also been supported by DOE/NNSA. In 2006 and 2008, major emphases were file systems, storage, and I/O, including an annual national workshop to spur thinking among researchers about the R&D agenda in these topics; parallel language and programming environments; and HEC operating systems.

DARPA High-Productivity Computing System (HPCS) Program: Now in its final and prototyping phase (Phase III), this program begun in 2001 to pioneer a new generation of innovative, highly productive, economically viable HEC systems was opened by DARPA for participation by other agencies, becoming the first activity in which the HEC agencies could work collaboratively to implement the *Plan's* recommendations for development of new HEC requirements analyses, performance metrics, and assessment tools (such as means of calculating the total cost of ownership). Agencies involved in these activities included NSF, OSD, DOE/SC, NSA, NASA, and DOE/NNSA. DOE/SC and NSA are providing Phase III funding support.

Leadership Systems: The *Federal Plan* proposed that HEC agencies develop "leadership systems" – highest-capability computing platforms – and open them to U.S. scientists to engage in leading-edge computational science and engineering research. In FY 2009, the time on DOE/SC leadership systems made available to outside researchers through the agency's INCITE program will rise from 250 million hours to a billion hours. Also in FY 2009, NSF, DOE/SC, and DOE/NNSA will continue their acquisitions of prototype systems at or approaching the petascale level (see HEC I&A Budget Highlights on page 2).

Petascale Computing: As they move toward acquisition of petascale systems that may involve 100,000 or more processors, NSF, DOE/SC, and DOE/NNSA are collaborating in research activities focused on issues in petascale architectures, software, programming environments, and applications.

System Performance Assessment: Standard metrics used to assess the performance of high-end computers do not measure how a system will perform on the most demanding scientific applications. The HEC agencies are continuing their collaborative work to develop an interagency suite of HEC benchmarks that can accurately represent Federal advanced computing demands. Such a project was called for in the *Federal Plan* to improve the efficiency of the Federal HEC acquisitions process for both agencies and vendors; to provide a more common measure of performance across Federal HEC systems; and to promote interagency cooperation in acquisitions. Initial investments by DARPA and NSF generated the HPC Challenge (HPCC) suite of system benchmarks, composed of seven recognized computational kernels intended to span varied HEC architectures and memory-access patterns. OSD (HPCMP) is now leading a follow-on effort by the HEC agencies to develop a comparable suite of application benchmarks typifying the computational workloads of Federal HEC systems. In 2008, four applications used by multiple agencies and representing varied computational and programming characteristics will be tested on selected Federal platforms. Subsequent steps will include testing of additional applications, development of a Federal Web site for benchmark results and test-case datasets, and exploration of new overall system performance metrics.

Production Software Inventory: The HEC agencies are also developing a detailed inventory of production software installed on government high-end systems. In a preliminary 2007 survey, DOE/SC and DOE/NNSA collected data on the major categories of HEC software – operating and runtime systems, programming environments, and applications support – by type of software, function, and package name, for 30 systems managed by DoD, DOE/SC, NSA, NASA, NIST, and DOE/NNSA. An analysis of the survey results found that 20 software packages are used by many of the systems. However, there is "a long tail" of 135 software packages used by only one system. The survey found that, with a few exceptions, various forms of open-source software are in use across the types of software reported. Areas with substantial commonality include languages, MPI, tools, and Linux; specialized software was reported in system management and certain kinds of development tools. A key goal of this effort is to develop an approach for interagency cooperation in supporting and maintaining production-level open-source software for the Federal HEC infrastructure.

Cyber Security and Information Assurance (CSIA)

NITRD Agencies: NSF, DARPA, OSD and DoD Service research organizations, NIH, NSA, NASA, NIST
Other Participants: DHS, DOT, FAA, FBI, IARPA, State, Treasury, TSWG

CSIA focuses on research and development to prevent, resist, detect, respond to, and/or recover from actions that compromise or threaten to compromise the availability, integrity, or confidentiality of computer- and network-based systems. These systems provide both the basic infrastructure and advanced communications in every sector of the economy, including critical infrastructures such as power grids, emergency communications systems, financial systems, and air-traffic-control networks. These systems also support national defense, national and homeland security, and other vital Federal missions, and themselves constitute critical elements of the IT infrastructure. Broad areas of concern include Internet and network security; confidentiality, availability, and integrity of information and computer-based systems; new approaches to achieving hardware and software security; testing and assessment of computer-based systems security; and reconstitution and recovery of computer-based systems and data.

President's 2009 Request

Strategic Priorities Underlying This Request
CSIA R&D includes both foundational and applied research across the broad range of technologies and capabilities needed to improve security, assurance, and trust in the computer-based systems and networks that support national defense, national and homeland security, economic competitiveness, and other national priorities. Key research areas include:

Near-term functional cyber security and information assurance: Improvements in operating systems, cryptography, and identity management that enable systems of national significance to function as intended in the face of cyber events; software protection, assured information sharing, and collaboration across multiple domains and security enclaves; indications and warnings for situational awareness and responses to full-spectrum, multi-layer cyber attack (e.g., detection, assessment, attribution, automated response); methods for assured operations in high-threat environments including rapid reconstitution

Longer-term infrastructure and scientific foundations: Policy-based security management infrastructure for processing, storage, and communication of sensitive information; security for emerging network technologies (e.g., mobile, wireless, pervasive computing); computational foundations of software engineering to develop high levels of assurance in next-generation information-intensive systems; empirical and analytical studies to measure and validate new concepts for a principled approach to building complex systems rapidly, securely, and affordably

Larger social issues: Privacy concerns of individuals; usability of technologies; public awareness of IT risks, vulnerabilities, and protection requirements, particularly for emerging technologies; cost-effective techniques for security and confidentiality of sensitive Federal systems; standards, metrics, tests, and validation programs to promote security in systems and services, educate consumers, and establish minimum security requirements for Federal systems; guidance on secure development, implementation, management, and operations; education of next-generation cyber security workforce

Highlights of Request

Team for Research in Ubiquitous Secure Technology (TRUST): Multi-university center with industrial partners to develop new science and technology that will transform the ability of organizations (software vendors, operators, local and Federal agencies) to design, build, operate trustworthy information systems for critical infrastructures; allied centers in specific topics (ACCURATE, CCIED, TCIP, SAFE) – NSF

Software protection: Develop novel assurance technologies (e.g., automated function extraction, kernel-mode protection, anti-forensics) for critical software such as weapons codes; enable software to detect and react to unauthorized use (autonomic protections); software provenance analysis; hardware and software tamper-proofing methods – DARPA, OSD, AFRL, ONR, NSA

Secure software engineering: Develop theoretical foundations and precise standards, technologies, automation methods for engineering software security and survivability; software vulnerability, cost-benefit analysis tools (e.g., OSD's QuERIES); security practices for early phases of systems development lifecycle; ontology of security properties; formal methods for validation, verification of composable systems; lightweight analysis; online program disassembly – NSF, OSD, AFRL, NIST

Security management infrastructure: Develop policy-based access control systems; principles, frameworks, models, methods for identity, authentication, and privilege management in dynamic environments; management tools (threat analysis, attack- and risk-based decision models; survivability analysis framework; automated and real-time diagnostics for system security-policy flaws, configuration anomalies, vulnerabilities; Resiliency Engineering Framework for assessing organizational security-management capabilities) – NSF, DARPA, OSD, AFRL, ARO, NSA, NIST

Assured information sharing: DoD-wide priority to enhance technologies and tools to secure communications and data sharing across multiple, heterogeneous networks, platforms, security levels, and secure enclaves (e.g., AFRL's Assured, Load-Balancing Enterprise); high-assurance, programmable, certifiable guard; secure virtualization platforms (SVPs) protecting systems from software-based attacks; demonstrate secure collaboration through cyber sensing station – OSD and DoD Service research organizations, NSA

Network defense: Technologies and tools for situational awareness, threat anticipation, characterization, and avoidance, attack warning, intrusion protection and detection, and rapid response (containment, repair, self-regeneration to operational state); behavior-based network monitoring and active defense; defense against large-scale attacks (e.g., DDoS, worms, botnets, spyware); prototype cyber operations center; security of emerging net-centric systems of systems and strategic computing resources (e.g., NASA perimeter protection effort) – NSF, DARPA, OSD, AFRL, ARL, ARO, ONR, NSA, NASA, NIST

Cryptography: Cryptographic algorithms and engineering; identity-based encryption; provable security; key management; lightweight cryptographic systems; conditional and revocable anonymity; improved hash functions; photonics, novel materials, classical and quantum cryptographic methods and standards – NSF, DARPA, OSD, ONR, NSA, NIST

Cryptographic Hash Competition: Worldwide competition in which candidate algorithms are submitted for selection as a NIST Federal Information Processing Standard (FIPS) – NIST

Privacy: Privacy-preserving technologies and methods; location privacy – NSF, NSA, NIST

Wireless and sensor networks: Assured access, jamming-resistant communications (advanced antennas, software-defined radio technology, RF watermarking); RFID counterfeit detection; analytical and simulation techniques, standards to characterize mobility protocols; security technologies, pervasive computing – NSF, DARPA, OSD, AFRL, ARO, NSA, NIST

Standards, testing, and metrics: Quantitative risk-analysis methods and tools; quantitative methods and tools to support cryptographic conformance determination and validation; models and standards for protection, sharing of sensitive information; standards and tests to assess, validate system security; trusted computing base; development of trustworthy protocols, applications (BGP, IPv6, SIP, DNS); leadership in national and international standards bodies – NIST, NSF, OSD, ARL

Planning and Coordination Supporting Request

Roadmapping process: Use inputs solicited from Federal, industry, and academic representatives to inform planning activities; in partnership with these groups, develop an R&D roadmap associated with priorities and gaps identified in the *Federal Plan for CSIA R&D* – CSIA IWG

Co-funding: NSF TCIP Center – DHS, DOE/OE; biometrics R&D – NSF, NIST, DHS; secure core, formal verification, security-related software errors R&D – NSF, DARPA

Research data: Collaboration in research data confidentiality and usability – NSF, NIH

Information Security Automation Program: Multiagency collaboration to address deficiencies in how vulnerabilities (software flaws and misconfigurations) are described, checked, remediated, and mapped to compliance policies – NIST, OSD, NSA, DISA

Computer security architecture: Planning meetings for possible multiagency activities – NSF, DARPA, OSD and DoD Service research organizations, NSA, CIA, DNI

Interagency cooperation: Discussions on secure and resilient recovery mitigation of systems against insider attacks, possible R&D co-sponsorship – NSF, Treasury; deployment and testing of prototype security technologies – OSD, DOE/NNSA; intrusion detection/monitoring, intrusion-tolerant systems – DARPA, AFRL, NSA; proposal reviews – multiple CSIA agencies

Workshops: Security and privacy for sensor networks and embedded systems – NSF, AFRL, ARO; privacy and data confidentiality – NSF, vendors; Cryptographic Hash Competition – NIST, Federal agencies, academia, vendors; Federal Desktop Core Configuration (FDCC) – NIST, Federal agencies, vendors; Security Content Automation Protocol (SCAP) – NIST, Federal agencies, vendors

International collaboration: EU workshop on experimental evaluation and collaborative defenses; supplemental travel grants for Japanese and NSF researchers for collaborative research – NSF, Japan, EU; ministerial-level efforts to promote Internet privacy and IP protection – NSF, OECD; TTCP Information Assurance and Defensive Information Warfare Panel (Australia, Canada, New Zealand, UK and U.S.) - DoD; IETF security standards panels – CSIA agencies

Testbeds and methods for experimentation and evaluation: Continued joint development of research testbeds including DETER, ORBIT; repository of anonymized sharable test data based on actual events/behaviors; open- source software and wide distribution of benchmark results; open-source communication simulation models – NSF, OSD, NIST, DHS

INFOSEC Research Council: Provides a forum for coordination of ongoing R&D and develops long-term research agendas through the *Hard Problem List* – Multiple agencies

Additional 2008 and 2009 Activities by Agency

NSF: Continue investments in Cyber Trust; support for cyber security research including formal methods (access control rules analysis, analysis of policy, verification of composable systems, improved trust functions); formal models (access control, artificial diversity and obfuscation, deception); applications (critical infrastructures, health records, voice over IP, geospatial databases, sensor networks, federated systems); hardware enhancements for security (virtualization, encryption of data in memory, high performance IDS, TPM); security enhancements for research cyberinfrastructure; emphasis on usability, privacy, and theoretical foundations

DARPA: Trusted, Uncompromised Semiconductor Technology (TrUST) program R&D to advance science and technology for ensuring that integrated circuits (IC) can be trusted regardless of origin and fabrication process

OSD: Methods to analyze, synthesize network flow for situational awareness across organizations; application-centric protections against nation-class and insider threats; automated, scalable, adaptable, sustainable, protections; high assurance secure virtual platforms; tools for malware detection, analysis, and removal; protection of high-speed networks and supercomputer centers

AFRL: Prototype cyber operations center; cyber craft; cyber attack detection/traceback/attribution (with IARPA, Firestarter); insider threat indicators; digital data embedding including steganography and watermarking

ARO/ARL/CERDEC: Collaborative technology alliance in communications and networks; intrusion detection for MANETs; highly efficient security services and infrastructure

ONR: Data fusion and data mining; maritime domain awareness; surveillance

NSA: Centers of Academic Excellence (recognition for universities doing IA R&D); Scholarship for Service; security for mobile devices in hostile environments; high-speed cryptography

NASA: Perimeter controller/enforcer for dynamic port-access control for network-intensive applications; two-factor authentication for remote access to HEC systems; secure unattended proxy (SUP) for automated file transfers

NIST: Configurable access control mechanism (supported by DHS); National Vulnerability Database (funded by DHS); automated combinatorial testing; technical security guidance documents for Federal agencies; methods for detecting, identifying botnets; cryptographic standards; planning for cryptographic hash competition; mathematical foundations of measurement science for information systems

TSWG: SCADA Cyber Attack Alert Tool to alert operators to the existence, nature, and extent of cyber attacks through reports based on a standard set of attack definitions against geospatially distributed, resource-limited, and time-critical systems

Human Computer Interaction and Information Management (HCI&IM)

NITRD Agencies: NSF, DARPA, OSD and DoD Service research organizations, NIH, NASA, NIST, AHRQ, NOAA, EPA, NARA
Other Participants: GSA, IARPA

HCI&IM focuses on R&D to expand human capabilities and knowledge through the use and management of information by computer systems and by humans, facilitated by hardware, software, and systems technologies. These technologies include robotics, multimodal interaction technologies, visualization, agents, cognitive systems, collaborative systems, and information systems that support the organization and refinement of data from discovery to decision and action. HCI&IM outcomes support U.S. national priorities such as the American Competitiveness Initiative, transformative scientific research, national defense, homeland security, emergency planning and response, education and training, health care, space exploration, weather forecasting, and climate prediction.

President's 2009 Request

Strategic Priorities Underlying This Request
Today's increasingly data-centric world requires the effective strategic use of and access to information assets. To advance the role of HCI&IM in providing strategic support for national priorities, R&D in this area focuses on:

Information integration: To support complex human ideas, analysis, and timely decision-making, large amounts of disparate forms of raw information must be managed, assimilated, and accessible in formats responsive to the user needs. Next-generation methods, technologies, and tools are needed to fully integrate and efficiently manage massive stores of distributed, heterogeneous information (e.g., science and engineering research data, Federal records, health information). Key research issues include:

- **Information standards:** Data interoperability and integration of distributed data; usability; provenance and integrity (metadata); generalizable ontologies; focused data structure research for complex digital objects
- **Decision support:** Timeliness of and access to data; user-oriented techniques and tools for summarization, synthesis, analysis, and visualization of information for critical decision-making; advanced mobile, distributed information for emergency personnel; measurement, management of human responses to data
- **Information management:** Intelligent rule-based data management, efficient integration, maintenance, and access to complex, large-scale collections of heterogeneous data; innovative systems architecture; scalable technologies; integration of policies (differential sensitivity, security, user authentication) with data; integrated distributed data repositories; testbeds; sustainability and validation of complex models
- **Information infrastructure:** New approaches, technologies, and tools for long-term preservation, curation, sustainability, accessibility, and survivability of significant electronic data and information collections; multidisciplinary R&D in ways to convert data into knowledge and discovery; virtual organizations

Multimodal interfaces and data: HCI capabilities enabling quick, easy access to and communication and understanding of heterogeneous information (e.g., audio and text in diverse languages, video, images) for national defense and security applications and assistive devices; user-oriented interfaces

Active systems: Systems that learn, reason, and automatically adapt to new and unforeseen events; intelligent sensing and control systems; robotic devices for emergency response, hazardous environments, and exploration

Highlights of Request

Cyber-enabled Discovery and Innovation (CDI): Multidisciplinary research focused on the creation of new knowledge from digital data, including novel algorithms, data mining and dimension reduction methodologies, new visualization methods to enhance human cognition, and innovative technologies to address data confidentiality, privacy, security, provenance, and regulatory issues – NSF

Effective stewardship of science and engineering data: Issues of federation, preservation, curation, analysis, and access to large, heterogeneous collections of scientific data and information (e.g., DataNet program in sustainability of long-term, multidisciplinary data stewardship); tools for high-capacity data management; address broad needs of data-intensive science for new concepts, tools, and systems – NSF

Cognitive systems: Computational perceptual and cognitive modeling and application to joint cognitive systems design; decision-support systems/tools; improve performance (autonomy, trustworthiness, reliability) of automated and robotic systems; human-robot teaming – DARPA, ONR, NASA, NIST

Global Autonomous Language Exploitation (GALE): Software technologies to transcribe, translate, and distill huge volumes of speech and text in multiple languages, automatically and efficiently providing relevant

actionable information to military personnel – DARPA, NIST, CENTCOM, DLI, other agencies

Multimodal language recognition and translation: Improve multilingual language technology performance in areas such as speech-to-text transcription, spontaneous two-way communications translation, text retrieval, document summarization/distillation, automatic content extraction, speaker and language recognition, term detection, multimodal interfaces, usability – NSF, DARPA, ONR, NIST, IARPA, with NARA, other agencies

Information integration, accessibility, and management: Advanced scalable technologies and tools for high-capacity data integration, management, exploitation, and grid computing with increasingly complex, heterogeneous scientific data; fusion of massive-scale data sets (e.g., Earth System Modeling Framework, GEOSS, electronic health records); modeling, analysis, visualization techniques and tools; ontologies and metadata; efficient data access and transmission; automated integration, image understanding – NSF, ONR, NIH, NASA, NIST, AHRQ, NOAA, EPA, NARA

Engineered clinical knowledge: Clinical decision support systems and standards; physician/personal electronic health records; preventable adverse drug effects – AHRQ, NIH, NIST, FDA, HHS (CMS), other agencies

Human-in-the-loop: HCI and systems integration; decision-support systems and tools; distributed collaboration and knowledge management; computational cognitive process modeling and measurement; virtual reality technologies for simulation and training – NSF, DARPA, ONR, NASA, NIST, NOAA, EPA

Biomedical imaging: For detection, diagnosis, monitoring, image-guided therapies – NSF, DARPA, NIH, NIST

Text Retrieval Conference and TREC Video Retrieval: Evaluation of information-discovery technologies – NIST, NSF, NARA. IARPA

Planning and Coordination Supporting Request

HCI&IM research needs: Develop document identifying R&D agenda in key topic areas – HCI&IM CG

Joint Workshop on Data Path: Proposed workshop targeting architectures, technologies, and information-management processes needed to optimize "full data path" processing of ultra-large data and electronic records collections – NARA and other HCI&IM agencies

Biodiversity and ecosystem informatics: Interagency task group – NSF, NIH, DOE/SC, USDA, USGS

Environmental databases and data distribution: Multiagency collaboration to expand sharing, interoperability of diverse large-scale data sets – NASA, NOAA, EPA

Information access and preservation: Systems architectures to support optimizable and scalable ingest of processing petascale electronic records; data management architectures – NARA, NSF, OSD and DoD Service research organizations, NASA, NIST

Multiscale modeling: Explore possible joint R&D effort in areas of common interest – NSF, NIH

Additional 2008 and 2009 Activities by Agency

NSF: Academic R&D in information privacy; intelligent robots, vision technology; integrative intelligence (systems of agents, modalities, domains); data in ubiquitous network environments; interoperability; user-controlled data abstraction and display; collaborative environments, virtual organizations; affective computing; multidisciplinary research emphasis on Adaptive Systems Technology (AST), including research to replicate the physical behaviors of living systems in computing systems

NIH (NLM): Africa Medical Informatics Initiative; new Discovery Initiative for searching medical and biological data resources; MedLinePlus "information for the people"; Visible Human Web2 initiative

NASA: Prototypes for new exploration vehicle flight deck; human-centered automation for aviation safety; decision-support systems and technologies for mission control; hyperwalls for petascale visualization

NIST: Biometrics evaluation, usability, and standards (fingerprint, face, iris, voice/speaker, multimodal biometrics); evaluation methods for multimedia (video retrieval, motion image quality, audio and video analysis, content extraction and standards, smart-space technologies); performance measurement of interactive systems; usability of voting systems; ontologies for manufacturing information integration, supply chain; engineering informatics; computational biology; mathematical knowledge management

AHRQ: Patient safety and quality improvement program to reduce medical errors in ambulatory care; health care IT data standards; regional, state health information networks; metrics of economic implications of health IT

NOAA: Technologies for disseminating weather and climate data in multiple formats to a variety of citizen users

EPA: Computational toxicology; grid-based applications (human exposure modeling, air quality, energy models); distributed data and modeling center; Advanced Monitoring Initiative testbeds, GEOSS demonstration projects

NARA: Advanced decision-support technologies for ultra-high-confidence processing of very large Presidential electronic records collections

Large Scale Networking (LSN)

NITRD Agencies: NSF, DARPA, OSD and DoD Service research organizations, NIH, DOE/SC, NSA, NASA, NIST, AHRQ, DOE/NNSA, NOAA
Other Participants: USGS

LSN members coordinate Federal agency networking R&D in leading-edge networking technologies, services, and enhanced performance, including programs in new network architectures, heterogeneous multimedia testbeds, network security, mobile wireless networks, infrastructure, middleware, end-to-end performance measurement, networks for disaster response, and advanced network components; grid and collaboration networking tools and services; and engineering, management, and use of large-scale networks for scientific and applications R&D. The results of this coordinated R&D, once deployed, can help assure that the next generation of the Internet will be scalable, trustworthy, and flexible.

President's 2009 Request

Strategic Priorities Underlying This Request

Federal Plan for Advanced Networking Research and Development: Solicit and incorporate comments from university, Federal lab, industry, and other experts to finalize, publish strategic plan for Federal R&D

Ad hoc, secure, mobile wireless technology: Identify current and future research needed to incorporate secure mobile wireless networking into heterogeneous networking capabilities

Troubleshooting heterogeneous, multimedia, multidomain, end-to-end networking: Identify methods, tools, resources, and needed research for isolating, fixing, and repairing faults and failures affecting applications over end-to-end heterogeneous networks

Highlights of Request

Advanced testbeds: Investigate federation, agile circuit-switching, interdomain resource sharing, security, and management of heterogeneous networks to support research applications (e.g., NSF's Underwater Community Testbed) using VINI, DRAGON, Emulab, DOE/SC's Next Generation Testbed; coordinate with OMNInet, Optiputer, TeraGrid, Internet2Net, National LambdaRail, and regional ONTs – NSF, DARPA, DOE/SC

Innovative architectures: Develop network architecture concepts to enable robust, secure, flexible, dynamic, heterogeneous future networking capabilities, (e.g., NSF's NETS and FIND program, virtualization, DOE/SC's OSCARs) – NSF, DARPA, OSD, DOE/SC, NASA

Network security research: Develop technologies for detection of anomalous behavior, quarantines; standards, modeling, and measurement to achieve end-to-end security over heterogeneous, multidomain networks and infrastructure supporting multimedia open science applications (e.g., DOE/SC's SciDAC, NSF's CDI); critical infrastructure protection; trustworthy networking; privacy, confidentiality, authentication, policy, cryptography, and quantum communication – NSF, DARPA, OSD, DOE/SC, NASA, NIH, NIST

Federated networks and network management: Develop protocols for agile networking, resource reservation, security, and management across multidomain hybrid networks – NSF, DARPA, OSD, DOE/SC, NASA

Wireless and sensor networking: Advance standards, capabilities, and management (e.g., power, data fusion, heterogeneous interfaces, spectrum constraints) for robust, secure, dynamic, and mobile networks (wireless, radio, sensor); sensing and control systems – NSF, DARPA, OSD, NASA, NIST

Applications over advanced networks: Work with users to implement sharing of resources for open science communities; enable international science cooperation over networks – NSF, DOE/SC, NIH, NIST, NOAA

Community testbeds, grid access to resources: Develop technologies, protocols, and tools to enable heterogeneous, dynamic users to securely share resources for large-scale science cooperation (e.g., NIH's BIRN, caBIG) and disaster response – NSF, DARPA, OSD, NIH, DOE/SC

Disaster response and management: Disaster Information Management Research Center – NIH (NLM)

Large-scale data flows: Develop and test terabit-plus transport protocols and capabilities (e.g., Coronet, ORCA, SATCOM-CX, InfiniBand single-stream flows over WANs) – NSF, DARPA, OSD, DOE/SC, NASA, NOAA

Delay-tolerant networking: Develop protocols and methods for interoperability with intermittent connectivity – NSF, DARPA, OSD, NSA, NASA

Theoretical foundations of networking: Develop fundamental methods for modeling networks as complex autonomous, and dynamic systems – NSF, DARPA, OSD, NASA, NIST

End-to-end performance monitoring and measurement: Develop methods, tools, and testbed capabilities – NSF, OSD, DOE/SC, NSA, NASA, NIST

IPv6 and cyber security: Develop and implement near-term mandated capabilities – OSD, NIST

Planning and Coordination Supporting Request

Interagency research agenda: Collaborative development of vision and draft Federal Plan for Advanced Networking R&D including matrix of R&D priorities pointing to the middle of the next decade – LSN agencies

Cooperative R&D efforts: Networking research projects (NSF, DARPA, DOE/SC); efficiency and security of electric power networks (NSF, DARPA); Internet Infrastructure Protection Program (DARPA, NIST)

Workshops: Planning for April 2008 workshop on Critical Challenges for Optical Networking; NSF workshop on cooperation with the OECD; DOE/SC workshop on ESnet R&D, with NSF; NSF workshop on Cyber Defense Initiative Biological and Environmental Research Requirements

Coordination by LSN Teams

- **Joint Engineering Team (JET): NSF, OSD (HPCMP), NIH, DOE/SC, NSA, NASA, NIST, NOAA, USGS, with participation by academic organizations (CAIDA, CENIC, Internet2, ISI, MAX, NLANR, StarLight), a national lab (ANL), supercomputing centers (ARSC, MCNC, PSC), universities (FIU, IU, UIC, UMd, UNC, UU, UW), and vendors** – Advanced networking testbeds, coordination of end user requirements, engineering of research testbeds (JETnets); security best practices, applications testbeds (DNSSec, IPv6, IPv6 multicast, performance measurement); interdomain and end-to-end metrics and monitoring; tool sharing and exchange; international coordination; transit and services cooperation
- **Middleware And Grid Infrastructure Coordination (MAGIC) team: NSF, NIH, DOE/SC, NIST, NOAA, with participation by academic organizations (EDUCAUSE, Internet2, ISI, UCAR), national labs (ANL, LANL, LBNL, PNL), universities (UIUC, UMd, UNC, UWisc) and vendors** – Middleware and grid tools and services; grid standards and implementation status (TeraGrid, OSG, caBIG, BIRN), grid security and privacy (e.g., coordinated certificate authorities); international coordination
- **Information exchange**: Multiagency participation in review panels, informational meetings, principal investigator (PI) meetings; tactical coordination among program managers with common interests; coordination of JET meetings with DOE ESSC and Internet2 Joint Techs Meetings; GMPLS forum coordinating development of standards for interdomain signaling in agile optical networks

Additional 2008 and 2009 Activities by Agency

NSF: Global Earth Observation System of Systems (GEOSS); distributed, mobile, and embedded systems; theoretical foundations of networking and communications, including SING program

DARPA: Radio networking in challenging environments (network-centric radio systems, power and spectrum management, interface multiple access, brood of spectrum supremacy, LANdroids, wireless electronic protect/attack); data fusion and management (e.g., SAPIENT); dynamic quarantine of worms; collective technology for dynamic teams, software agents, and sensors

OSD (HPCMP): Network monitoring tools; security (IPsec, VPN portals, attack-detection tools, filters, encryption); network high-speed access to Hawaii and Alaska

DoD Service research organizations: Battlefield airborne communications node; rapid attack information dissemination execution relay; airborne network gateway programs; satellite communications; coalitions joint spectrum management planning tool

NIH: Computational grids for biomedical research, bio-informatics, clinical needs; focus on QoS, security, medical data privacy, disaster response, network management, and collaboratory infrastructure technologies

DOE/SC: Interdomain dynamic circuit reservation and management; multidomain hybrid networking; 100 Gbps optical overlay; DANTE, Internet2, CANARIE, ESnet evolution and cooperation (Internet2, DICE)

NSA: Delay-tolerant and ad hoc networking; optical receiver

NASA: Space, planetary wireless, ubiquitous, and high-performance networking (high throughput with security); bandwidth on demand; agile lambda switching

NIST: Public safety communication (e.g., P25 standards); ubiquitous information technologies for health care; indoor communications and localization; broadband quantum key distribution

AHRQ: Statewide and regional demonstrations of health information exchange networks, integration with the National Health Information Network architecture

NOAA: Integration of and access to HPC centers; high-data-rate testbed

High Confidence Software and Systems (HCSS)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, NSA, NASA, NIST
Other Participants: DOE (OE), FAA, FDA

HCSS R&D supports development of scientific foundations and innovative and enabling software and hardware technologies for the design, control, assurance, verification and validation, and certification of complex, networked, distributed computing systems and cyber-physical (IT-enabled) systems. To be capable of providing advanced services, these systems, including their software, must be reliable, predictable, adaptable, robust, safe, scalable, secure, stable, and in many cases certifiably dependable. The goal is to provide a sound and practical technology base for deeply and fully integrating embedded computation and physical dynamics, communication, networking, and control in a unified, coordinated, and continuous manner to routinely build high-confidence, optimally performing computing systems that interact properly with humans and the physical world in changing environments and unforeseen conditions. These systems, often components of larger physical and IT systems, are essential for effectively operating life-, safety-, security-, and mission-critical applications. These include defense and intelligence systems that are vital to U.S. military success and leadership, large-scale enterprise applications that can accelerate and enhance U.S. industrial competitiveness, global-scale critical infrastructures that provide foundational services for economic security, and human-utility devices that can improve citizens' quality of life.

President's FY 2009 Request

Strategic Priorities Underlying This Request
To build these fundamentally new classes of sensing, communication, and control technologies that uniformly integrate physical dynamics and computation in complex distributed systems, research is required in:

New scientific foundations for building high-confidence cyber-physical systems (CPS): New computational concepts, methods, and tools including new architectural principles, frameworks, dynamic models, and protocols for platforms and software systems and for engineered systems that currently are beyond human capability to construct reliably and predictably. These systems will have cyber capability deeply integrated in physical components; will be networked at every scale; are complex at multiple temporal and spatial scales; will dynamically reorganize and reconfigure; and will be highly automated and even autonomic. These systems will require understanding and reconciliation of the fundamental interactions between the cyber and physical worlds.

High-confidence, real-time, critical core technologies: Composable, configurable, real-time certifiable embedded systems technology substrates to reduce dependence on an aging and increasingly obsolete technology base; reconfigurable, reliable, predictable, and secure physical and engineered systems whose operations are integrated, monitored, and controlled by a computational core that is usually real-time, networked, embedded, composable, and distributed. These next-generation systems are poised to render obsolete today's systems software architectures (e.g., monolithic real-time operating systems [RTOS] designed for single-system applications; middleware as ad hoc extensions to enable, support, or effect networked systems; and virtual machines with RTOS as a general-purpose fixed architecture).

Next generation of assured, high-confidence critical CPS infrastructures: Critical cyber-physical systems that must be built on a solid basis of science and engineering include: *aviation and air space management* (adaptive avionics, air-traffic control systems, control of aircraft, and unmanned aerial vehicles); *transportation networks* (intelligent automotive and highway systems): *medical device and electronic health management systems* (dynamically configured, integrated intensive care or emergency transport units; secure nationwide health records system; hospital information systems; home care; assisted living); *intelligent industrial, manufacturing, and building/home environments (automated production, heating, lighting, and air conditioning generation, distribution, monitoring, and usage made operational via supervisory control and data acquisition [SCADA] and other networked control systems); first-responder systems* (reliable systems for emergency responders); *national and homeland defense systems* (counterterrorism, missile defense, war fighter protection, reconnaissance, and counterintelligence)

Highlights of Request

Cyber-enabled Discovery and Innovation (CDI): Expanded focus to include software for tomorrow's complex systems, including cyber-physical systems; address challenges of large-scale interacting systems, investigate their non-linear interactions and aggregate or emergent phenomena to better predict capabilities for design, control, and decision-making about complex systems – NSF

Cyber-physical systems: Continuing effort to develop a next-generation real-time technology base for architectures and virtualization of CPS, including complex embedded, hybrid, autonomous, and adaptive systems, parallel and distributed operating systems; high-confidence system service composition – NSF, AFRL, ARO, NSA, NASA, NIST, FAA, FDA

High-confidence systems and foundations of assured computing: Methods and tools for modeling, measuring, analyzing, evaluating, and predicting performance, correctness, efficiency, reliability, dependability, scalability and usability of complex, real-time, distributed, and mobile systems; high-confidence platforms for sensing and control; virtualization, architectures, components, composition, and configuration; systems of systems governance, engineering, analysis and testing of software and hardware; programming language semantics and computational models; design, development, verification, and validation for reliable computing – NSF, OSD, AFRL, ARO, NSA, NASA, NIST, FDA

Information assurance requirements: Methods and tools for constructing, analyzing security structures such as management architectures and protocols; assurance technologies for cross-domain sharing of sensitive information; assured compilation of cryptographic designs and specifications to platforms of interest – NSA; cross-enterprise document sharing in electronic health systems, conformance measurements for health information networks – NIST

Flight Critical System Software Initiative (FCSSI): New applied research start (Mixed Critical Architecture Development, a follow-on to development of certification requirements for embedded systems design); add formal methods for V&V to certification focus on infinite state systems – AFRL, NSF with other DoD Service research organizations, NASA, NSA

Standards and test methods for industrial control systems (ICS) and networks: Approaches to balancing safety, security, reliability, and performance in SCADA and other ICS used in manufacturing; ensuring performance and interoperability of factory floor network communication devices and systems – NIST

Verification Grand Challenge: R&D to develop deployable assurance technologies; annual conference on verified software and roadmap – NSA, NSF

Planning and Coordination Supporting Request

National Workshop Series: Academic, industry, and government stakeholder workshops to identify new R&D needed and develop roadmaps for building next-generation, real-time, high-confidence CPS technologies for life-, safety-, and mission-critical applications; topics have included:

- **Verified Software, Theories, Tools, and Experiments (VSTTE) Planning Workshop** – NSA
- **Stimulating and Sustaining Excitement and Discovery in K-12 STEM Education** – NSA, NSF
- **National Workshop on New Directions in Composition and Systems Technology for High-Confidence Software Platforms for Cyber-Physical Systems** – NSF, NSA, NASA, NIST, FDA
- **Joint Workshop on High-Confidence Medical Devices, Software, and Systems & Medical Device Plug-and-Play Interoperability** – NSF, AHRQ, ARO with NIH, FDA

National Academies Symposium released the study, *Software for Dependable Systems: Sufficient Evidence?* – NSA, NSF with ARO, ONR, NASA, NIST, FAA, FDA

Eighth Annual HCSS Conference: Showcasing of promising research to improve system confidence – NSA with NSF, ONR, NASA, FAA

Hybrid Systems Workshop – NSA, NSF

Static Analysis Methods/Tools Summit: Annual summit on software security for vendors, users, academics **–** NIST, NSA, NSF

Software Assurance Metrics and Tool Evaluation: Annual workshop series for users and developers to compare efficacy of techniques and tools, develop taxonomies of vulnerabilities and tools – NIST, NSA

Mixed Criticality Architecture Requirements (MCAR) Planning Review Workshop – Phase II of systems requirements for design for certification – AFRL, NSF with other DoD Service research organizations, NSA, NASA

Joint Laboratory for the Assessment of Medical Imaging Systems – NIH, FDA

Biomedical imagery: Development of technical standards for change measurements in patient therapeutic applications – NIH, NIST, FDA, CMS

Standards and software assurance metrics for SCADA and ICS: Collaborative development activity – NIST, DOE/OE; ICS procurement language specification project – NIST, DOE/OE

Scholar-in-Residence Program – Ongoing interagency partnership for the investigation of emerging scientific and engineering trends in medical device technologies – NSF, FDA

Cooperative proposal evaluation – NSF, AFRL, NSA, NASA, NIST

Additional 2008 and 2009 Activities by Agency

NSF: Joint exploratory research (CISE and ENG directorates) towards CPS; ongoing core research in computing processes and artifacts; ongoing core computer systems research (CSR)

OSD: Technologies for assuring that software is free from vulnerabilities

AFRL: R&D in technologies, design methods, and tools for safety and security certification of onboard aircraft embedded systems operating in a system-of-systems environment (e.g., unmanned aerial vehicles); emphasis on "mixed criticality" (air safety combined with security) interdependencies requiring deep interaction, integration of hardware and software components; Flight Critical System Software Initiative Symposium

AFOSR: Integrated specification and verification environment for component-based architectures of large-scale distribution systems; a framework for modeling and analyzing this system

ARO: Software/system prototyping, development, documentation, and evolution; virtual parts engineering research; reliable and secure networked embedded systems; reliable and effective mechanisms to monitor and verify software execution status

NIH: Assurance in medical devices such as pulse oximeters, cardio-exploratory monitors for neonates; telemedicine; computer-aided detection and diagnosis; computer-aided surgery and treatment (such as radiation); neural interface technologies such as cochlear implants, brain-computer interfaces

NSA: Assured cryptographic implementations (software and hardware); protocol analysis and verification; domain-specific workbench developments (interpreters, compilers, verifiers, and validators); assured content management and collaboration services; assured implementation and execution of critical platform components and functionality

NASA: Aeronautics research in integrated vehicle health management, integrated intelligent flight deck, and integrated resilient aircraft control; enabling V&V technologies for NextGen Airspace System (separation assurance and super-density programs); exploration systems research in reliable software technologies (automated testing, auto-coding, formal V&V, compositional verification)

NIST: Computer forensics tool testing, National Software Reference Library (funded by DOJ/NIJ); software assurance metrics, tools, and evaluation, National Vulnerability Database, Software Assurance Forum; trustworthy software (foundations, metrology, guidance and specifications for development); mathematical foundations of measurement science for information systems; ongoing standards and test methods for industrial control systems and networks; test methods for Voluntary Voting System Guidelines

DOE/OE: Next Generation Control Systems (**s**caleable, cost-effective methods for secure communication between remote devices and control centers; cost-effective security solutions for new architecture designs and communication methods; risk analysis; National SCADA Test Bed; secure SCADA communications protocol; middleware for inter-utility communications and cyber security; virtual architecture modeling tools

FDA: Formal methods-based design (assured verification, device software and system safety modeling and certification, forensics analysis, engineering tool foundations); architecture platform, middleware, resource management (plug-and-play, vigilance and trending systems); component-based design frameworks; patient modeling and simulation; adaptive patient-specific algorithm; requirements and metrics for certifiable assurance and safety

Social, Economic, and Workforce Implications of IT and IT Workforce Development (SEW)

NITRD Agencies: NSF, NIH, DOE/SC, DOE/NNSA
Other Participants: GSA

The activities funded under the SEW PCA focus on the co-evolution of IT and social and economic systems as well as the interactions between people and IT devices and capabilities; the workforce development needs arising from the growing demand for workers who are highly skilled in information technology; and the role of innovative IT applications in education and training. SEW also supports efforts to speed the transfer of networking and IT R&D results to the policymaking and IT user communities at all levels in government and the private sector. A key goal of SEW research and dissemination activities is to enable individuals and society to better understand and anticipate the uses and consequences of IT, so that this knowledge can inform policymaking, IT designs, and the IT user community, and broaden participation in IT education and careers.

President's 2009 Request

Strategic Priorities Underlying This Request

Human-centered computing: Develop new knowledge about and understanding of the design, use, and implications of new technologies in economic, social, and legal systems, and their dynamic interactions, with special emphasis on information privacy and human-robot interaction

Public policy: Sponsor activities that bring SEW researchers and research findings together with policymakers and practitioners to foster informed decision-making

Federal information sharing: Develop interoperability models and best practices for information sharing as part of the Federal Enterprise Architecture and E-government initiatives

Government IT practitioner communities: Build communities of practice across all levels of government and private-sector organizations in which practitioners, with support from researchers, can work collaboratively on implementing emerging technologies to improve government services

Preparing the workforce of the 21st century: Revitalize education to prepare a globally competitive U.S. workforce by expanding access to and integrating computing concepts, methods, and technologies at every stage of the educational pipeline – from K-12 to undergraduate and graduate training; support doctoral and post-graduate programs to expand the highly skilled workforce in such specialized IT fields as bio-informatics and computational science

Highlights of Request

Cyber-enabled Discovery and Innovation (CDI): R&D to address the challenges of distributed knowledge environments that enhance discovery, learning, and innovation across boundaries; better understand the design, implementation, and sustenance of large-scale socio-technical systems such as virtual organizations that integrate humans and cyberinfrastructure to revolutionize the conduct of science and enable innovation in a strong digitally enabled economy; utilize knowledge environments at all levels of education and integrate computational discovery techniques in the education of scientists – NSF

Creativity and IT: Advance understanding of the relationships among IT, creativity, and innovation; develop computational models of cognition and approaches that encourage creativity in scientific research and education; continue broadening participation in IT activities by underserved communities; transform IT education in U.S. universities and colleges; develop a globally aware workforce – NSF

Human-centered computing: Focus on co-evolution of social and technical systems to create new knowledge about human-machine partnerships – NSF

Preparing the workforce of the 21st century: Investments that infuse computational thinking into computing education at all levels and in all fields of science and engineering – NSF

Bioinformatics fellowships and training: Graduate and post-doctoral programs to expand the ranks of professionals trained in both IT and applications of IT in biomedical research, health care systems – NIH (NLM)

Computational Science Graduate Fellowship Program: Support for advanced computational science training activity at national laboratories – DOE/NNSA, DOE/SC

Collaborative Expedition Workshops: Open workshop series exploring cost-effective implementations of emerging technologies for the delivery of services at all levels of government, establishing "communities of practice" among IT implementers across government and the private sector, developing reference standards for interoperable Federal information sharing, and fostering communication between researchers and practitioners to inform policy development – CIO Council, GSA, NSF, with NITRD agencies

Planning and Coordination Supporting Request

SEW activities provide a bridge between the networking and IT R&D community and the larger arena of government policymakers and IT implementers. SEW's partnership with GSA and the Federal Chief Information Officers (CIO) Council supports the Collaborative Expedition Workshops, now in their seventh year, to encourage collaboration among government and community implementers of IT and to demonstrate promising IT capabilities emerging from Federal research. NSF often co-sponsors these events and invites researchers to give talks on SEW-related topics in order to bridge gaps between research and policy. The focus is on emerging technologies for applications in such areas as emergency preparedness and response, environmental protection, public health and health care systems, government information services for citizens, and agency projects under the Administration's Federal Enterprise Architecture (FEA) and E-government initiatives. FY 2008 plans include:

Scientific collaboration: Explore lessons from national science communities' "build to share" infrastructure and discovery methods (e.g., tools, governance, security, privacy)

NITRD participation: Work with IWGs/CGs to build workshops around high-priority NITRD interests and interagency R&D topics (e.g., scientific peer/merit review, roadmapping, identity management)

Selected impacts of workshop planning and coordination:

Broad participation: Total workshop attendance in the thousands (Federal, state, and local government, academia, industry, and other communities); 60-100 participants per workshop; counters stove-piping

Spread of Wiki technology: Growing use of cost-effective, efficient tool for collaborative work across the Federal government; 1,700 Wiki pages with 4,000 community files developed, drawing nearly 2 million visits; 5.2 million files downloaded to date, including public comment on E-government implementation (e.g. Federal Funding and Transparency Act)

Communities of Practice (CoPs): More than a dozen self-organized groups totaling more than 1,000 participants (e.g., Chief Architects, Capital Planning, IT Performance Management, Enterprise Process Improvement, Knowledge Management Working Group, Semantic Interoperability, Spatial Ontology, XML, Federal XBRL, GeoSpatial, Service-Oriented Architecture, National Transportation Knowledge Network, Agile Financial Data Services, Health Information Technology Ontology Project); use Expedition Workshops to leverage learning and collaborative prototyping around data and information sharing

Information standards: Development and implementation of reference models (e.g., National Information Exchange Model developed by DOJ, DHS for interagency sharing of critical information builds on Data Reference Model developed by CIO Council with contributions from workshop participants)

Interoperability: Adoption of interoperability models and standards in OMB activities under FEA

Additional 2008 and 2009 Activities by Agency

NSF: Continue investments in core research and education programs in human-centered computing; expand opportunities for innovative education and curriculum-development projects; broaden participation in computing by underrepresented minorities

GSA: Explore emerging standards and technologies that improve interoperability, ease of use, and cost-effectiveness of Federal IT implementations; foster open CoPs around applications of emerging technologies to improve government services

Software Design and Productivity (SDP)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, NASA, NIST, NOAA
Other Participants: DISA

SDP R&D will lead to fundamental advances in concepts, methods, techniques, and tools for software design, development, and maintenance that can address the widening gap between the needs of Federal agencies and society for usable, dependable software-based systems and the ability to produce them in a timely, predictable, and cost-effective manner. The SDP R&D agenda spans both the engineering components of software creation (e.g., development environments, component technologies, languages, tools, system software) and the business side of software management (e.g., project management, schedule estimation and prediction, testing, document management systems) across diverse domains that include sensor networks, embedded systems, autonomous software, and highly complex, interconnected systems of systems.

President's 2009 Request

Strategic Priorities Underlying This Request
Software is a critical enabler of America's security, economy, and quality of life and thus is a national priority. The formidable technical challenges of improving software quality, from the fundamental science to the application level, are SDP R&D priorities, including:

Software for tomorrow's complex systems:
- **Mathematical foundations of software and systems architectures:** Next-generation concepts and methods for developing and analyzing software for complex systems; synchronization and timing; dependability; scalability
- **Algorithms and software for petascale levels:** New approaches for advanced applications other than high-end computation
- **Ultra-large-scale (ULS) systems:** R&D in self-adapting system concepts, architectures, and technologies; enabling adaptations and system augmentations at the edge; verifying and certifying the behavior, performance, and reliability of complex, reconfigurable, heterogeneous ULS systems; component-based architectures

Predictable, timely, cost-effective software development: Innovative methods, technologies, and tools for systems and software engineering, rapidly evaluating alternative solutions to address evolving needs; measuring, predicting, and controlling software properties and tradeoffs; virtualized and model-based development environments
- **Standards development and implementation:** New methods and tools with a focus on shortening the development-validation-implementation-testing cycle

Software interoperability and usability: Interface and integration standards, representation methods to enable software interoperability, data exchanges, interoperable databases; supply-chain system integration

Highlights of Request
Software complexity: Foundational computational models, techniques, languages, tools, metrics, and processes for understanding and engineering high-quality software for increasingly complex systems, applications, and systems-of-systems (SoS); model-based software technologies for SoS interoperability; scalable subsystem composition; scalable software architectures – NSF, OSD

Cyber-enabled Discovery and Innovation: Activity to create new computational concepts, methods, tools to spur innovation in science and engineering – NSF

Systems and Software Producibility Collaboration and Evaluation Environment (SPRUCE): Rigorous testing of new technologies, methodologies and theories for testing software-intensive systems; software producibility research products and methods – OSD

Interface standards for information interoperability: Product representation scheme for interoperability among computer-aided engineering systems; standards for exchange of instrument and measurement data; methods to facilitate search and exchange of mathematical data; ontological approaches to facilitate the process of integrating supply chain systems; interoperability of databases for bioinfomatics, chemical and materials properties – NIST

Reuseable Libraries for Common Defense-Specific Software Functions: National Academy of Sciences study on advancing software-intensive systems producibility – OSD

Planning and Coordination Supporting Request

Software Interoperability: Planning for workshop examining interoperability in an era of network-enabled applications that require software systems to interact with other systems over a variety of networks (Internet, cellular networks, enterprise networks, and others) and over a lengthy lifecycle – NIST, NSF

Software for Complex Systems: Planning for a workshop to identify the critical issues in software design and development – NSF, all other interested government agencies

Procedure to release software code base: Working on release of DISA-developed suite of software tools to as wide a community as possible for future collateral development – NSF, DISA

Additional 2008 and 2009 Activities by Agency

NSF: Academic R&D in foundations of software design and development; science and engineering of software for real-world systems (micro and nanoscale embedded devices, global-scale critical infrastructures); software engineering, languages, analysis, and testing; components and composition; formal methods; verification and synthesis; design and implementation; information design and integration in software systems; software for cyberinfrastructure, domain-specific applications

OSD: R&D in product-line systems (expand traditional development into system evolution), incorporate emerging technologies in aspect-oriented approaches, service-oriented architectures, net options value, and mechanism design; dynamic systems (predictability of software systems to meet quality attributes, systems of systems governance, engineering and test methods, model-based engineering, mission success for complex environments); software engineering process management (zero-defect software, integrating enterprise workflow, high-maturity processes, appraisal quality evaluation); acquisition support; capability for successful technology transition

AFOSR: FY 2008 Multidisciplinary University Research Initiative (MURI)) entitled "Harnessing Complexity of Human-Machine Systems" to develop the scientific underpinnings and propose revolutionary approaches for mathematically modeling and comprehending large-scale complex military systems with an emphasis on how human and machine components of these systems interact at a fundamental level

NASA: Parallel programming standards development for increased code scalability and programmer productivity; automated and assistive code parallelization tools and libraries that reduce the barrier to developing efficient HPC software

NIST: Interoperability and interface standards in such fields as automotive, aerospace, semiconductor, building/construction, medical/health care, homeland security; technology focus areas in model-based design/manufacturing, product data integration, sensor systems integration, sustainable (green) manufacturing, supply chain integration, and long term data retention; 2008 NIST Interoperability Conference

DISA: Development of legal, logistical procedures to release DISA-developed Corporate Management Information System (CMIS), a Web-based suite of applications including a learning management system, a balanced scorecard system, a telework management application, an SF50 action tracking system, travel assistance, and other office productivity tools.

Agency NITRD Budgets by Program Component Area

FY 2008 Budget Estimates
and
FY 2009 Budget Requests
(Dollars in Millions)

Agency		High End Computing Infrastructure & Applications (HEC I&A)	High End Computing Research & Development (HEC R&D)	Cyber Security & Information Assurance (CSIA)	Human-Computer Interaction & Information Management (HCI &IM)	Large Scale Networking (LSN)	High Confidence Software & Systems (HCSS)	Social, Economic, & Workforce Implications of IT (SEW)	Software Design & Productivity (SDP)	Total [1]
NSF	2008 Estimate	257.4	78.6	68.1	234.8	82.6	56.6	98.6	54.8	931.5
	2009 Request	**298.4**	**91.5**	**87.6**	**266.5**	**95.8**	**67.6**	**112.0**	**70.8**	**1,090.3**
DARPA			92.0	124.4	205.3	109.0				530.7
			142.6	**106.8**	**184.9**	**135.9**				**570.2**
OSD and DoD Service research orgs. [2]		247.6	18.1	38.6	109.6	136.1	25.6		6.7	582.3
		249.6	**15.6**	**40.7**	**92.9**	**114.1**	**26.9**		**7.8**	**547.5**
NIH		159.4	76.4	1.1	182.7	68.1	7.7	10.8	4.6	510.7
		159.4	**76.3**	**1.1**	**181.7**	**68.0**	**7.7**	**10.8**	**4.6**	**509.6**
DOE/SC/NE/FE [3]		282.0	73.1			47.6		5.0		407.6
		334.6	**73.1**			**52.2**		**5.0**		**465.0**
NSA			93.5	15.5		2.9	25.2			137.1
			72.6	**17.8**		**1.8**	**27.2**			**119.3**
NASA		59.4		0.3	6.5	1.3	4.8			72.3
		60.1		**0.2**	**5.5**	**0.7**	**4.3**			**70.7**
NIST		10.7	2.4	20.8	11.8	5.8	4.9		5.6	62.0
		10.7	**2.4**	**25.8**	**11.8**	**5.8**	**4.9**		**5.6**	**67.0**
AHRQ					39.8	5.0				44.8
					39.8	**5.0**				**44.8**
DOE/NNSA		8.4	14.3			1.3		4.3		28.3
		8.2	**15.7**			**0.9**		**4.7**		**29.5**
NOAA		15.9	1.9		0.5	2.9			1.6	22.8
		18.0	**1.9**		**0.5**	**2.9**				**23.3**
EPA		3.3			3.0					6.3
		3.3			**3.0**					**6.3**
NARA					4.5					4.5
					4.5					**4.5**
TOTAL (2008 Estimate) [1]		1,044.1	450.4	268.7	798.5	462.4	124.8	118.7	73.3	3,341
TOTAL (2009 Request) [1]		**1,142.4**	**491.8**	**279.8**	**791.2**	**483.0**	**138.5**	**132.6**	**88.7**	**3,548**

1 Totals may not sum correctly due to rounding.
2 The budget for OSD and the DoD service research organizations includes funding for the High Performance Computing Modernization Program and the Missile Defense Agency.
3 The DOE/SC/NE/FE budget includes funding for DOE's Office of Science (SC) and, for the first time this year, funding for the Office of Nuclear Energy (NE) and the Office of Fossil Energy (FE).

NITRD Program Budget Analysis

Fiscal Year Overview for 2008-2009

Differences between the President's Budget request for a given year and estimated spending for that year reflect revisions to program budgets due to evolving priorities, as well as Congressional actions and appropriations. Consequently, some of the 2008 estimates cited in this report may change pending discussions between the Administration and Congress. Other factors affecting 2008 NITRD budget estimates and 2009 budget requests are the addition of DOE's Office of Nuclear Energy and Office of Fossil Energy to DOE reporting, along with the Office of Science. Further, agencies have continued to work collectively on improving the PCA definitions, as reflected by changes in the definitions outlined in OMB Circular A-11, and individually on improving the classification of investments within the PCAs, resulting in changes in NITRD Program budgets.

2008 Summary

The estimated 2008 NITRD budget of $3.341 billion is $0.280 billion, approximately 9 percent, more than the $3.061 billion 2008 President's budget request. The overall change is due to both decreases and increases in individual agency NITRD budgets, which are described below.

2009 Summary

The President's 2009 budget request for the NITRD Program is $3.548 billion, an increase of $0.207 billion, approximately 6 percent, over the 2008 estimate. Major contributors to this change are NITRD Program budget increases at NSF, DARPA, DOE, and NIST, consistent with the Administration's American Competitiveness Initiative, partially offset by decreases at DoD (OSD and DoD Service research organizations), NSA, NASA, and NIH.

NITRD Program Budget Analysis by Agency

This section describes changes greater than $10 million either between 2008 requested funding and 2008 estimated spending or between 2008 estimated spending and 2009 requests. Smaller changes are discussed only if they represent shifts in funding focus. Budget numbers in these descriptions are rounded from initial agency numbers with three decimals to the nearest whole number.

NSF

Comparison of 2008 request ($994 million) and 2008 estimate ($931 million): The decrease of $63 million is primarily due to NSF decreases in HEC I&A, LSN, and SEW, partially offset by an increase in HEC R&D. HEC I&A cyberinfrastructure-related investments will be scaled back by $46 million; LSN research on advanced testbeds, architectures, and theoretical foundations of networking will be scaled back by $24 million; and SEW investments in areas of workforce development will be scaled back by $11 million. HEC R&D will be increased by $11 million due to a re-balancing of funding between deployment of cyberinfrastructure and cyberinfrastructure research.

Comparison of 2008 estimate ($931 million) and 2009 request ($1,090 million): The 2009 budget request includes increases in all PCAs. This includes $41 million in HEC I&A for increased activity in modeling and simulation of complex systems, numerical algorithms and software implementations, and grid computing infrastructure; $12 million in HEC R&D to fund a new Science and Engineering beyond Moore's Law activity in computing hardware technologies and related programming models, languages, and tools to inform future computing systems; $20 million for CSIA research on cyber security foundations, network security, and systems software supporting the *Federal Plan for Cyber Security and Information Assurance Research and Development*; $32 million for HCI&IM research on creating new knowledge from digital data, visualization methods, and data confidentiality, privacy, security, provenance, and regulatory issues, as well as new Adaptive Systems Technology multidisciplinary research; $13 million for LSN research on advanced testbeds and architectures; $11 million for HCSS research in areas such as software for complex cyber-physical systems and mobile, portable, and pervasive computing devices; $13 million for SEW research to infuse computational thinking into computing education and science and engineering; and $16 million for SDP research on the scientific and engineering principles for developing software for complex cyber-based systems.

DARPA

Comparison of 2008 request ($412 million) and 2008 estimate ($531 million): The $119 million increase is due to increases of $23 million in HEC R&D to support centers, institutes, and partnerships for math and computer sciences; $27 million in CSIA to include the TrUST research program; and $67 million in LSN for additional programs supporting large-scale data flows for military communications and networking in the air-to-air-to-ground and deeply deployed operational environments.

Comparison of 2008 estimate ($531 million) and 2009 request ($570 million): The increase of $39 million is the result of the addition of $51 million to HEC R&D to meet milestone requirements for the HPCS program and to support the math and computer science institutes and partnerships, and $27 million to LSN to expand the above-mentioned communications efforts, partially offset by decreases of $17 million in CSIA due to transitioning selected information assurance projects and $20 million in HCI&IM due to completion and transition to Service field units of software tools developed in collaborative cognition programs.

OSD and DoD Service Research Organizations

Comparison of 2008 request ($511 million) and 2008 estimate ($582 million): The 2008 estimate for OSD and DoD Service research organizations is $71 million higher than the 2008 request due to Congressional add-ons that affect HEC I&A, HEC R&D, CSIA, and HCI&IM.

Comparison of 2008 estimate ($582 million) and 2009 request ($548 million): The 2009 request for OSD and DoD Service research organizations is $34 million below the 2008 estimate because Congressional add-ons from 2008 are not included in the 2009 request.

NIH

Comparison of 2008 request ($418 million) and 2008 estimate ($511 million): The $93 million increase is due primarily to the addition of reporting by an NIH institute that did not previously track NITRD expenditures, partially offset by a decrease of $12 million in HCI&IM reflecting a reallocation of expenditures across several institutes.

DOE

Comparison of 2008 request ($370 million) and 2008 estimate ($408 million) and comparison of 2008 estimate ($408 million) and 2009 request ($465 million): The increases are largely due to the addition of the Office of Nuclear Energy to the NITRD Program and to increased operational costs at the Leadership Computing Facilities.

NSA

Comparison of 2008 request ($103 million) and 2008 estimate ($137 million): The increase of $34 million is due to late additional funding for developing the El Dorado system, expansion of the Advanced Computing Systems program, and additional funding of $28 million provided by Congress to initiate the Integrated High End Computing (IHEC) Program.

Comparison of 2008 estimate ($137 million) and 2009 request ($119 million): The $17 million decrease is due to completion of the development of the El Dorado system plus a decrease in the level of funding needed for the IHEC program in a continuing as opposed to a launch mode.

NASA

*Comparison of 2008 request ($87 million) and 2008 estimate ($72 million)***:** The $15 million decrease is due principally to a NASA decision to report only direct costs of projects beginning with the FY 2008 estimates.

NIST

Comparison of 2008 request ($54 million) and 2008 estimate ($62 million) and comparison of 2008 estimate ($62 million) and 2009 request ($67 million): The change from 2008 request to 2008 estimate is due to the inclusion of projects not previously included in the NITRD categorization process, particularly those that use information technology to enable scientific discovery (e.g., modeling and simulation for complex multi-phase fluid flow, magnetic materials, and image analysis). The 2009 CSIA request also includes a cyber security initiative.

NITRD Program Budget Summary by PCA

Using the information presented above, this section provides an analysis of the NITRD Program budget by PCA, summarizing the more substantial differences between 2008 requested funding and 2008 estimated spending and between 2008 estimated spending and 2009 requests. The changes are described above.

HEC I&A

Comparison of 2008 request ($1,023 million) and 2008 estimate ($1,044 million): The $21 million increase is largely due to increases of $14 million at OSD and DoD Service research organizations, $27 million at NIH, $31 million at DOE, and $9 million at NIST, partially offset by decreases of $46 million at NSF and $12 million at NASA.

Comparison of 2008 estimate ($1,044 million) and 2009 request ($1,142 million): The $98 million increase is largely due to increases of $41 million at NSF and $53 million at DOE, and smaller increases at other agencies.

HEC R&D

Comparison of 2008 request ($289 million) and 2008 estimate ($450 million): The $161 million increase is due largely to increases of $12 million at NSF, $23 million at DARPA, $16 million at OSD and DoD Service research organizations, $74 million at NIH, and $34 million at NSA.

Comparison of 2008 estimate ($450 million) and 2009 request ($492 million): The $42 million increase is largely due to increases of $12 million at NSF and $51 million at DARPA, partially offset by a decrease of $21 million at NSA.

CSIA

Comparison of 2008 request ($218 million) and 2008 estimate ($269 million): The $51 million increase is largely due to increases of $27 million at DARPA, $16 million at OSD and DoD Service research organizations, and $10 million at NIST.

Comparison of 2008 estimate ($269 million) and 2009 request ($280 million): The $11 million increase is largely due to increases of $20 million at NSF and $5 million at NIST, partially offset by a decrease of $17 million at DARPA.

HCI&IM

Comparison of 2008 request ($767 million) and 2008 estimate ($798 million): The $31 million increase is largely due to an increase of $31 million at OSD and DoD Service research organizations and smaller increases at NSF and NIST, partially offset by a decrease of $12 million at NIH.

Comparison of 2008 estimate ($798 million) and 2009 request ($791 million): The $7 million decrease is largely due to decreases of $20 million at DARPA and $17 million at OSD and DoD Service research organizations, partially offset by an increase of $32 million at NSF.

LSN

Comparison of 2008 request ($416 million) and 2008 estimate ($462 million): The $46 million increase is largely due to an increase of $67 million at DARPA, partially offset by a decrease of $24 million at NSF.

Comparison of 2008 estimate ($462 million) and 2009 request ($483 million): The $21 million increase is largely due to increases of $13 million at NSF and $27 million at DARPA, partially offset by a decrease of $22 million at OSD and DoD Service research organizations.

HCSS

Comparison of 2008 request ($146 million) and 2008 estimate ($125 million): The $21 million decrease is due to decreases of $6 million at OSD and DoD Service research organizations and $15 million at NIST.

Comparison of 2008 estimate ($125 million) and 2009 request ($139 million): The $14 million increase is largely due to an increase of $11 million at NSF.

SEW

Comparison of 2008 request ($131 million) and 2008 estimate ($119 million): The $12 million decrease is largely due to a decrease of $10 million at NSF.

Comparison of 2008 estimate ($119 million) and 2009 request ($133 million): The $14 million increase is largely due to an increase of $13 million at NSF.

SDP

Comparison of 2008 estimate ($73 million) and 2009 request ($89 million): The increase of $16 million is due to an increase of $16 million at NSF.

National Science and Technology Council
Committee on Technology
Co-Chairs

Richard Russell, Deputy Director for Technology, OSTP

C.H. Albright, Jr., Under Secretary of Energy, Department of Energy

James M. Turner, Acting Director, National Institute of Standards and Technology

Subcommittee on Networking and Information Technology Research and Development
Co-Chairs

Christopher L. Greer, NCO

Jeannette M. Wing, NSF

NSF
Representatives
Daniel E. Atkins
Jeannette M. Wing
Alternate
Deborah L. Crawford
José Munoz

DARPA
Representative
Anthony J. Tether

OSD and DoD Service research organizations
Representative
André M. van Tilborg
Alternate
Robert Gold

NIH
Representative
Karin A. Remington
Alternates
Michael J. Ackerman
Karen Skinner

DOE/SC/NE/FE
Representative
Michael Strayer
Alternates
Daniel A. Hitchcock
Norman H. Kreisman

NSA
Representative
George R. Cotter
Alternate
Candace S. Culhane

NASA
Representative
Bryan A. Biegel
Alternate
James R. Fischer

NIST
Representative
Cita M. Furlani
Alternate
Kamie Roberts

AHRQ
Representative
J. Michael Fitzmaurice

DOE/NNSA
Representative
Robert Meisner
Alternate
Thuc T. Hoang

NOAA
Representative
William T. Turnbull
Alternate
Michael Kane

EPA
Representative
Gary L. Walter

NARA
Representative
Robert Chadduck

OMB
Representative
Joel R. Parriott

OSTP
Representative
Charles H. Romine

NCO
Representative
Christopher L. Greer
Alternate
Sally E. Howe

Interagency Working Groups, Coordinating Groups, and Team Chairs

High End Computing (HEC) Interagency Working Group
Chair
Cray J. Henry, DoD
Vice-Chair
José L. Muñoz, NSF

Cyber Security and Information Assurance (CSIA) Interagency Working Group
Co-Chairs
Annabelle Lee, DHS
William D. Newhouse, DoD

Human-Computer Interaction and Information Management (HCI&IM) Coordinating Group
Co-Chairs
Sylvia Spengler, NSF
Gary L. Walter, EPA

Large Scale Networking (LSN) Coordinating Group
Co-Chairs
Daniel A. Hitchcock, DOE/SC
Allison Mankin, NSF

LSN Teams:

Joint Engineering Team (JET)
Chair
George R. Seweryniak, DOE/SC

Middleware and Grid Infrastructure Coordination (MAGIC) Team
Chair
Kevin L. Thompson, NSF
Vice-Chairs
Michael R. Nelson, GU
Ken Klingenstein, Internet2

Networking Research Team (NRT)
Chair
Thomas Ndousse-Fetter, DOE/SC

High Confidence Software and Systems (HCSS) Coordinating Group
Co-Chairs
Helen D. Gill, NSF
William Bradley Martin, NSA
Albert J. Wavering, NIST

Social, Economic, and Workforce Implications of IT and IT Workforce Development (SEW) Coordinating Group
Co-Chairs
C. Suzanne Iacono, NSF
Susan B. Turnbull, GSA

Software Design and Productivity (SDP) Coordinating Group
Co-Chairs
Michael J. Foster, NSF
Simon P. Frechette, NIST

Participation in the NITRD Program

The following goals and criteria developed by the NITRD Program are intended to enable agencies considering participation to assess whether their research and development activities fit the NITRD framework.

NITRD Goals

- Provide research and development foundations for assuring continued U.S. technological leadership in advanced networking, computing systems, software, and associated information technologies
- Provide research and development foundations for meeting the needs of the Federal government for advanced networking, computing systems, software, and associated information technologies
- Accelerate development and deployment of these technologies in order to maintain world leadership in science and engineering; enhance national defense and national and homeland security; improve U.S. productivity and competitiveness and promote long-term economic growth; improve the health of the U.S. citizenry; protect the environment; improve education, training, and lifelong learning; and improve the quality of life.

Evaluation Criteria for Participation

Relevance of Contribution
The research must significantly contribute to the overall goals of the NITRD Program and to the goals of one or more of the Program's eight Program Component Areas (PCAs) – High End Computing Infrastructure and Applications (HEC I&A), High End Computing Research and Development (HEC R&D), Cyber Security and Information Assurance (CSIA), Human-Computer Interaction and Information Management (HCI&IM), Large Scale Networking (LSN), High Confidence Software and Systems (HCSS), Social, Economic, and Workforce Implications of Information Technology (IT) and IT Workforce Development (SEW), and Software Design and Productivity (SDP) – in order to enable the solution of applications and problems that address agency mission needs and that place significant demands on the technologies being developed by the Program.

Technical/Scientific Merit
The proposed agency program must be technically and/or scientifically sound, of high quality, and the product of a documented technical and/or scientific planning and review process.

Readiness
A clear agency planning process must be evident, and the organization must have demonstrated capability to carry out the program.

Timeliness
The proposed work must be technically and/or scientifically timely for one or more of the PCAs.

Linkages
The responsible organization must have established policies, programs, and activities promoting effective technical and scientific connections among government, industry, and academic sectors.

Costs
The identified resources must be adequate to conduct the proposed work, promote prospects for coordinated or joint funding, and address long-term resource implications.

Agency Approval
The proposed program or activity must have policy-level approval by the submitting agency.

Glossary

ACCURATE - NSF-funded A Center for Correct, Usable, Reliable, Auditable, and Transparent Elections
AFOSR - Air Force Office of Scientific Research
AFRL - Air Force Research Laboratory
AHRQ - HHS's Agency for Healthcare Research and Quality
ANL - DOE's Argonne National Laboratory
ARL - Army Research Laboratory
ARO - Army Research Office
ARSC - Arctic Region Supercomputing Center
ASC - DOE/NNSA's Advanced Simulation and Computing program
ASC Purple - DOE/NNSA's 100-teraflops SMP supercomputing platform
AST - NSF's Adaptive Systems Technology program
BGP - Border Gateway Protocol
BIRN - NIH's Biomedical Informatics Research Network
BISTI - NIH's Biomedical Information Science and Technology Initiative
BlueGene - A vendor supercomputing project dedicated to building a new family of supercomputers
BlueGene/L - Scalable experimental new supercomputing system being developed in partnership with DOE/SC and DOE/NNSA; expected to achieve 300-teraflops+ processing speeds
BlueGene/P - The next generation in the BlueGene line after BlueGene/L
BlueGene/Q - Latest-generation BlueGene architecture
CaBIG - NIH's cancer Biomedical Informatics Grid
CAIDA - Cooperative Association for Internet Data Analysis
CANARIE - Canadian Advanced Network and Research for Industry and Education
CCIED - NSF-supported Collaborative Center for Internet Epidemiology and Defenses
CDI - NSF's Cyber-enabled Discovery and Innovation program
CENIC - Corporation for Network Initiatives in California
CENTCOM - United States Central Command
CERDEC - U.S. Army's Communications-Electronics Research, Development, and Engineering Center
CG - Coordinating Group
CIA - Central Intelligence Agency
CIO - Chief information officer
CISE - NSF's Computer and Information Science and Engineering directorate
CMIS - DISA's Corporate Management Information System
CMS - HHS's Centers for Medicare and Medicaid Services
CoP - Communities of practice
Coronet - DARPA's CORre Optical NETworks program
CPS - Cyber-physical system(s)
CREATE - OSD's Computational Research and Engineering Acquisition Tools and Environments program
CSIA - Cyber Security and Information Assurance, one of NITRD's eight Program Component Areas
CSR - Computer systems research
DANTE - Delivery of Advanced Network Technology to Europe program
DARPA - Defense Advanced Research Projects Agency
DDoS - Distributed denial of service
DETER - NSF- and DHS-initiated cyber DEfense Technology Experimental Research network
DHS - Department of Homeland Security
DICE - Data Intensive Computing Environment
DISA - Defense Information Systems Agency
DLI - Defense Language Institute
DNI - Director of National Intelligence
DNS - Domain Name System
DNSSec- Domain Name System Security protocol
DoD - Department of Defense
DOE - Department of Energy
DOE/NNSA - DOE/National Nuclear Security Administration
DOE/OE - DOE's Office of Electricity Delivery and Energy Reliability
DOE/SC - DOE's Office of Science
DOJ - Department of Justice
DOT - Department of Transportation
DRAGON - NSF's Dynamic Resource Allocation (via GMPLS) Optical Network
DREN - DoD's Defense Research and Engineering Network
Educause - Non-profit organization promoting advancement of IT in higher education
Emulab - Network emulation testbed supported by NSF, DARPA
ENG - NSF's Engineering directorate
EPA - Environmental Protection Agency
ESMF - Earth System Modeling Framework
ESnet - DOE/SC's Energy Sciences network
ESSC - DOE/SC's Energy Sciences network (ESnet) Steering Committee
EU - European Union
FAA - Federal Aviation Administration
FAST-OS – Forum to Address Scalable Technology for runtime and Operating Systems
FBI - Federal Bureau of Investigation
FCSSI - Flight Critical Systems Software Initiative
FDA - Food and Drug Administration
FDCC - Federal Desktop Core Configuration
FEA - Federal Enterprise Architecture
FIND - NSF's Future Internet Network Design program
FIPS - Federal Information Processing Standard
FIU - Florida International University
FY - Fiscal Year
GALE - DARPA's Global Autonomous Language Exploitation program
GEOSS - Global Earth Observation System of Systems, a cooperative effort of 34 nations, including the U.S., and 25 international organizations to develop a comprehensive, coordinated, and sustained Earth observation system
GMPLS - Generalized MultiProtocol Label Switching
GSA - General Services Administration
GU - Georgetown University
HCI&IM - Human-Computer Interaction and Information Management, one of NITRD's eight Program Component Areas
HCSS - High Confidence Software and Systems, one of NITRD's eight Program Component Areas
HEC - High-end computing
HEC I&A - HEC Infrastructure and Applications, one of NITRD's eight Program Component Areas
HEC R&D - HEC Research and Development, one of NITRD's eight Program Component Areas
HEC-URA - HEC University Research Activity, jointly funded by multiple NITRD agencies
HHS - Department of Health and Human Services
HPC - High performance Computing
HPCMP - OSD's High Performance Computing Modernization Program
HPCS - DARPA's High Productivity Computing Systems program
I/O - Input/output
IARPA - Intelligence Advanced Research Projects Activity
IC - Integrated circuit
ICS - Industrial control systems
ID - Initial delivery

IDS - Intrusion detection system
IETF - Internet Engineering Task Force
IHEC - NSA's Integrated High End Computing program
IM - Information management
INCITE - DOE/SC's Innovative and Novel Computational Impact on Theory and Experiment program
INFOSEC – Information security
Internet2 – Higher-education consortium for advanced networking and applications deployment in academic institutions
IPsec - IP security protocol
IPv6 - Internet Protocol, version 6
ISI - Information Sciences Institute
IT - Information technology
IT R&D - Information technology research and development
IU - Indiana University
IWG - Interagency Working Group
JET - LSN's Joint Engineering Team
JETnets - Federal research networks supporting networking researchers and advanced applications development
K-12 - Kindergarten through 12th grade
LANdroids - DARPA networking R&D program
LANL - DOE's Los Alamos National Laboratory
LBNL - DOE's Lawrence-Berkeley National Laboratory
LCF - DOE's Leadership Computing Facility
LSN - Large Scale Networking, one of NITRD's eight Program Component Areas
MAGIC - LSN's Middleware and Grid Infrastructure Coordination team
MANET - Mobile ad hoc network
MAX - Mid-Atlantic eXchange
MCAR - Mixed Criticality Architecture Requirements
MCNC - Microelectronics Center of North Carolina
MIDAS - NIH's Modeling of Infectious Disease Agents Study
MPI - Message-passing interface
MURI - Multidisciplinary University Research Initiative
NARA - National Archives and Records Administration
NASA - National Aeronautics and Space Administration
NationalLambda Rail - Consortium of organizations working to provide an optical network for research
NCAR - NSF-supported National Center for Atmospheric Research
NCBC - NIH's National Centers for Biomedical Computing
NCLS - NASA's National Leadership Computing System
NCO - National Coordination Office for NITRD
NERSC - DOE/SC's National Energy Research Scientific Computing Center
NETS - NSF's Networking Technology and Systems program
NIH - National Institutes of Health
NIJ - DOJ's National Institute for Justice
NIST - National Institute of Standards and Technology
NITRD - Networking and Information Technology Research and Development
NLANR - NSF-supported National Laboratory for Applied Network Research
NLM - NIH's National Library of Medicine
NOAA - National Oceanic and Atmospheric Administration
NRL - Naval Research Laboratory
NRT - LSN's Networking Research Team
NSA - National Security Agency
NSF - National Science Foundation
NSTC - National Science and Technology Council
OECD - Organisation for Economic Co-operation and Development
OMB - White House Office of Management and Budget
OMNInet - Large-scale metro optical network testbed supported by national labs, universities, Canadian organizations, and vendor partners
ONR - Office of Naval Research
ONT - Optical networking testbed
Optiputer - NSF-funded five-year project to interconnect distributed storage, computing, and visualization resources using photonic networks
ORBIT - NSF-supported Open Access Research Testbed for Next-Generation Wireless Networks
ORCA - Online Representations and Certifications Application
ORNL - DOE's Oak Ridge National Laboratory
OSCARS - DOE/SC's On-Demand Secure Circuits and Advance. Reservation System
OSD - Office of the Secretary of Defense
OSG - Open Science Grid
OSTP - White House Office of Science and Technology Policy
P25 - Project 25, a standards development process for design, manufacture, and evaluation of interoperable wireless communications products for public safety professionals
PCA - Program Component Area
PCAST - President's Council of Advisors on Science and Technology
PF - Petaflop(s), a thousand teraflops
PI - Principal investigator
PNL - DOE's Pacific Northwest Laboratory
PSC - NSF-supported Pittsburgh Supercomputing Center
QoS - Quality of service
QuERIES - DoD's Quantitative Evaluation of Risk for Investment-Efficient Strategies program
R&D - Research and development
RF - Radio frequency
RFID - Radio frequency identification
RTOS - Real-time operating system
SAFE - NSF-supported Situational Awareness for Everyone center
SAPIENT - NSF's Situation-Aware Protocols In Edge Network Technologies program
SATCOM-CX - DARPA-supported SATellite COMmunications research program
SCADA - Supervisory control and data acquisition
SCAP - Security Content Automation Protocol
SciDAC - DOE/SC's Scientific Discovery through Advanced Computing program
SDP - Software Design and Productivity, one of NITRD's eight Program Component Areas
SEBML - NSF's Science and Engineering Beyond Moore's Law program
SEW - Social, Economic, and Workforce Implications of IT and IT Workforce Development, one of NITRD's eight Program Component Areas
SING - NSF's Scientific Foundations for Internet's Next Generation program
SIP – Session Initiation Protocol
SoS - Systems-of-systems
SPRUCE - Systems and Software Producibility Collaboration and Evaluation Environment
StarLight - NSF-supported international optical network peering point in Chicago
State - Department of State
SUP - Secure unattended proxy
SVP - Secure virtualization platform
TCIP - NSF-supported Trustworthy Cyber Infrastructure for the Power grid
TeraGrid - NSF's terascale computing grid
TF - Teraflop(s), a trillion floating point operations (per second)
TLCC07 - DOE/NNSA's Tri-Laboratory Linux Capacity Cluster
TPM - Telepresence mode
Treasury - Department of the Treasury
TREC - Text REtrieval Conference
TrUST - DARPA's Trusted, Uncompromised Semiconductor Technology program

TRUST - NSF's Team for Research in Ubiquitous Secure Technology
TSWG - Technical Support Working Group
TTCP - The Technical Cooperation Program
UCAR - University Corporation for Atmospheric Research
UIC - University of Illinois at Chicago
UIUC - University of Illinois at Urbana-Champaign
ULS - Ultra-large-scale systems
UMd - University of Maryland
UNC - University of North Carolina
USDA – U.S. Department of Agriculture
USGS - U.S. Geological Survey
UU - University of Utah
UW - University of Washington
UWisc - University of Wisconsin
V&V - Verification and validation
VINI - NSF-supported VIrtual Network Infrastructure program
VPN - Virtual private network
VSTTE - Verified software, theories, tools, and experiments
WAN - Wide area network
XBRL - eXtensible Business Reporting Language
XML - eXtensible Markup Language
XT4 - HEC system at DOE/SC's National Energy Research Scientific Computing Center

National Coordination Office (NCO) for
Networking and Information Technology Research and Development (NITRD)

Christopher L. Greer, Ph.D.
Director

Sally E. Howe, Ph.D.
Associate Director
Executive Editor, FY 2009
NITRD Budget Supplement

Martha K. Matzke
Editor, FY 2009
NITRD Budget Supplement

Suite II-405
4201 Wilson Boulevard
Arlington, Virginia 22230
(703) 292-4873
FAX: (703) 292-9097
nco@nitrd.gov

Web Site
http://www.nitrd.gov

Acknowledgements

Developing the content for the FY 2009 Supplement required technical information from and support by a large number of Federal agency representatives involved in NITRD Program activities and by NCO technical and administrative staff. The editors extend sincerest thanks and appreciation to all.

Contributors

Michael Ackerman, NIH
Nekeia Bell, NCO
Trudy E. Bell, NCO
Bryan A. Biegel, NASA
Paul E. Black, NIST
Robert B. Bohn, NCO
Robert Bonneau, AFOSR
Raymond A. Bortner, AFRL
Robert Chadduck, NARA
Almadena Y. Chtchelkanova, NSF
Zohara Cohen, NIH
Leslie Collica, NIST
Deborah L. Crawford, NSF
Candace S. Culhane, NSA
Warren Debany, AFRL
David Ferraiolo, NIST
J. Michael Fitzmaurice, AHRQ
Michael Foster, NSF
Simon Frechette, NIST
Kenneth Freeman, NASA
Judith Froscher, ONR, NRL
Cita M. Furlani, NIST
Dan Gallahan, NIH
Helen Gill, NSF
Robert Gold, OSD
Kevin Harnett, DOT
Cray J. Henry, HCPMP
Alan Hevner, NSF
Thomas Hinke, NASA
Daniel A. Hitchcock, DOE/SC
Thuc T. Hoang, DOE/NNSA
David Homan, AFOSR
C. Suzanne Iacono, NSF
Frederick C. Johnson, DOE/SC
Rodger Johnson, DREN
Paul Jones, FDA
Henry Kenchington, DOE/OE
Frankie D. King, NCO
Steven King, OSD
Rita Koch, NSF
Annabelle Lee, DHS
Sander L. Lee, DOE/NNSA
Tsengdar Lee, NASA
Karl Levitt, NSF
Stephen Lucas, ARO, ARL, CERDEC
David Luginbuhl, AFOSR
Peter Lyster, NIH
Allison Mankin, NSF
Paul Mansfield, NSA
Michael Marron, NIH
William Bradley Martin, NSA
Wendy Martinez, ONR
Ernest L. McDuffie, NCO
Piyush Mehrotra, NASA
Robert Meisner, DOE/NNSA
Scott Midkiff, NSF
Grant Miller, NCO
Paul Miner, NASA
Virginia Moore, NCO
José L. Muñoz, NSF
Thomas Ndousse, DOE/SC
Richard Nelson, DISA
William D. Newhouse, DoD
Mark Powell, FAA
Karin A. Remington, NIH
Kamie Roberts, NIST
Stephen Roznowski, NSA
Mark Schneider, NSA
William J. Semancik, NSA
William Spees, FDA
Sylvia Spengler, NSF
Michael Strayer, DOE/SC
David Su, NIST
Judith D. Terrill, NIST
Anthony J. Tether, DARPA
Diane R. Theiss, NCO
Susan B. Turnbull, GSA
William T. Turnbull, NOAA
Gary L. Walter, EPA
Cliff Wang, ARO
Al Wavering, NIST
Alan Welday, HPCMP

National Coordination Office for Networking and Information Technology Research and Development
The annual NITRD Supplement to the President's Budget is prepared and published by the National Coordination Office for Networking and Information Technology Research and Development (NCO/NITRD). The NCO/NITRD supports overall planning, budget, and assessment activities for the multiagency NITRD enterprise under the auspices of the NITRD Subcommittee of the National Science and Technology Council's Committee on Technology.

To Request Additional Copies
To request additional copies of this Supplement to the President's FY 2008 Budget or other NITRD Program publications, please contact: NCO/NITRD, Suite II-405, 4201 Wilson Boulevard, Arlington, Virginia 22230; (703) 292-4873; fax: (703) 292-9097; e-mail: nco@nitrd.gov. Electronic versions of NITRD documents are also available on the NCO Web site: *http://www.nitrd.gov*.

Buy American Report
Congress requires information concerning non-U.S. high-performance computing and communications funding activities. In FY 2008, no NITRD agency entered into grants, contracts, cooperative agreements, or cooperative research and development agreements for information technology research and development with either 1) a company other than a company that is either incorporated or located in the U.S. and that has majority ownership by individuals who are citizens of the U.S., or 2) an educational institution or nonprofit institution located outside the U.S. In FY 2008, no NITRD procurement exceeds $1 million for unmanufactured articles, materials, or supplies mined or produced outside the U.S., or for manufactured articles, materials, or supplies other than those manufactured in the U.S. substantially all from articles, materials, or supplies mined, produced, or manufactured in the U.S.

Cover design and printing: The cover was designed by NSF Scientific Designer/Illustrator James J. Caras and printing was overseen by Electronic Publishing Specialist Kelly DuBose, both of the Information Dissemination Branch of NSF's Office of Information and Resource Management.

National Science and Technology Council

Subcommittee on Networking and
Information Technology Research and Development
Suite II - 405, 4201 Wilson Blvd., Arlington, Virginia 22230
(703) 292-4873
http://www.nitrd.gov