NITRD

FY 2010

Networking and Information Technology Research and Development

Supplement to the President's Budget

May 2009

SUPPLEMENT TO THE PRESIDENT'S BUDGET

FOR FISCAL YEAR 2010

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

May 2009

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

May 14, 2009

MEMBERS OF CONGRESS:

I am pleased to forward with this letter the annual report on the Federal government's multiagency Networking and Information Technology Research and Development (NITRD) Program. The NITRD effort, comprising 13 member agencies and many more that participate in NITRD activities, exemplifies the central role of scientific research in laying new foundations for long-term U.S. economic growth and prosperity.

The advanced networking and computing technologies developed through sustained Federal R&D investments catalyzed the emergence of the digital age, transforming communications, commerce, science, government, and social interactions around the globe. Today, the work of the NITRD agencies is more essential than ever to ensure the U.S. continues to lead in a fast-paced, digital world. Networking and information technology R&D innovations providing next-generation tools and capabilities are needed to advance our national security and defense, understand and act upon environmental stresses, reform the health care system, increase energy efficiencies and develop renewable energy sources, strengthen the security of our critical infrastructures, including cyberspace, and revitalize our educational system.

The coordinated and collaborative research activities described in this Supplement to the President's 2010 Budget leverage Federal research dollars across the NITRD agencies to generate cost-effective and broadly useful results that no single agency could attain. This report describes the creative and effective partnerships for NIT innovation conducted across the Federal government. Thank you for your interest in this vital Federal research activity.

Sincerely,

John P. Holdren
Director

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Introduction and Overview

This Supplement to the President's Fiscal Year (FY) 2010 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), the Next Generation Internet Research Act of 1998 (P.L. 105-305), and the America COMPETES Act of 2007 (P.L. 110-69). The NITRD Program, now in its 18th year, provides a framework and mechanisms for coordination among Federal agencies that support R&D in advanced networking and information technology. Considered a model of effective multiagency collaboration, the Program is one of the few such activities in the Federal government.

The NITRD Supplement describes the FY 2010 networking and information technology R&D plans and current technical and coordination activities of the 13 Federal agencies currently 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.

NITRD activities and plans are coordinated in 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 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, the Supplement presents, in brief, the interagency strategic priorities underlying the 2010 budget request, programmatic highlights of the request, ongoing and anticipated interagency planning and coordination activities, and additional technical activities, by agency. NITRD agencies engaged in various R&D and coordination activities are listed in NITRD budget order followed by the other agencies participating in the activity; if there is a lead agency for the activity, that agency is listed first; agencies listed after the word "with" are in-kind contributors 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.

The President's 2010 budget request for the NITRD Program is $3.926 billion; the 2009 NITRD budget estimate totaled $3.882 billion. Details of the NITRD budget, including 2009 estimates and 2010 requests by agency and by PCA, are presented in the budget table on page 21 and discussed in the budget analysis beginning on page 23.

Within the past year, the NITRD Program has been tasked with expanded responsibilities for coordination of Federal cyber R&D. Details of these new activities are described on page 9.

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

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

NITRD Agencies: NSF, NIH, DOE/SC, OSD and DoD Service research organizations, NIST, NASA, NOAA, DOE/NNSA, 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 2010 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 scientific and engineering applications software 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 at the University of Tennessee becomes operational

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

DOE/SC: Upgrade LCF system at ORNL to 1.6 PF (early FY 2009); expansion of ANL's LCF resources by upgrading BlueGene/P to 550 TF; NERSC 360-TF XT4 in full production and integrated into a common high-performance file system

OSD (HPCMP): Modernize HEC platforms and data-storage subsystems at multiple supercomputing centers

NASA: Upgrade supercomputing resources at Ames (including the 500 TF Pleiades system) and Goddard to 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 full system; deploy and operate the Tri-Laboratory Linux Capacity Clusters (TLCCs); initiate operation of Sequoia Initial Delivery (ID) system, also known as "Dawn"

Applications

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

NIH: Scientific computing efforts such as biomolecular modeling, physiological modeling, and multiscale modeling that use HEC resources or are in pre-HEC state.

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

OSD (HPCMP): CREATE program continues development of highly scalable application codes (aircraft, ships, antennae); HPC software institutes continue support for selected mission applications

NIST: Mathematical modeling, computational simulation, high-end visualization for measurement science, modeling of hydration, flow of cement and concrete, nano-optics, atomic properties, and structure of buildings

NASA: Enable increased scale and enhanced fidelity in aerospace, Earth science, and astrophysics modeling

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

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

EPA: Applications in computational toxicology (toxicity modeling and toxicology database development), 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

NIH: Grid computing infrastructure and tools for R&D (e.g., BIRN, CaBIG, BISTI, CVRG)

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

OSD (HPCMP): Operate, sustain supercomputing centers and support services for DoD RDT&E programs

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

NASA: Increase commonality and enhance or adopt operational best practices across computing centers

NOAA: Explore ways to coordinate Federal HEC resources "on demand" (surge computing) for critical events and continue to explore proof of concept partnerships for hurricane, weather, and climate-change modeling

DOE/NNSA: Develop ASC common operating environment for deployment across its national lab platforms

EPA: Continue building data and information exchange components, 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, NIST, NOAA, DOE/NNSA

System reviews, benchmarking: Collaborations – NSF, DOE/SC, NSA, NASA, NOAA, DOE/NNSA

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

Multiscale modeling in biomedical, biological, and behavioral systems: Interagency collaboration to advance modeling of complex living systems (e.g., Interagency Modeling and Analysis Group (IMAG) multiscale modeling initiative, MIDAS Project) – NSF, NIH, OSD

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

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

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

Additional 2009 and 2010 Activities by Agency

NSF: Support Data-intensive Computing program projects that increase ability to build, use systems and applications; expand TeraGrid to include new systems; develop cyberinfrastructure software (e.g., for debugging, fault tolerance, performance tuning, middleware, data handling); operational support for TeraGrid

NIH: International networks for biomedical data, software sharing; NIH Roadmap National Centers for Biomedical Computing (NCBCs); Cancer Imaging and Computational Centers; P41 computational centers; NLM servers; bioinformatics centers; proteomics, 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

OSD (HPCMP): HEC services for R&D and test communities (e.g., platforms, computational science software support); computational science institutes for DoD priorities (air armament, health force protection, weather prediction, ground sensors, space situational awareness, rotorcraft, networks, microwaves, munitions)

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

NASA: Advance visual supercomputing with hyperwalls and concurrent visualization; broaden HEC user base

NOAA: Detailed design for next-generation NOAA HPC architecture optimizing number, locations of HPC systems; award systems integration contract for planning and migration to the next-generation architecture

DOE/NNSA: Support production-level systems and software environments for weapons stockpile program and continue computing-related transformational activities under the Nuclear Weapons Complex Initiative

EPA: 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, DOE/SC, OSD and DoD Service research organizations, NSA, NIST, NASA, NOAA, DOE/NNSA

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 2010 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

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

Planning and Coordination Supporting Request

Planning

Technical and planning workshops: Annual File System and I/O Workshop to coordinate HEC-URA effort; Federal Application Benchmark Workshop to plan multiagency benchmarking activity – NSF, DARPA, DOE/SC, OSD, 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, DOE/SC, OSD, NIST, NASA, NOAA, DOE/NNSA

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, DOE/SC, NSA, NASA, DOE/NNSA

Additional 2009 and 2010 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 Cyber-enabled Discovery and Innovation (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)

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

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

NSA: Center for Exceptional Computing (hosts visiting scholars); continuation of the Integrated High End Computing program

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

Cyber Security and Information Assurance (CSIA)

NITRD Agencies: NSF, DARPA, OSD and DoD Service research organizations, NSA, NIST, NASA
Other Participants: DHS, DISA, 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 2010 Request

Strategic Priorities Underlying This Request

R&D priority areas for the CSIA agencies range from fundamental investigation of scientific bases for hardware, software, and system security to applied research in security technologies and methods, approaches to cyber defense and attack mitigation, and infrastructure for realistic experiments and testing. Emphases include:

Foundations: Foundations of cyber security as a multidisciplinary science; new models, logics, algorithms, and theories for analyzing and reasoning about reliability, security, privacy, and usability; new analyzable and decomposable security models; harmonization of risk (security and safety) modeling frameworks; assured and trustworthy systems and compositions of systems from untrustworthy components; cyber security metrics; social and technical dimensions of a trustworthy computing future; foundation for modeling risk and contributing factors in characteristics and behaviors of organizations, groups, and individuals – including semantics of trust; secure software engineering and development; cryptography and quantum computation-resistant cryptography

Applied and information infrastructure security: Secure virtual platforms; assured information sharing; security for emerging network technologies (mobile, wireless, pervasive computing); identity management principles, frameworks, standards, models, and technologies; security automation; secure protocols; vulnerability detection and mitigation

Situational awareness and response: Full-spectrum, multi-layer cyber attack indications and warnings, detection, assessment, and attribution; assured operations in high threat environments; security event visualization; cognitive policy-based security systems and management

Infrastructure for R&D: Testbeds, ranges, tools, platforms, repositories to support cyber security experimentation

Highlights of Request

Foundations

Cyber Trust Centers: Team for Research in Ubiquitous Secure Technology (TRUST); A Center for Correct, Usable, Reliable, Auditable, & Transparent Elections (ACCURATE); Collaborative Center for Internet Epidemiology & Defenses (CCIED); Trustworthy Cyber Infrastructure for the Power Grid (TCIP); Security Through Interaction Modeling (STIM, now SAFE) – NSF

Secure software engineering: Metrics for cost-benefit and risk analysis tools (e.g., OSD's QuERIES); identify operational security practices for early phases of systems development life cycle; formal methods for validation, verification of composable systems; scalable secure systems; lightweight analysis – NSF, OSD, NIST, DHS

Software protection: Function extraction technologies to automate the computation of software behavior; embedded software security technologies; software cross-domain security; malicious code detection, mitigation, and prevention; software anti-tamper – DARPA. OSD, ARO, CERDEC, ONR, NSA

Hardware and firmware security: Virtualization technologies (e.g., NSA's Secure Virtual Platform); secure OS; encryption of data in memory; security processors; high-performance intrusion-detection technologies and trusted platform modules – NSA, NSF, OSD, AFRL

Cryptography: Cryptographic algorithms and engineering for increasing network speeds; cryptographic key management; quantum cryptographic methods and standards; quantum information science and security; quantum computation-resistant cryptography – NSA, NSF, DARPA, ONR, NIST

Applied and information infrastructure security

Security management infrastructure: Policy-based access control systems; principles, frameworks, models, and 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); next-generation biometric measurements and standards – NSF, DARPA, OSD, AFRL, ARO, CERDEC, NSA, NIST

Cyber Conflict Defense S&T: Harden key networks and systems; assure missions; defenses to disrupt adversaries' cyber preparation and execution – DARPA, OSD

Assured information sharing: DoD-wide priority to enhance technologies and tools to secure communications and data sharing across multiple, heterogeneous networks, platforms, and security levels; demonstrate secure collaboration through cyber sensing station – OSD and DoD Service research organizations, NSA

Information Security Automation Program (ISAP): Multiagency initiative to enable automation and standardization of technical security operations; applying Security Content Automation Protocol (SCAP), a method for using specific standards to enable automated vulnerability management, measurement, and policy compliance evaluation (e.g., FISMA compliance) – NIST, OSD, NSA, DHS, DISA

Mobile wireless and sensor networks: Security architectures for airborne/enclave networks, security of classified information on wireless networks; assured access anti-jam communications (physical layer information assurance); wireless, optical geolocation; trustworthy information delivery in mobile tactical systems (including sensor networks); secure handover for roaming between heterogeneous networks – NSF, DARPA, OSD, AFRL, ARO, NSA, NIST

Situational awareness and response

Network protection and defense: Technologies and tools for situational awareness across organizations; threat anticipation and avoidance; attack sensing, warning, and response; cognitive policy-based intrusion protection and detection; rapid response (containment, adaptation, repair, self-regeneration); behavior-based network monitoring and active defense; defense against large-scale attacks (e.g., DDoS, worms, botnets, spyware); routing security management tool; traceback, attribution, real-time forensics; prototype cyber operations center; security of emerging net-centric systems of systems and strategic computing resources – NSF, DARPA, OSD, AFRL, ARL, ARO, CERDEC, HPCMP, ONR, NSA, NIST, NASA, DHS

Infrastructure R&D

National Cyber Range (NCR): Enable a revolution in the Nation's ability to conduct cyber operations and defend against cyber threats by providing a persistent cyber testing range – DARPA

Experimental Research Testbed (DETER): experimental infrastructure to support next-generation cyber security technologies; allows repeatable medium-scale Internet emulation experiments – DHS, NSF

Information infrastructure security: Secure protocols; Domain Name System Security (DNSSEC); process control systems security; Internet route monitoring; modeling of Internet attacks – NIST, DHS, GSA, OMB

Protected Repository for the Defense of Infrastructure Against Cyber Threats (PREDICT): research data repository to create and develop new models, technologies, and products to assess cyber threats to the country's computing infrastructure and increase cyber security capabilities – DHS

Standards, testing, and metrics: Quantitative risk-analysis methods and tools; evidence-based security metrics; 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; reliable information-assurance metrics; leadership in national and international standards bodies – NIST, NSF, OSD, ARL, ARO, DHS

Planning and Coordination Supporting Request

Co-funding: Cyber Trust awards (secure processing core, formal verification, detection of security-related software errors) – NSF, DARPA; TCIP Center – NSF, DOE, DHS; biometrics – NSF, DHS; National Cyber Defense Initiative (NCDI) – NSF, DNI, DoD, DHS; National Centers of Academic Excellence in Information Assurance Education and Research – NSA, DHS; joint support for developing technologies to help law enforcement detect and attribute cyber crimes – AFRL, NIJ, U.S. Secret Service, law enforcement agencies

Workshops: Security/privacy for sensor nets and embedded systems – NSF, ARO; privacy and data confidentiality – NSF, IT vendors

Joint solicitations: Planning for joint effort on confidentiality and usability of research data – NSF, NIH; discussions toward collaboration on secure and resilient recovery mitigation of systems against insider attacks – NSF, Treasury

Collaborative deployment: Coordinate testing and deployment of DoD software-protection technologies within the DOE HPC environment – OSD, AFRL, DOE/NNSA

Interagency cooperation: Ongoing information exchanges on vulnerability assessment: auditing; DoS-attack mitigation; firewalls; access control; botnet detection – DHS, ONR, AFRL

Technical standards: Developing, maintaining, and coordinating validation programs for many cryptographic standards – NIST, NSA; participation in IETF security groups to develop standard representations and corresponding reference implementations of security-relevant data – OSD, NSA, NIST

Testbeds: Continued joint development of research testbeds, such as DETER, PREDICT, Web*DECIDE – NSF, DHS, Treasury

INFOSEC Research Council: Participation in technical forum for coordination of ongoing Federal R&D – CSIA agencies

Additional 2009 and 2010 Activities by Agency

NSF: Trustworthy Computing (formerly Cyber Trust) program seeking new models, logics, algorithms, and theories for analyzing and reasoning about all aspects of trustworthiness (reliability, security, privacy, and usability); fundamentals of cryptography; remediation of security weaknesses in current algorithms or protocols; exploration of new computing models that promise to improve trustworthiness

DOE/SC: Planning for basic research in cyber security focused on the unique needs of open science networks and scientific computing facilities; current interests are mathematics of large datasets to address fundamental issues in finding key features and meeting extreme-scale computing challenges, risk assessment in complex systems

OSD: Continue to lead DoD coordination through the DoD Information Assurance S&T Steering Council; continued focus on multidisciplinary university research (MURI) awards; leading the development of software-protection techniques

AFRL: Cyber Science (fault tolerance, botnet and anomaly detection, applications of game theory, fundamental scientific basis for Cybercraft); integrated cyber defense to ensure continued mission operations

ARO/ARL/CERDEC: Army Cryptographic Modernization Office; tactical security tools evaluations; biometric pilot programs; information assurance program support

ONR: Cyberspace and complex software; botnets; software producibility with a focus on security

NSA: Developing low cost, high assurance, programmable, "easier" to certify guard; privilege-management capability for information sharing in dynamic policy environments; leveraging commodity hardware, virtualization, measurement, and attestation to develop Secure Virtual Platform

NIST: Federal Computer Security Program Managers' Forums; technical and managerial guidance, standards; global electronic ID verification; international hash competition; product assurance research; voting security; Software Analysis Tool Exposition (SATE): analysis and evaluation of software assessment tools and technologies to advance integrity, security, and reliability in software; advanced models, methods, technologies, and standards to enhance software experimentation, testing, and measurement

DHS: DHS Secure Wireless Access Pilot (DSWAP); IronKey Pilot (1,000+ users across DHS); network data visualization for information assurance; Internet tomography; data anonymization tools, techniques

IARPA: Large-scale system defense; accountable information flow; network-event data visualization; network-attack traceback; National Intelligence Community Enterprise Cyber Assurance Program (NICECAP)

NITRD Program Assigned Key Role in Coordinating Cyber Security R&D

The NITRD Program has been tasked with coordinating unclassified Federal R&D cyber security efforts. In February 2008, the Office of Science and Technology Policy (OSTP) called for an Interagency Task Force from NITRD agencies and others to develop two research-related plans on a fast-track basis. To expedite quick turnaround on this tasking, the 21 task force members divided into two groups. One developed a plan for overall coordination of the Federal cyber R&D portfolio; the other crafted a plan – called "Leap-Ahead" – for accelerating high-risk, high-return research to help maintain the Nation's technological edge in cyberspace. Both plans cited NITRD's long track record in multiagency R&D planning and collaboration as positioning the Program to move ahead quickly. For example, the 2006 *Federal Plan for Cyber Security and Information Assurance Research and Development* developed by the NITRD Program's Cyber Security and Information Assurance Interagency Working Group (CSIA IWG) provides a detailed technical baseline that can guide setting Federal cyber R&D priorities.

The CSIA IWG has been augmented by a new Senior Steering Group (SSG) for cyber security (with members representing both classified and unclassified sectors) and has assumed two new assignments: leading the cyber R&D coordination activity and coordinating the focused "Leap-Ahead" initiative. The two activities are shaped by the following *first principles*: Improve synergy between classified and unclassified Federal research; enable a broad multidisciplinary, multisector effort; engage the widest possible range of stakeholders across the public and private sectors; exploit all existing R&D models and develop new, streamlined approaches for high-risk/high-payoff R&D; and implement an end-to-end strategy including basic and applied research for invention and innovation; prototyping, development, hardening, and commercialization for deployment, adoption, and diffusion; and maintenance, refinement, and evolution for operational management and continuity.

In October 2008, the SSG formally launched the National Cyber Leap Year, a novel two-stage effort to seek out "a few revolutionary ideas with the potential to reshape the cyber security landscape." The Cyber Leap Year's goals are: (1) constructing a national research and technology agenda that both identifies the most promising ideas and describes the strategy that brings those ideas to fruition; and (2) jumpstarting game-changing, multidisciplinary development efforts. In three broadly distributed Requests for Input (RFIs), the SSG invited interested stakeholders across all public and private sectors to submit either technology concepts or mechanisms based on technologies that would make it possible for the United States to leap ahead of current barriers to improved cyber security and fundamentally "change the game" within a decade. The RFI called for proposals in three categories: "morph the gameboard" (e.g., ideas that make it harder for attackers to maneuver), "change the rules" (e.g., ideas that change network protocols to favor society's values), or "raise the stakes" (e.g., ideas that make it costlier and riskier to attack).

A total of 238 responses was received from 158 submitters. Five categories for potential game-changing initiatives emerged from combinations of innovative submissions received under the RFIs. These five categories will provide the focus for a national cyber security summit planned for summer 2009. The results of the summit will guide the development of a leap-ahead plan for focused cyber security R&D activities.

Human Computer Interaction and Information Management (HCI&IM)

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

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 2010 Request

Strategic Priorities Underlying This Request

Information integration: To support complex human ideas, analysis, and timely decision-making, large amounts of multi-source forms of raw information must be managed, assimilated, visualized, and accessible in formats responsive to the user's needs. Information discovery, use, sharing, and re-purposing across domains will require next-generation methods, technologies, and tools to fully integrate and efficiently manage massive stores of distributed, heterogeneous information (e.g., ultra-large-scale science and engineering research data, Federal records, health information). Key research areas include:

- **Information standards:** Data interoperability, integration of distributed data; generalizable ontologies; data format description language (DFDL) for electronic records and data; data structure research for complex digital objects; interoperability standards for semantically understood ubiquitous health information exchanges
- **Decision support:** Portals and frameworks for data, processes; user-oriented techniques, tools for information summarization, synthesis, analysis, visualization for decision making; mobile, distributed information for emergency personnel; measurement, management of human responses to data; collaborative information triage
- **Information management:** Intelligent rule-based data management; access to and cost-effective integration, meta-analysis, and maintenance of complex, large-scale collections of heterogeneous data; innovative architectures for data-intensive computing; scalable technologies; integration of policies (differential sensitivity, security, user authentication) with data; integrated distributed data repositories and computing grids; testbeds; sustainability and validation of complex models

Information infrastructure: Unsolved technical challenges in management of the Federal government's electronic records; technologies (data transfer, mass storage), and tools for long-term preservation, curation, sustainability, accessibility, and survivability of vital electronic records, digital data collections, and health records; multidisciplinary R&D in ways to convert data into knowledge and discovery; virtual organizations

Active systems: Systems that learn, reason, and automatically adapt to new and unforeseen events; onboard autonomy; intelligent sensing and control systems; robotic devices for emergency response, urban search and rescue, bomb disposal, and exploration

Highlights of Request

Effective stewardship of science and engineering data: Issues in access to and federation, preservation, curation, and analysis of large, heterogeneous collections of scientific data, information, and records – NSF, NIH, NIST, NASA, NOAA, EPA, NARA

Data-Intensive Computing: New cross-cutting focus on innovative approaches to processing, retrieving, exploring, analyzing, and communicating about ultra-large data stores by exploiting massive parallelism; address broad needs of data-intensive science for new concepts, tools, and systems – NSF

Cognitive and adaptive systems: Apply cognitive and perceptual modeling to joint cognitive systems design; decision-support systems/tools; improve performance (autonomy, trustworthiness, reliability) of automated and robotic systems; intelligent robots; human-robot teaming; affective computing – NSF, DARPA, NIST, NASA

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, NIST, NARA, IARPA

Information integration, accessibility, and management: Advanced technologies, system architectures, and tools for highly optimizable, scalable ingest and processing; high-capacity data integration, management, exploitation, and grid computing with increasingly complex, heterogeneous scientific data; fusion of massive-scale data sets; modeling, analysis, visualization techniques and tools; ontologies and metadata; efficient data access, transmission; automated integration; image understanding – NSF, NIH, NIST, NASA, AHRQ, NOAA, EPA, NARA

Cyber-enabled Discovery and Innovation: Multidisciplinary research on creation of new knowledge from digital data, including novel algorithms, data mining, dimension-reduction methods; visualization methods to enhance human cognition; technologies for data confidentiality, privacy, security, provenance, and regulatory issues – NSF

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

Human-in-the-loop: HCI and systems integration; personalization in design; decision-support systems and tools; distributed collaboration and knowledge management, virtual organizations; computational cognitive and perceptual process modeling and measurement; virtual reality technologies for simulation and training, user-controlled data abstraction, visualization, and display – NSF, DARPA, NIST, NASA, NOAA, EPA

Text Retrieval Conference and TREC Video Retrieval: Evaluation of information-discovery technologies; relevance feedback; legal discovery; recognition of opinion in blogs – NIST, NSF, NARA. IARPA

Planning and Coordination Supporting Request

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

Data mining and data-intensive computing: Joint funding and programs – NSF, DHS, other agencies

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

Information access, management, and preservation: Collaborations in IWG on Digital Data; scalable repository architectures; data management and decision-support technologies; data grids – NSF, NIST, NASA, NARA

Multiscale modeling: Exploration, joint program development in areas of mutual interest – NSF, NIH; Earth System Modeling Framework – NASA, NSF, DOE/SC, NOAA, other agencies

Visualization: Multimodal, cross-group coordination to consider feature extraction for anomaly detection; integration of multiple types of data and records at scale or format; use of visualization as an interface – NSF, NIH, NIST, NASA, NOAA, EPA, NARA, other agencies

Additional 2009 and 2010 Activities by Agency

NSF: Academic R&D in information privacy; machine vision technology; integrative intelligence (systems of agents, modalities, domains); data in ubiquitous network environments; human-computer partnerships; socially intelligent computing; universal access

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

NIST: Biometrics evaluation, usability, and standards (fingerprint, face, iris, voice/speaker, multimodal biometrics); multimedia evaluation methods (video retrieval, audio and video analysis, smart-space technologies, medical imaging); evaluation and measurement tools for 3D shape searching; digital data preservation metrology and standards; usability of voting systems; ontologies for manufacturing information integration, supply chain; measurement and standards for manufacturing robots; engineering informatics sustainability

NASA: Constellation Problem Reporting and Corrective Action (PRACA) System; flight-deck prototypes for new exploration vehicle (Orion); IM for flight controllers; human-centered automation for aviation safety; decision-support technologies for Next Generation Air Traffic Management; education outreach technologies

AHRQ: Patient safety, quality improvement program in ambulatory care; regional, state, patient safety organization health information networks

NOAA: Technologies for providing real-time weather and climate data in multiple formats for scientists, forecasters, first responders, and citizens; regional climate visualization; disaster planning, mitigation, response, and recovery

EPA: Focus on knowledge bases and databases for computational toxicology; technologies to improve visualization of distributed data and models; pilot projects for distribution and search of environmental data

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

ONC: Health care IT data standards; metrics of economic implications of health IT

Large Scale Networking (LSN)

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

LSN members coordinate Federal agency networking R&D in leading-edge networking technologies, services, and enhanced performance, including programs in network security, future Internet design, heterogeneous multimedia community testbeds; middleware, end-to-end performance measurement, networks for disaster response, network science and engineering of complex networks; advanced networking components, grid and collaboration networking tools and services; and engineering, management, and enabling large-scale networks for scientific and applications R&D including large-scale data transfers and virtual organization functionality. 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 to support user applications.

President's 2010 Request

Strategic Priorities Underlying This Request

Federal Plan for Advanced Networking Research and Development: Build on the *Federal Plan* and the FY 2008 Networking Research Challenges Workshop to develop programs and plans addressing critical technical challenges in networking security, heterogeneous networking, multidomain transparency and functionality, and advanced technologies and applications

Virtual organizations (VOs) over networking: Enable VO environments providing seamless services over multidomain heterogeneous networks through identity management, performance measurement, resource access and allocation, and common middleware

Performance measurement over multimedia, multidomain networks: Identify middleware, coordination, tools, and research needed to enable performance measurement across heterogeneous network domains for network security, management, and troubleshooting

Highlights of Request

Fundamental research in networking: Develop concepts and methods for modeling networks as complex, autonomous, and dynamic systems – NSF, DARPA, DOE/SC, NIST

Innovative architectures: Develop network architecture concepts to enable robust, secure, flexible, dynamic, heterogeneous future networking capabilities – NSF, DARPA, DOE/SC, OSD, NASA

Network security research: Technologies for detection of anomalous behavior, quarantines; standards, modeling, and measurement to achieve end-to-end security over heterogeneous, multidomain networks and infrastructure for open science; critical infrastructure protection; trustworthy networking; privacy, confidentiality, authentication, policy, cryptography, and quantum communication – NSF, NIH, DARPA, DOE/SC, OSD, NIST, NASA

Security implementation (IPv6, DNSsec and Trusted Internet Connections [TICs]): Develop and implement near-term mandated capabilities – NSF, NIH, DOE/SC, OSD, NSA, NIST, NASA

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

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

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

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

Community testbeds, grid access to resources: Technologies, protocols, and tools to enable secure resource sharing by heterogeneous, dynamic users in large-scale science efforts – NSF, NIH, DARPA, DOE/SC, OSD

Public-safety networking, disaster recovery, and crisis management: Disaster Information Management Research Center, public-safety communications, implant communication system – NIH (NLM), NIST

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, DOE/SC, OSD, NASA, NOAA
Delay-tolerant networking: Protocols, methods for interoperability – NSF, DARPA, OSD, NSA, NASA
E2e performance monitoring/measurement: Methods, tools, testbeds – NSF, DOE/SC, OSD, NSA, NIST, NASA
Cyber-physical systems: Networking for trustworthy, reliable cyber-physical systems – NSF

Planning and Coordination Supporting Request
Interagency research agenda: *Federal Plan for Advanced Networking R&D* including matrix of R&D priorities pointing to the middle of the next decade, Networking Research Challenges Workshop – LSN agencies
Cooperative R&D efforts: Networking research projects (NSF, DARPA, DOE/SC); efficiency and security of cyber-physical systems (NSF, DARPA); Internet Infrastructure Protection Program (DARPA, NIST)
Workshops: DOE workshops on Advanced Networking for Distributed Petascale Science and Terabits Networking; NSF workshops for NCDI, GENI, NetSE
Coordination by LSN Teams

– **Joint Engineering Team (JET): NSF, NIH, DOE/SC, OSD (HPCMP), NSA, NIST, NASA, 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 testbeds, coordination of end user requirements, engineering of research networks and testbeds (JETnets); security best practices, applications testbeds (DNSSec, IPv6, IPv6 multicast, performance measurement); TICs coordination; interdomain and end-to-end metrics, 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, ESG, CEDPS, 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

Additional 2009 and 2010 Activities by Agency
NSF: NetSE (subsumes FIND) focus on new theoretical foundations, principles, methods to reason about dynamics, behavior of large-scale networks; interdependence among physical, informational, and social networks; and tradeoffs among communication, computation, and storage; other efforts include NECO; ANET; XPLR; CISE Expeditions; distributed, mobile, embedded, hybrid, and critical systems; data-intensive and trustworthy computing
NIH: Computational grids for biomedical research, clinical needs; focus on security, medical data privacy, wireless, ultra-low bandwidth, GIS technologies, disaster response, and collaboratory infrastructure technologies
DARPA: Radio networking in challenging environments (information theory for MANET, power and spectrum management, interface multiple access, brood of spectrum supremacy, Quint networking technology, 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 (e.g., ASSIST, CLENS)
DOE/SC: Federated networks for large-scale science; multidomain dynamic switched circuits; cyber security for open science, distributed software enabling scientific collaboration; ESG, CEDPS, DANTE, Internet2, CANARIE; ESnet evolution and cooperation (DICE); grid certificate services
OSD (HPCMP): Network monitoring tools; security (IPsec, VPN portals, security assessment script, Kerberos development, filters, encryption, data attribution, Computer Emergency Response Team [CERT], flow analysis), IPv6 deployment; TICs; network high-speed access to Hawaii and Alaska
NSA: Delay-tolerant and ad hoc networking; laser characterization
NIST: Cyber and network security; pervasive IT; IPv6; public-safety communication; measurement metrology; broadband quantum key distribution; complex systems; seamless secure mobility; implant communication systems
NASA: Space, planetary wireless, ubiquitous, high-performance networking with security (intrusion detection, firewalls); software-defined radio; agile lambda switching; traffic monitoring; architectures/data distribution
AHRQ: With ONC, improve health care quality through 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; support to remote users; high-data-rate testbed

High Confidence Software and Systems (HCSS)

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

HCSS R&D supports development of scientific foundations and innovative and enabling software and hardware technologies for the engineering, V&V, assurance, and certification of complex, networked, distributed computing systems and cyber-physical (IT-enabled) systems. The goal is to enable seamless, fully synergistic integration of computational intelligence, communication, control, sensing, actuation, and adaptation with physical devices and information processes to routinely realize high-confidence, optimally performing systems that are essential for effectively operating life-, safety-, security-, and mission-critical applications. These systems must be capable of interacting correctly, safely, and securely with humans and the physical world in changing environments and unforeseen conditions. In many cases, they must be certifiably dependable. The vision is to realize dependable systems that are more precise and highly efficient; respond more quickly; work in dangerous or inaccessible environments; provide large-scale, distributed coordination; augment human capabilities; and enhance societal quality of life. New science and technology are needed to build these systems with computing, communication, information, and control pervasively embedded at all levels, thus enabling entirely new generations of engineering designs that can enhance US competitiveness across economic and industrial sectors. Development of these future systems will require long-term sustained Government support, new educational strategies that span the boundaries of engineering and computer science, and a 21st century workforce capable of advanced innovation.

President's FY 2010 Request

Strategic Priorities Underlying This Request
To build these fundamentally new classes of computing, sensing, communication, and control, the HCSS group is initiating research to fill gaps in the science, technology, assurance, and education infrastructure.

New crosscutting scientific foundations for building high-confidence CPS: Abstracting and integrating the fundamental scientific and engineering principles, models, and theories from a cross-section of critical domains and technologies for the analysis and design of CPS will lead to: the development of new computational concepts, methods, tools, components, and architectures that will accelerate progress in a wide range of application domains; and possibilities for new systems that cannot be realized with today's methods and technologies. Such new foundations can bridge the gaps between approaches to the cyber and physical elements of systems.

New high-confidence, assured, run-time infrastructure for real-time systems: Today, disparate methods are used to separately develop cyber and physical subsystems. Future hardware and software components, middleware, and operating systems for CPS should go beyond today's technology to facilitate the deep integration of computation into physical processes and engineered systems. This entails novel cyber-physical interfaces and innovative mechanisms to deal with complexity, timing, distribution, and uncertainty. The mixed criticality of computations running on contemporary platforms is of particular concern. CPS hardware and software should be highly dependable, composable, and certifiable from components to fully integrated systems.

Next generation of assured, high-confidence critical CPS: Critical CPS that are built on scientifically and technologically based principles and that could potentially impact grand challenges in a number of sectors critical to U.S. leadership and competitiveness include: adaptive avionics, air-traffic control systems, decentralized control of aircraft, and unmanned aerial vehicles; intelligent automotive and highway systems; dynamically configured, integrated intensive care or emergency transport units, secure nationwide health records system, hospital information systems, home care, assisted living; net-zero energy building systems; highly automated power generation, transmission, and distribution; highly automated supervisory control and data acquisition (SCADA) and other networked control systems; counterterrorism, missile defense, warfighter protection, reconnaissance, and counterintelligence.

Creation of novel educational curricula and a research community for CPS: Creation of a new research community that shares a commitment to integrate CPS theory and methodology in education and to promote increased interest, understanding, and use of CPS systems through the development of new education curricula.

Highlights of Request
Cyber-physical systems: Expanded program to support research advances for enabling physical, biological, and engineered systems whose operations are integrated, monitored, and/or controlled by a computational core, and

interact with the physical world, with components networked at every scale, and computing deeply embedded in every physical component, possibly even in materials. The computational core is an embedded system, usually demands real-time response, and is often distributed. The behavior of CPS is a fully integrated hybridization of computational, physical, and human interaction – NSF, AFRL, ARO, NSA, NIST, NASA, FAA, FDA

Emerging Frontiers in Research Innovation (EFRI): New focus on advances in sensing and dynamic control of engineered systems; biosensing and bioactuation – NSF

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

High-confidence systems and foundations of assured computing: Methods and tools for modeling, measuring, analyzing, evaluating, and predicting performance, correctness, efficiency, 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; specification and synthesis, programming language semantics, and computational models; advance tools design, development, V&V, and analysis for dependable computing; techniques for assuming developed applications are free from malware and vulnerabilities – NSF, OSD, AFRL, AFOSR, ARO, NSA, NIST, NASA, FDA

Information assurance requirements: Methods and tools for constructing, analyzing security structures such as management architectures and protocols; assurance technologies for cross-domain creation, editing, and sharing of sensitive information in collaboration environments that span multiple security levels; 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): Continuation of applied research (Mixed Criticality Architecture Development, a follow-on to development of designing for certification requirements for embedded systems); methods for V&V to certification focus; infinite state systems – AFRL, NSF with other DoD Service research organizations, NSA, NASA

Standards and test methods for intelligent industrial control systems security (ICS) and networks: Approaches to balancing safety, security, reliability, and performance in SCADA and other ICS used in manufacturing and other critical infrastructure industries (e.g., water, electric power, oil & gas, chemicals, pharmaceuticals, food & beverage, materials processing); ensuring performance and interoperability of factory floor network communication devices and systems; leading the NIST Smart Grid Industrial-to-Grid Domain Expert Working Group to achieve interoperability of Smart Grid devices – 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 Research Workshop Series: Academic, industry, and government stakeholder workshops to identify new R&D for building 21st century CPS technologies for life-, safety-, and mission-critical applications; topics include:

- **High Confidence Medical Device CPS** – NSF, NSA, NIST, FDA
- **Future Energy CPS** – NSF, NSA, NIST
- **High Confidence Transportation CPS: Automotive, Aviation, and Rail –** NSF, AFRL, NSA, NIST, NASA with DOT, FAA, FDA, NTSB
- **CPS: Closing the Loop** (Part of the IEEE/ACM Embedded Systems Week Conference) – NSF
- **CPS Week (Theme of the IEEE Real-Time and Embedded Applications Symposium** – NSF, AFRL, NSA, NIST, NASA
- **High Confidence Automotive CPS (2008) –** NSF, NIST, FDA, NTSB
- **Verified Software, Theories, Tools, and Experiments (VSTTE) Workshop** – NSA
- **Static Analysis Tools Exposition (SATE):** Annual summit on software security for vendors, users, and academics **–** NIST, NSA, NSF with DHS

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

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

Mixed Criticality Architecture Requirements (MCAR) Birds of a Feather and Workshop: Phase III of systems requirements for design for certification – AFRL, NSF with other DoD Service research organizations, NSA, NASA, FAA, and NTSB

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)

Modeling Synergies in Large Human-Machine Networked Systems (2008 MURI) – AFRL

Scholar-in-Residence Cooperative Program – Continuing interagency partnership to investigate emerging scientific and engineering trends for the certification of medical device technologies – NSF, FDA

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

Additional 2009 and 2010 Activities by Agency

NSF: CISE and ENG directorates' joint research program addressing challenges in three CPS themes (Foundations; Methods and Tools; and Components, Run-time Substrates, and Systems); ongoing core research in software foundations, communications and information foundations, and computer systems research (CSR)

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; neural interface technologies such as cochlear implants, brain-computer interfaces

AFRL: Design methods, tools for safety and security certification of onboard aircraft embedded systems operating in a system-of-systems environment (e.g., UAVs); emphasis on mixed criticality (air safety combined with security) interdependencies requiring deep interaction, integration of hardware and software components

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

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, execution of critical platform components and functionality

NIST: Cross-enterprise document sharing; computer forensics tool testing, National Software Reference Library (funded by DOJ/NIJ); software assurance metrics, tools, and evaluation, National Vulnerability Database; software assurance forum; Internet infrastructure protection; seamless mobility; trustworthy information systems; 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

NASA: Aeronautics safety R&D with new emphasis enabling technologies for software health management, integrated vehicle health management, integrated intelligent flight deck, and integrated resilient aircraft control; enabling V&V technologies for NextGen airspace systems for separation assurance and super-density programs; exploration systems research in reliable software technologies (automated testing, auto-coding, formal V&V)

DOE/OE: Next Generation Control Systems (scaleable, 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

FAA: Evaluate COTS technology and V&V techniques in complex and safety-critical systems for regulatory compliance and intended performance

FDA: Formal methods-based design (assured verification, device software and system safety modeling and certification, component composition, forensics analysis, engineering tool foundations); architecture platform, middleware, resource management (plug-and-play, vigilance and trending systems); component-based foundations for accelerated design and verifiable system integration

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 among people, organizations, and cyberinfrastructure 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 2010 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

Broadening participation in computing – Develop effective undergraduate and graduate-level recruitment and retention strategies to increase the number of U.S. citizens and permanent residents pursuing academic careers in computing, with initial emphasis on underrepresented groups, and improve computing research and education opportunities for *all* students

Federal IT innovation through practitioner communities and emerging technologies: Build communities of practice across all levels of government and private-sector organizations in which practitioners, with support from researchers, can work collaboratively on cost-effective implementations of emerging technologies to improve government services; develop interoperability models and best practices for information sharing as part of the Federal Enterprise Architecture and E-government initiatives

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

Computational thinking for everyone – Explore the nature and meaning of computational thinking for everyone, with emphasis on its cognitive and educational implications for students aged 5-18, and consider how computational thinking might be incorporated in K-12 education

Highlights of Request

Cyber-enabled Discovery and Innovation (CDI): R&D addressing distributed knowledge environments that enhance discovery, learning, and innovation across boundaries – NSF

Virtual Organizations as Socio-technical Systems (VOSS): Scientific research to advance understanding of the nature of effective virtual organizations and how they can enable and enhance scientific, engineering, and education production and innovation – NSF

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

Creativity and IT: Advance interdisciplinary understanding of the relationships among IT, creativity, and innovation; develop computational models of cognition and approaches that encourage creativity in scientific research and education – NSF

IT Education and Workforce: R&D to include under-represented groups in graduate computer science programs, broaden and diversify the IT workforce – NSF

Computational Thinking for K-12: National Academies workshops on the nature and meaning of computational thinking; cognitive, organizational, and educational dimensions – NSF

Collaborative Expedition Workshops: Open workshop series exploring cost-effective implementations of emerging technologies for the delivery of services at all levels of government – CIO Council, GSA, NSF, with NITRD agencies

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

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. A key current focus is:

Strategic leadership for NIT education: Multiagency effort led by SEW to explore possible Federal initiatives to support America's strategic leadership across the digital landscape by identifying vital NIT education and workforce goals – SEW and other Federal agencies

SEW's partnership with GSA and the Federal Chief Information Officers (CIO) Council supports the Collaborative Expedition Workshops, now in their eighth year, to encourage collaboration among government and community implementers of IT and demonstrate promising IT capabilities emerging from Federal research. FY 2009 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: Continue to work with IWGs/CGs to host joint workshops around high-priority NITRD interests and interagency R&D topics (e.g., scientific peer/merit review, roadmapping); joint workshops held in 2008 with LSN, HCSS, HCI-IM, and HEC on identity management, certification, and scalable data 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; 1,800 Wiki pages with 5,000 community files developed, drawing nearly 2 million visits per year; 7 million files downloaded per year, including public comment on E-government implementations (e.g. Federal Funding and Transparency Act, Federal Segment Architecture Methodology, Data Reference Model, 2.0, and Visualization to Understand Expenditures in Information Technology)

Communities of Practice (CoPs): Over the past five years, 47 self-organized groups totaling more than 3,000 participants; 17 new CoPs in 2008 including Federal Data Architecture Committee, Intergovernmental Transportation Knowledge Networks (Eastern, Midwest, and Western), Federal Research Evaluation Network, Health Informatics Education and Decision Support, and Collaboration Across Distributed Scientific Communities; 10 communities graduated from hosting to self-support

Information standards and interoperability: Development and implementation of interoperability reference models (e.g., Data Reference Model, Geospatial Profile) and standards in OMB activities under the Federal Enterprise Architecture

Additional 2009 and 2010 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 and intergovernmental collaboration

Software Design and Productivity (SDP)

NITRD Agencies: NSF, NIH, OSD, AFOSR, AFRL, ARL, ARO, NRL, ONR, NIST, NASA, 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) for diverse domains that cut across information technology, industrial production, evolving areas such as the Internet and the World Wide Web, and highly complex, interconnected software-intensive systems.

President's 2010 Request

Strategic Priorities Underlying This Request
Critical U.S. defense, security, and economic capabilities depend on software-based systems. Improving the quality and cost-effectiveness of this increasingly complex software constitutes a core technical challenge in information technology that requires breakthrough innovations, ranging from the fundamental science and engineering of software to the application level. SDP R&D priorities include:

Research to rethink software design: From the basic concepts of design, evolution, and adaptation to advanced systems that seamlessly integrate human and computational capabilities

- **Foundations:** New computational models and logics, techniques, languages, tools, metrics, and processes for developing and analyzing software for complex software-intensive systems (e.g., a principled approach to software engineering that can provide assurances, (e.g., accountability, real-time, security, and affordability)
- **New paradigms:** Potentially transformative research that rethinks the development process, the tool chain, the partitioning of tasks and resources; open technology development (open-source and open-systems methods); technology from non-traditional sources; multidisciplinary and cross-cutting concepts and approaches; emerging scenarios such as multicore, software-as-a-service, cloud computing, end-user programming; modeling of human-machine systems

Predictable, timely, cost-effective development of software-intensive systems: Disciplined 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; scalable analysis, test generation, and optimization with traceability to requirements

- **Advanced integration standards:** Computer-interpretable standards; semantic foundations for integration; automated schema generation and validation
- **Software application interoperability and usability:** Interface and integration standards, representation methods to enable software interoperability, data exchanges, interoperable databases; supply-chain system integration; standardized software engineering practices for model development

Highlights of Request

Software and hardware foundations: Scientific and engineering principles and new logics, languages, architectures, and tools for specifying, designing, programming, analyzing, and verifying software and software-intensive systems – NSF, OSD, NASA, NIST, Air Force, Navy

Cyber-Enabled Discovery and Innovation: Agency-wide activity to develop new computational concepts, methods, and tools to spur science and engineering innovation – NSF

Computer systems research: Transform and rethink the software stack for computer systems in different application domains – NSF

Robust intelligence: Design of software-intensive intelligent systems that operate in complex, realistic, and unpredictable environments – NSF

Software-Intensive Systems Producibility: Continue implementation of Software and Systems Test Track for new technologies, methods, and theories for testing software-intensive systems; formal models for system and software development; software technologies for systems of systems; pre-competitive infrastructure software development technologies – OSD, Air Force. Army, Navy

Intelligent software design: Automation and scaling of test suite generation and validation and system-level verification testing; automated analysis technology for model-based software development, with autocode verification; transformational approaches to drastically reduce software life-cycle costs and complexity while extending life span for developing new Constellation exploration systems – NASA

Standards for information interoperability: 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 integrating supply-chain systems; interoperability of databases for bioinfomatics, chemical and materials properties – NIST

Planning and Coordination Supporting Request

Highly dependable computer and communication systems: Joint program ending in FY 2009 – NASA, NSF

Programming language curriculum: Workshop – NSF, NSA

Software and Systems Test Track: Open invitation to NITRD agencies to use – OSD

Software-intensive and cyber-physical systems: Coordinating on common research interests – NSF. OSD

Software verification and validation: Effective approaches for next-generation air transportation – NASA, FAA

Earth System Modeling Framework: Long-term multiagency effort to build, use common software toolset, data standards – NASA, NOAA, DoD Service research organizations, other 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 – DISA

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

Additional 2009 and 2010 Activities by Agency

NSF: Cross-cutting programs (Trustworthy Computing, Data-Intensive Computing, and Network Science and Engineering) supporting academic R&D in SDP-related topics; intellectual foundations of software design; software for real-world systems (micro- and nano-scale embedded devices, global-scale critical infrastructures, cyber-physical systems, networked and distributed systems); tools, documentation to support formal methods research; open source development communities

OSD: Continue R&D in model-based development, predictable software attributes, system virtualization, disciplined methods in interdependent development of software and systems; adapt producibility advances to exploit or accommodate changes in infrastructure; increase DoD awareness of off-the-shelf (OTS) innovations globally, speed DoD research via better use of OTS, and assess emerging OTS with strong DoD potential

AFOSR: Expand work in formal methods and new approaches for emerging software and systems challenges; devise new theories and behavioral models for development of complex, networked systems with human and machine components (includes FY 2008 Multidisciplinary University Research Initiative (MURI)) entitled "Harnessing Complexity of Human-Machine Systems")

ONR/NRL: Complex software; software producibility and security; legacy code re-engineering; analysis tools for modeling and testing software component interactions, assessing error-handling policies

NIST: Standards development and testing tools supporting interoperability such as schema validation, automated test generation (conformance testing), naming and design rules; product data models and modeling tools; methods to facilitate 3D shape search; Units markup language

NASA: Defined interfaces for international partners; architecture for SensorWeb for Earth sciences; integrated vehicle health management tools and techniques to enable automated detection, diagnosis, prognosis, and mitigation of adverse events during flight; integrated aircraft control design tools and techniques; physics-based multidisciplinary analysis optimization framework (MDAO) for cost-effective advanced modeling in development of next-generation air- and space-craft

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 2009 Budget Estimates
and
FY 2010 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	2009 Estimate	323.4	77.6	63.3	250.3	99.00	62.1	73.8	54.8	1,004.3
	2010 Request	**314.3**	**106.6**	**67.4**	**283.4**	**110.6**	**74.8**	**95.2**	**58.5**	**1,110.8**
NIH [2]		419.1	66.4		248.1	61.5	93.6	13.2	33.9	935.8
		424.6	**67.8**		**252.6**	**61.9**	**95.0**	**13.4**	**34.5**	**949.8**
DARPA			139.0	125.4	184.9	129.7				579.1
			145.0	**143.6**	**187.6**	**106.4**	**4.9**			**587.5**
DOE [3]		285.2	79.1			49.3		6.0		419.5
		312.2	**92.7**			**54.8**		**8.0**		**467.7**
OSD and DoD Service research orgs. [4]		235.0	3.4	71.1	83.8	94.9	27.9		16.7	532.7
		237.6	**3.5**	**70.0**	**26.9**	**72.7**	**22.7**		**18.2**	**451.6**
NSA			122.7	36.9		1.6	7.5			168.7
			60.9	**32.2**		**2.2**	**6.7**			**102.0**
NIST		11.8	3.6	23.4	12.3	5.7	4.5		4.9	66.1
		12.8	**4.1**	**29.3**	**13.4**	**5.9**	**7.0**		**7.4**	**79.8**
NASA		58.0			7.5	2.4	4.0		2.2	74.0
		58.4			**7.0**	**2.4**	**4.0**		**1.5**	**73.2**
AHRQ					43.8	1.0				44.8
					43.8	**1.0**				**44.8**
NOAA		24.8	0.2		0.5	2.0			0.5	28.0
		26.7	**0.2**		**0.5**	**3.0**			**0.5**	**30.9**
DOE/NNSA		4.8	9.4			1.0		2.9		18.1
		6.5	**6.0**			**.8**		**4.2**		**17.5**
EPA		3.3			3.0					6.3
		3.3			**3.0**					**6.3**
NARA					4.5					4.5
					4.5					**4.5**
TOTAL (2009 Estimate) [1]		1,365.4	501.3	320.1	838.7	448.0	199.6	95.9	113.0	3,882
TOTAL (2010 Request) [1]		**1,396.4**	**486.8**	**342.5**	**822.7**	**421.7**	**215.0**	**120.8**	**120.6**	**3,926**

[1] Totals may not sum correctly due to rounding.

[2] At the request of Congress, NIH embarked on a process to provide better consistency and transparency in the reporting of its funded research. This new process, implemented through the Research, Condition, and Disease Categorization (RCDC) system, uses sophisticated text data mining (categorizing and clustering using words and multiword phrases) in conjunction with NIH-wide definitions used to match projects to categories. The definitions are a list of terms and concepts selected by NIH scientific experts to define a research category. Due to significant methodology changes, it is likely that annual totals for categories (year over year) will exhibit a noticeable one-time adjustment. The research category levels represent NIH's best estimates based on the category definitions.

[3] The DOE budget includes funding from DOE's Office of Science and Office of Nuclear Energy.

[4] The budget for OSD and the DoD service research organizations includes the High Performance Computing Modernization Program.

Agency NITRD American Recovery and Reinvestment Act (ARRA) Budgets[5] by Program Component Area

FY 2009 ARRA Budget

(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 [6]
NSF	2009 ARRA	62.3	36.5	26.4	67.7	60.4	37.0	38.8	10.9	339.9
DOE [7]		104.6	31.0			19.0		2.0		156.6
NASA		12.5								12.5
NIST		4.0		9.4	1.5	0.3	8.4		8.4	32.1
NOAA		26.3	130.7			8.0				165.0
TOTAL (2009 ARRA) [1]		**209.7**	**198.2**	**35.8**	**69.2**	**87.7**	**45.4**	**40.8**	**19.3**	**706**

Under the American Recovery and Reinvestment Act (ARRA) of 2009, signed into law by President Obama on February 17, 2009, five Federal agencies report preliminary allocations of $706 million to investments in NITRD research areas (note that these figures may change). The NITRD agencies will use their ARRA funds to modernize, expand, and upgrade networking and high-end computing infrastructures and facilities for advanced scientific research; expand R&D in cyber security, human-computer interaction and information management, high-confidence software and systems, and software design; and increase investments in education and training for a diverse, highly skilled IT workforce.

5 Based on preliminary allocations of Recovery and Reinvestment Act of 2009 (PL 111-5) appropriations. These figures may change.
6 Totals may not sum correctly due to rounding.
7 The DOE budget includes funding from DOE's Office of Science and Office of Nuclear Energy.

NITRD Program Budget Analysis

Fiscal Year Overview for 2009-2010

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. In addition, the NITRD 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.

2009 Summary

The 2009 NITRD budget estimate of $3.882 billion is $0.334 billion, approximately 9 percent, more than the $3.548 billion 2009 President's budget request. The overall change is due to both decreases and increases in individual agency NITRD budgets, which are described below.

2010 Summary

The President's 2010 budget request for the NITRD Program is $3.926 billion, an increase of $0.044 billion, approximately 1 percent, over the 2009 estimate.-The overall change is due to both decreases and increases in individual agency NITRD budgets, which are described below.

NITRD Program Budget Analysis by Agency

This section describes changes greater than $10 million either between 2009 requested funding and 2009 estimated spending or between 2009 estimated spending and 2010 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 2009 request ($1,090 million) and 2009 estimate ($1,004 million): The decrease of $86 million is primarily due to a significant reduction in appropriated NSF funding from the 2009 request level, which resulted in decreases in HEC R&D, CSIA, HCI&IM, LSN, SEW, and SDP, partially offset by a $25 million increase in HEC I&A, reflecting a recasting of certain computing foundations research into this PCA.

Comparison of 2009 estimate ($1,004 million) and 2010 request ($1,111 million): The increase of $107 million includes $29 million in HEC R&D for programs including the Science and Engineering beyond Moore's Law effort, petascale applications, Strategic Technologies for Cyberinfrastructure (STCI), and Software Development for Cyberinfrastructure (SDCI); $33 million in HCI&IM to support increases including the multidisciplinary CDI emphasis on creation of new knowledge from digital data and innovative technologies to address data confidentiality, privacy, security, provenance, and regulatory issues; $12 million in LSN for increases including activities in the NetSE program, which encompasses the FIND program, and for the NeTS program, and increased support for the IRNC program; and $21 million in SEW for new opportunities including the use of cyberinfrastructure as a platform for online laboratory experiences for students and teachers, and increased support for cyberinfrastructure training, education, advancement, and mentoring for the 21st century workforce.

OSD and DoD Service Research Organizations

Comparison of 2009 request ($548 million) and 2009 estimate ($533 million): The 2009 estimate for OSD and DoD Service research organizations is $15 million lower than the 2009 request largely due to decreases of $15 million in HEC I&A, $13 million in HEC R&D, $19 million in LSN and smaller decreases in other PCAs, partially offset by a $30 million increase in CSIA.

Comparison of 2009 estimate ($533 million) and 2010 request ($452 million): The 2010 request for OSD and DoD Service research organizations is $81 million below the 2009 estimate largely due to decreases of $57 million in HCI&IM and $22 million in LSN.

NIH

Comparison of 2009 request ($510 million) and 2009 estimate ($936 million): The $426 million increase is due to the agency's move, as mandated by Congress, to a new automated reporting process (Research, Condition, and Disease Categorization, or RDCC); the change has led to a complete recalibration of reporting in NITRD areas, which previously had been subject to differing interpretations across the independently reporting centers and institutes.

Comparison of 2009 estimate ($936 million) and 2010 request ($950 million): The $14 million increase is due to small increases in several PCAs, partially offset by a small decrease in one PCA.

DOE

Comparison of 2009 request ($465 million) and 2009 estimate ($420 million): The $45 million decrease is due to a $50 million decrease in HEC I&A, partially offset by smaller increases in other PCAs.

Comparison of 2009 estimate ($420 million) and 2010 request ($468 million): The $48 million increase is largely due to an increase of $27 million in HEC I&A for research on the challenges of extreme-scale in computing architectures, data management, and software to enable productive use of multicore processors for scientific applications, and an increase of $14 million in HEC R&D to support leadership computing facilities at ANL and ORNL, including enhancements to infrastructure support and preparations for next-generation computers, and smaller increases in other PCAs.

NSA

Comparison of 2009 request ($119 million) and 2009 estimate ($169 million): The increase of $50 million is due to a late addition of $2 million for HEC technology development and a $48 million Congressional add-on that affects HEC R&D. In addition, an examination and re-categorization of projects previously reported in CSIA and HCSS resulted in shifts in funding between the two PCAs for FY 2009.

Comparison of 2009 estimate ($169 million) and 2010 request ($102 million): The $67 million decrease is due to the non-sustainment of 2009 Congressional add-ons, a planned decrease of $19 million in required funding support for the DARPA HPCS program, and smaller decreases in other PCAs.

NIST

Comparison of 2009 estimate ($66 million) and 2010 request ($80 million): The $14 million increase is due to small increases in several PCAs.

DOE/NNSA

Comparison of 2009 request ($30 million) and 2009 estimate ($18 million): The decrease of $12 million is due to reduction of the ASC program's budget by Congress and internal NNSA decisions.

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 2009 requested funding and 2009 estimated spending and between 2009 estimated spending and 2010 requests. The changes are described above.

HEC I&A

Comparison of 2009 request ($1,142 million) and 2009 estimate ($1,365 million): The $223 million increase is largely due to increases of $25 million at NSF and $260 million at NIH, partially offset by decreases of $15 million at OSD and DoD Service research organizations, $50 million at DOE, and smaller decreases at other agencies.

Comparison of 2009 estimate ($1,365 million) and 2010 request ($1,396 million): The $31 million increase is largely due to an increase of $27 million at DOE, and smaller increases at other agencies.

HEC R&D

Comparison of 2009 request ($492 million) and 2009 estimate ($501 million): The $9 million increase reflects an increase of $50 million at NSA, partially offset by decreases of $14 million at NSF, $13 million at OSD and DoD Service research organizations, $10 million at NIH, and smaller decreases at other agencies.

Comparison of 2009 estimate ($501 million) and 2010 request ($487 million): The $14 million decrease is largely due to a decrease of $62 million at NSA, partially offset by increases of $29 million at NSF and $14 million at DOE.

CSIA

Comparison of 2009 request ($280 million) and 2009 estimate ($320 million): The $40 million increase is largely due to increases of $18 million at DARPA primarily for the National Cyber Range, $30 million at OSD and DoD Service research organizations, and $19 million at NSA, partially offset by a decrease of $25 million at NSF and smaller decreases at other agencies.

Comparison of 2009 estimate ($320 million) and 2010 request ($343 million): The $23 million increase is largely due to increases of $19 million at DARPA for expanded efforts in cyber security technologies, and smaller increases at other agencies.

HCI&IM

Comparison of 2009 request ($791 million) and 2009 estimate ($839 million): The $48 million increase is largely due to an increase of $66 million at NIH, partially offset by a decrease of $17 million at NSF.

Comparison of 2009 estimate ($839 million) and 2010 request ($823 million): The $16 million decrease is largely due to a decrease of $57 million at OSD and DoD Service research organizations, partially offset by an increase of $33 million at NSF and smaller increases at other agencies.

LSN

Comparison of 2009 request ($483 million) and 2009 estimate ($448 million): The $35 million decrease is largely due to a decrease of $19 million at OSD and DoD Service research organizations and smaller decreases at other agencies.

Comparison of 2009 estimate ($448 million) and 2010 request ($422 million): The $26 million decrease is largely due to decreases of $24 million at DARPA, reflecting completion of cognitive networking and optical RF programs, and $22 million at OSD and DoD Service research organizations, partially offset by increases of $12 million at NSF and smaller increases at other agencies.

HCSS

Comparison of 2009 request ($139 million) and 2009 estimate ($200 million): The $61 million increase is largely due to an increase of $86 million at NIH, partially offset by a decrease of $19 million at NSA and smaller decreases at other agencies.

Comparison of 2009 estimate ($200 million) and 2010 request ($215 million): The $15 million increase is largely due to an increase of $13 million at NSF and smaller increases at other agencies.

SEW

Comparison of 2009 request ($133 million) and 2009 estimate ($96 million): The $37 million decrease is largely due to a decrease of $38 million at NSF, partially offset by smaller increases at other agencies.

Comparison of 2009 estimate ($96 million) and 2010 request ($121 million): The $25 million increase is largely due to an increase of $21 million at NSF and smaller increases at other agencies.

SDP

Comparison of 2009 request ($89 million) and 2009 estimate ($113 million): The $24 million increase is largely due to an increase of $29 million at NIH and smaller increases at other agencies, partially offset by a decrease of $16 million at NSF.

National Science and Technology Council
Committee on Technology
Co-Chairs
Vacant

Subcommittee on Networking and Information Technology Research and Development
Co-Chairs
Christopher L. Greer, NCO
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NSF
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OMB
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Joel R. Parriott

OSTP
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Charles H. Romine

NCO
Representative
Christopher L. Greer
Alternate
Ernest L. McDuffie

Interagency Working Groups, Coordinating Groups, and Team Chairs

High End Computing (HEC) Interagency Working Group
Chair
Cray J. Henry, OSD
Vice-Chair
Daniel A. Hitchcock, DOE/SC

Cyber Security and Information Assurance (CSIA) Interagency Working Group
Co-Chairs
Douglas Maughan, 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
Taieb Znati, NSF

LSN Teams:

Joint Engineering Team (JET)
Chair
Vince Dattoria, DOE/SC

Middleware and Grid Infrastructure Coordination (MAGIC) Team
Co-Chairs
Jennifer Schopf, NSF
Susan B. Turnbull, DOE/SC

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
Simon P. Frechette, NIST
Sol Greenspan, NSF

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
ARRA - American Recovery and Reinvestment Act of 2009 (P.L. 111-5)
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
ASSIST - DARPA's Advanced Soldier Sensor Information System and Technology activity
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
CEDPS - DOE/SC's Center for Enabling Distributed Petascale Science
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
CLENS - DARPA's Camouflaged Long Endurance Nano Sensor activity
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
COTS - commercial off the shelf
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
CVRG - NIH's CardioVascular Research Grid
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
GIS - geographic information 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
IRNC – NSF's International Research Network Connections program
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
NCDI - National Cyber Defense Initiative
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
NetSE – NSF's Network Science and Engineering 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
ONC - HHS's Office of the National Coordinator for Health IT
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
RDT&E - DoD's Research Development Test &Evaluation programs
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
SDCI – NSF's Software Development for Cyberinfrastructure (SDCI) 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
STCI – NSF's Strategic Technologies for Cyberinfrastructure program
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)
TIC - Trusted Internet Connection
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
UAV - unmanned aerial vehicle
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

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