NITRD

FY 2008

NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT

SUPPLEMENT TO THE PRESIDENT'S BUDGET

AUGUST 2007

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FOR FISCAL YEAR 2008

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

AUGUST 2007

MEMBERS OF CONGRESS:

I am pleased to forward with this letter the final annual report on the multi-agency Networking and Information Technology Research and Development (NITRD) Program, superseding the interim report that was provided to you in February of this year. This Supplement to the President's Budget for Fiscal Year 2008 describes research and development activities in advanced networking, computational science, and other information technologies that are funded by the Federal NITRD agencies. These Federal investments are an essential underpinning of the Nation's innovation ecosystem, contributing to both national security and economic competitiveness.

As information technology is a key enabler of virtually all science and technology R&D, the impact of the NITRD Program extends far beyond the research community directly supported by NITRD funding. The impact of an interagency program such as NITRD is maximized by coordinating agency investments as envisioned by the Congress in creating the original High Performance Computing program in 1991. This report of the NITRD program, now in its 16th year, provides a clear illustration of the value of interagency planning and coordination.

Investments made by the NITRD agencies help maintain the position of the United States as the world's leader in science and technology, as called for the President's American Competitiveness Initiative. These Federal investments in basic and applied research, advanced development, and education in advanced networking and other information technologies continue to enhance our economic prosperity. I am pleased to provide you with this report.

Sincerely,

John H. Marburger, III
Director

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Executive Summary

This Supplement to the President's Fiscal Year (FY) 2008 Budget provides a technical summary of the budget request for the Networking and Information Technology Research and Development (NITRD) Program, as required by the High-Performance Computing Act of 1991 (P.L. 102-194) and the Next Generation Internet Research Act of 1998 (P.L. 105-305). The NITRD Program, now in its 16th year, provides a framework and mechanisms for coordination among the many Federal agencies that support R&D in networking and information technology. The NITRD enterprise is an Administration interagency R&D budget priority for FY 2008.

The Supplement describes current technical and coordination activities and FY 2008 plans of the 14 Federal agencies in the NITRD budget crosscut as well as other agencies that are not part of the formal crosscut but participate in NITRD activities. Since the publication of the FY 2007 Supplement, the NITRD Subcommittee has welcomed the National Archives and Records Administration (NARA) as a NITRD member agency.

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; high-end computing research and development; cyber security and information assurance; human computer interaction and information management; large-scale networking; high-confidence software and systems; social, economic, and workforce implications of IT and IT workforce development; and software design and productivity. Agency program managers in each PCA meet monthly in an Interagency Working Group (IWG) or a Coordinating Group (CG) to exchange information and coordinate technical 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 PCA, the NITRD Budget Supplement presents strategic priorities underlying the FY 2008 budget request, highlights of the request, ongoing and anticipated interagency planning and coordination activities, and additional technical activities, by agency. Agencies that are engaged in cited activities as funders, performers, in-kind contributors, and participants are identified, with funders and performers listed first and, following the word "with," the in-kind contributors and participants. When applicable, lead agencies are listed first. Some large-scale activities may be listed 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.

Details of the NITRD budget, including 2007 estimates and 2008 requests by agency and by PCA, are presented in the budget table on page 20 and discussed in the budget analysis beginning on page 21.

NOTE: Abbreviations and acronyms are used throughout the Supplement to maintain brevity. A glossary, beginning on page 27, is provided for reference.

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

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

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

President's 2008 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 development of highest-capability systems for cutting-edge scientific research and national security applications

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

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

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

NSF: Towards a Petascale Computing Environment for Science and Engineering – multiyear acquisition of petascale system (by 2011) and mid-range systems as well as deployment of computational grids and advanced software systems to provide world-class HEC resources for academic research

OSD (HPCMP): Upgrade capabilities at multiple supercomputing centers

DOE/SC: Upgrade ORNL's Leadership Computing Facility (LCF) to 1 PF as a resource for scientific leadership; expand LCF resources at ANL through upgrade of BlueGene/P to 250+ TF for aging of materials and other computations; keep LBNL's NERSC-5 on path to 500 TF by 2010

NASA: Maintain a seamless environment for shared HEC capabilities, integrate user services with NASA missions; initiate acquisition of Columbia system follow-on at ARC; continue build-out of cluster system for Earth and space science research at GSFC

DOE/NNSA: Acquire innovative multicore, cell processor-based Roadrunner system

Applications

NSF: Modeling and simulation of complex systems across science and engineering; numerical algorithms and innovative software implementations that exploit and push the boundaries of cyberinfrastructure, computational science, and computing on the Teragrid; system software for applications that need to integrate computation and data acquisition while operating in heterogeneous and dynamically changing computing environments

NSF: Development and scaling of science and engineering applications whose access to petascale and grid systems would result in transformative advances in their respective scientific disciplines

OSD (HPCMP): New multiyear Computational Research and Engineering Acquisition Tools and Environments (CREATE) program to enhance development of highly scalable application codes

DOE/SC: Pioneer petascale applications; continue competitively selected FY 06 awards for SciDAC2 as well as partnerships with programs in genomics, nanoscale science, and fusion simulation; continue Institutes and Centers for Enabling Technology focusing on applied mathematics and computer science areas that support advanced scientific computation, modeling, simulation, and visualization (some application areas also supported by DOE/NNSA, NSF)

DOE/SC: Continue Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program – up to 80% of leadership systems and 10% of production systems allocated to external academic, industrial, and government research projects

NASA: From second round of National Leadership Computing System (NCLS) call for proposals, open part of Columbia system to external researchers pursuing demanding science and engineering challenges

NIST: Parallel and distributed application algorithms (e.g., large-scale multizone airflow analysis parallelization, with DARPA); fundamental mathematical tools and software infrastructure for HEC applications

DOE/NNSA: Develop and maintain weapons codes; deploy common capacity computing environment across labs

NOAA: Test Earth System Modeling Framework with modeling capabilities across the whole agency; evolve NOAA's R&D high-performance computing system into a "grid-like" environment

EPA: Develop algorithms and integrate state-of-the-art air quality models and tools for Remote Sensing Information Gateway distributed air-quality data modeling center (with NASA, NOAA)

Planning and Coordination Supporting Request

Computational science: Informing *Toward Better Understanding the Potential Impact of High-End Capability Computing on Science and Technology,* a National Academies study of the role of high-end computing in advancing cutting-edge research in major scientific fields – HEC agencies

Access to leadership-class computing: Coordination to make highest-capability HEC resources available to the broad research community with open calls for proposals, cycle sharing – DOE/NNSA, DOE/SC, NASA, NSF

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

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

Multiscale modeling in biomedical, biological, and behavioral systems: Interagency collaboration to advance modeling of complex living systems – NIH, NSF

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

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

Additional 2007 and 2008 Activities by Agency

NSF: Development of cyberinfrastructure software (e.g., for debugging, fault tolerance, performance tuning, middleware, data handling); operation and management support for Teragrid suppliers; data-rich science including bioinformatics, geoinformatics, and cognitive neuroscience

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

NIH: Support for international networks for biomedical data and software sharing (caBIG, BIRN); NIH Roadmap National Centers for Biomedical Computing (NCBCs); Cancer Imaging and Computational Centers; Modeling of Infectious Disease project (MIDAS, with NSF); P41 computational centers to develop tools and cyberinfrastructure; NLM information and analysis servers; bioinformatics resource centers for emerging and re-emerging infectious disease; proteomics and protein structure initiatives; systems biology centers

DOE/SC: Upgrade ORNL XT3 to 250 TF; install 100 TF BlueGene/P at ANL; expand SciDAC applications and infrastructure across DOE/SC and to include DOE/NNSA and NSF; support for computation- and data-intensive applications

NASA: Scale application codes for Columbia system; develop multitiered computing architecture

NIST: Virtual Measurement Laboratory – real-time tracker calibration, interfaces, representation, interaction analysis, selection, measurement, immersive visualization; high-accuracy computation of nanostructures, Object-Oriented Micromagnetics Modeling Framework; standards (interoperable MPI, sparse BLAS)

DOE/NNSA: Recompete Alliance Centers Program for Phase 2 with focus on predictive science; provide production-level computing environment

NOAA: Acceptance testing of new integrated R&D HEC system; integrated management and allocation of HEC resources; development, application, transition of advanced science and technology into operations

EPA: Port environmental applications to EPA Grid for faster, cost-effective risk assessments; assess related architecture, data management issues; scale, adapt environmental codes for exploratory data fusion techniques at differing temporal, spatial scales; integrate next-generation computing technology and mechanistic biology

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

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

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

President's 2008 Request

Strategic Priorities Underlying This Request

Next-generation HEC leadership: Develop innovative computing systems that combine increased speed, economic viability, high productivity, and robustness to meet Federal agency needs for HEC systems that can manage ultra-scale volumes of data and run multiscale, multidisciplinary scientific simulations

Petascale computing environments: Develop understanding of the architecture-application relationship in petascale applications on leadership systems, and of the mathematical and computer science foundations for petascale systems

New hardware and software directions: Explore novel approaches to solving technical challenges such as power use, thermal management, file system I/O latency; scalable runtime and operating system architectures, and language and development environments that increase the usability of large-scale multiprocessor systems

Productivity: Continue collaborative development of new metrics of system performance, 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

HEC-URA: University-based R&D in file systems and I/O, system software and tools for complex systems; Forum to Address Scalable Technology for runtime and Operating Systems (FAST-OS) recompetition – NSF, DARPA, DOE/NNSA, DOE/SC, NSA

Next-generation programming: R&D in parallel programming languages and programming environments for next-generation high-end systems – NSF, DARPA, NSA

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, DOE/NNSA, NSA

System on a chip: Pursue system-on-a-chip technology and self-monitoring of system processors' health and state; provide PCA technology for a new generation of onboard, embedded computing processing capabilities that will be mission- and technology-independent and able to adapt for optimal performance – DARPA

Expanded resources for scientific research: Expand SciDAC-enabling organizational resources including centers, institutes, and partnerships through conducting R&D to optimize the performance of HEC systems used for scientific research – DOE/SC, DOE/NNSA

Petascale systems and computational science: R&D in operating and runtime systems, programming models, file systems, performance modeling and optimization, software component architectures; mathematics and computer science (scalable algorithms, petascale infrastructure, optimization of complex systems, control theory, risk assessment) – DOE/SC, DOE/NNSA, NSF

Advanced computing systems: New effort to include research to improve power efficiency, chip-to-chip I/O, interconnects, productivity, resilience, and file system I/O – NSA

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

Software environments: Develop common system software and tools for high-end systems – DOE/NNSA, DOE/SC, NSF, OSD

System software: Sustain advanced systems initiative to meet requirements for nuclear weapons simulations – DOE/NNSA

Planning and Coordination Supporting Request

Planning

Technical and planning workshops: HPCS Productivity Workshops, second Storage and I/O Workshop to coordinate HEC-URA effort – DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD

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

Systems architecture

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

HPCS: Support architecture development in Phase III of HPCS Program – DARPA, DOE/SC, DOE/NNSA, NSA

BlueGene/Q: Assess architectural 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 – DARPA, NIST, NSA, NSF

Systems software development

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

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

Benchmarking and performance modeling: Collaborate on developing measurement tools to help improve the assessment and productivity of HEC systems – DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD

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

Additional 2007 and 2008 Activities by Agency

NSF: Support innovative research in complex software and tools for HEC environments; formal and mathematical foundations (algorithmic and computational science); foundations of computing processes and artifacts (software, architecture, design); emerging models for technology and computation (biologically motivated, quantum, and nanotechnology-based computing and design); distributed systems; create, test, and harden next-generation systems and software

OSD (HPCMP): Support HEC R&D activities (e.g., metrics development, benchmarking, performance modeling, file system and I/O subsystem modeling, testbeds) that are directly relevant to ongoing computer center operations or commercial supercomputer acquisitions

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: Investigate programming models, performance modeling and optimization, software component architectures; development time and execution time productivity (with HPCS); data analysis and management, interoperability, software development environments

NSA: Complete Black Widow and Eldorado projects, with systems available in 2007

DOE/NNSA: Pursue R&D in platforms, problem-solving environments, numerical methods, and user-productivity baseline in context of weapons simulations

Update: NITRD Agencies Implement *Federal Plan for High-End Computing*

Since the May 2004 release of the *Federal Plan for High-End Computing* by the White House Office of Science and Technology Policy (OSTP), the NITRD HEC agencies together have implemented key recommendations of the *Federal Plan* that are changing the face of the Federal high-end computing enterprise. Notable developments of national significance include the opening of the Government's highest-capability computing platforms to the broader research communities in academe, industry, and other Federal agencies and the launch of a new multiagency program of academic R&D in HEC system software and software development environments.

These and other steps to implement the *Federal Plan* are being fostered by the HEC Interagency Working Group (HEC IWG), which coordinates high-end computing policy, strategies, and programs across NITRD member and participating agencies. The *Federal Plan* was developed by the High-End Computing Revitalization Task Force (HECRTF), chartered in 2003 under the National Science and Technology Council (NSTC) to develop a plan for undertaking and sustaining a robust Federal high-end computing program to maintain U.S. leadership in science and technology. Highlights of NITRD agencies' implementation activities include the following:

High-End Computing University Research Activity (HEC-URA): NSF, DARPA, DOE/SC, and NSA launched this research effort in operating systems, languages, compilers, libraries, software tools, and development environments in 2004. In 2006, NSF and other agencies began funding research in file systems, storage, and I/O, kicking off the new focus with national workshops to spur thinking among researchers about the R&D agenda. Beginning in 2007, NSF is expanding funding in research in parallel language and programming environments. In 2007, DOE/SC will conduct a recompete of the FAST-OS activity (HEC operating system research).

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

Leadership Systems: The *Federal Plan* proposed that HEC agencies support "leadership high-end computing systems" – leading-edge computing facilities that could be opened to the national research community to enable breakthrough computational science and engineering. Today, this concept has been implemented by DOE/SC at four of its national laboratories through its INCITE program and by NASA through its National Leadership Computing Systems (NLCS) initiative. The two agencies have completed their second round of open solicitations for leadership-class computing resources, and they plan to conduct additional solicitations on a recurring basis. In FY 2007 and beyond, DOE/SC will allocate 80% of its leadership systems at ORNL and ANL for such research.

In 2006, NSF initiated its petascale and near-petascale high-end computing system acquisition and deployment activity consistent with the agency's "Cyberinfrastructure Vision for 21st Century Discovery" document. The strategy calls for a two-track approach: Track 2 deploys near-petascale systems and Track 1 will deploy a sustained petascale system in 2011, both targeted for the open science and engineering communities. Other agencies are planning similar procurements of leadership-class systems in the near future.

Approaching the Petascale: The HEC agencies are at the forefront of U.S. R&D to understand how to scale high-end computing technologies to the petascale (10^{15}) levels needed to investigate the world's most complex scientific and engineering problems. As they move toward acquisition in the next several years of petascale systems that may involve 100,000 or more processors, DOE/NNSA, DOE/SC, and NSF are collaborating in research activities focused on issues in petascale architectures, software, programming environments, and applications.

System Performance Assessment: The *Federal Plan* recommended that agencies work together to develop more precise ways to measure, compare, and assess system performance. DARPA, DOE/SC, NSF, and OSD (HPCMP) are participating in collaborative activities to improve the effectiveness of HEC system procurements.

Production Software Inventory: The HEC agencies are currently developing an inventory of production infrastructure software, including operating systems, middleware, tools, numerical and I/O libraries, and applications software. This inventory will enable the agencies to better understand and respond to common software issues, dependence on open source software, and gaps that may require future research, as well as to identify opportunities to leverage individual agencies' production software investments and experience.

Cyber Security and Information Assurance (CSIA)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, DARPA, NSA, NASA, NIST

Other Participants: DHS, DOT, DTO, FAA, FBI, 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.

NITRD Program: Coordination Activities Highlights
In 2006, the first full calendar year in which the CSIA Program Component Area (PCA) and the CSIA Interagency Working Group (IWG) were formally part of the NITRD Program, the CSIA agencies completed the *Federal Plan for Cyber Security and Information Assurance Research and Development* (April 2006) and began planning for follow-on activities. In key recommendations, the report called for development of a sustained, coordinated multiagency effort to address CSIA R&D, and proposed that the Federal government initiate a collaborative activity in partnership with industry and academia to develop a roadmap for Federal CSIA R&D.

As the first step in the roadmapping activity, the CSIA IWG in November 2006 broadly disseminated a Call for White Papers that invited interested stakeholders to address topics either related to CSIA R&D technical areas or to roadmapping processes and structure. The papers, which enable stakeholders to provide input that can help shape the future research and development agenda for CSIA technologies in the United States, are supporting the IWG's planning for workshops and other roadmapping-related activities in FY 2007-2008.

President's 2008 Request

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

Functional cyber security and information assurance: R&D to secure and protect large-scale and mission-critical information systems and networks, including approaches, methods, and tools for attack protection, prevention, detection, preemption, warning, mitigation, recovery, and forensics; situational awareness; access control and privilege and trust management; software protection

Infrastructure and domain-specific security: DNSSEC deployment; secure routing protocols; secure process control systems for critical infrastructures; wireless security, assured access; security for emerging networks, supercomputers, and heterogeneous traffic

Cyber security and information assurance assessment: Techniques and tools for software vulnerability and malicious code detection and analysis; system security and survivability standards and benchmarking; security and assurance standards, metrics, tests, and automated verification and validation methods

Scientific foundations: R&D in hardware and firmware security; secure operating systems; self-regenerating systems; trustable end devices; security policy management methods; cryptography, multilevel security; secure software engineering and lifecycle management; incorruptible data, code, executables; high-assurance, "secure by construction" code development methods and assured information sharing

Highlights of Request

Team for Research in Ubiquitous Secure Technology (TRUST): Multiuniversity center with industrial partners to develop new science and technology that will transform the ability of organizations (software vendors, operators, local and Federal agencies) to design, build and operate trustworthy information systems for critical infrastructures – NSF

Software protection: Develop high-assurance software protection and secure software engineering; implement out-of-band defense strategies, tamper-proof hardware, secure-application-launch protection for trust in end nodes; ubiquitous and seamless Secure Development Environment supporting the lifecycle of critical application software and data – OSD, AFRL, ARL/ARO/CERDEC, ONR/NRL, NSA, NSF, TSWG

Trusting the edge: Develop and validate technologies, techniques, and tools to provide distributed trust and assurance for the Global Information Grid (GIG) and mission-critical net-centric domains such as high-confidence airborne networking (by enabling an edge device to protect itself in a hostile environment and by creating the ability to monitor and assess its integrity) – OSD, AFRL, ARL/ARO/CERDEC, ONR/NRL, DARPA, NSA

Cognitive systems: Leverage technologies in learning, reasoning, deliberation, and reflection to develop systems that can maintain and improve critical functionality despite repeated attacks or errors – DARPA

Security management for critical infrastructures: Fundamental and applied R&D to advance and harden against attacks and system failures, especially for the automated computing systems and devices that control power grids, industrial processes, air-traffic-control systems, financial networks, wireless networks (cellular telephones) and other critical infrastructures – NSF, NSA, NIST, DHS, TSWG

Measurement science and technologies: Identify and address vulnerabilities in real time, assess effectiveness of security controls, and mitigate attacks; security metrics, test and validation – NSF, NSA, NIST, DHS, FBI

Situational awareness and response: Security event visualization and management and reconstitution of network assets and services based on cyber attack or physical fault; seamless, integrated situational awareness, rapid automated protection response, and behavior-based network monitoring capabilities – NSF, OSD, AFRL, ARL/ARO/CERDEC, NSA, DHS

Assured information sharing: Virtual private network, secure collaboration technologies; secure routing protocols, key management, identity management technologies; high-assurance, programmable guard; hardware enhancements; models and standards for protecting and sharing sensitive information and thwarting identity theft – NSF, OSD, AFRL, ONR/NRL, NSA, NIST, DHS

Testbeds: Cyber Defense Technology Experimental Research (DETER) cyber security testbed; security plan for GENI; infrastructure for R&D – NSF, NIST, ARL/ARO/CERDEC, DHS

Wireless: Advanced antennas for WLANs; insider threat detection, response**;** software**-**assisted (cognitive) radio technology**;** RF watermarking – NSF, OSD, AFRL, ARL/ARO/CERDEC, ONR/NRL, DARPA, NSA, NIST, DHS

Planning and Coordination Supporting Request

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

Network security issues: Collaborative activities in vulnerability assessment, intrusion detection and monitoring, fault-tolerant systems, proactive protection and mitigation strategies leading to a broadly applicable, deployable trustworthy platform – AFRL, ARL/ARO/CERDEC, DARPA, DHS, DTO, NSA, NSF, ONR/NRL, OSD

Software protection technologies: Develop and deploy new software-protection technologies in high-performance computing environments; gauge effectiveness through red-teaming activity – NASA, NSA, OSD

Grand challenge in security: Planning for possible co-sponsored competition to develop a secure system that will withstand attack – DARPA, DTO, NSF

Research data confidentiality and usability: Planning for joint proposal solicitation – NIH, NSF

Grants and proposals: Collaborate/coordinate on solicitations, reviews, evaluations, and funding – DARPA, DHS, DTO, NIST, NSA, NSF

Security metrics and measurement: Joint planning for a workshop – NIST, NSF

International coordination: U.S./UK technology alliance in network and information sciences – ARL; U.S./UK cooperative science and technology agreement, U.S./Canada Public Safety Technical Program – DHS; research collaborations with Japan and EU on security for control systems and other security-related topics – NSF

National Plan for Research and Development in Support of Critical Infrastructure Protection: Provide input to the NSTC Subcommittee on Infrastructure on cyber aspects of critical infrastructure protection – CSIA IWG

INFOSEC Research Council: Provides a forum for near-term operational R&D focus and proposes a long-term research agenda through the *Hard Problems List* – Multiple agencies

Additional 2007 and 2008 Activities by Agency

NSF: Industry/university cooperative research centers in information protection, security-critical applications, and experimental research in computer systems; ongoing awards in cryptography, formal methods, large-scale attack defense, preserving privacy in data mining, formal models; intrusion detection and response, hardware enhancements (virtualization, data encryption in memory, high-performance intrusion detection systems); future threats; education programs to prepare future generations of cyber security professionals

OSD: Security management infrastructure (techniques and tools for vulnerability analysis and risk assessment, benchmarking framework for improving operational security, virtual training environment); quantitative risk analysis methods; cyber forensics; secure coding techniques; innovative analysis techniques using DoD flow data; security technologies and tools for high-data-rate networks and supercomputing centers; participation in the Internet Engineering Task Force (IETF) security groups to develop standard representations and corresponding reference implementations of security-relevant data; SBIRs in topics to support GIG security

AFRL: Defensive cybercraft; network and system recovery and repair (with DARPA); predictable/customizable end-to-end QoS under degraded network conditions; large intrusion detection data analysis techniques; cyber attack detection/traceback/attribution (with DTO); digital data embedding; biometrics liveness

ARL/ARO/CERDEC: Secure, trustworthy information delivery in mobile tactical systems (including sensor networks); high-confidence software; self-healing survivable information system theory, modeling, and development; MURIs in high-speed wide-area-network intrusion detection, response, and analysis; distributed immune systems for wireless network information assurance; international technology alliance with U.K.

ONR/NRL: High-integrity multilevel security hypervisor providing secure foundation for server platforms; theories, techniques, and tools for developing security software; algorithms, methods for secure-by-construction development; MURI in adaptive trust management for service-oriented architecture; safe execution environments; protocol analysis; detection, exploitation of information in text, images, speech; voice biometrics

DARPA: Intrusion-tolerant information assurance technologies for current and emerging capabilities in mission-critical, command and control, intelligence, sensor, wireless, and mobile systems to provide survivable, trusted network-centric systems and cost-effective information protection solutions for DoD

NSA: Technologies for safe computing platform leveraging COTS hardware, virtualization, measurement, and attestation; intelligent, secure, flexible, self-protecting global infrastructure that provisions and monitors integrity of information assurance products and services through privilege management capability for dynamic (mobile) policy environments; cryptographic algorithms and engineering for faster networks; behavior-based network monitoring and active response capabilities; making information available to diverse users, but separable by classification, content, and intended use

NASA: Technologies and tools to enable seamless, secure network-intensive distributed high-end applications with strong perimeter protection system; approaches include secure unattended proxy (SUP) and perimeter controller/enforcer

NIST: Identity management; Federal information security standards and guidelines; cryptographic standards, forensics; authentication; vulnerability, database and reference data; access control and attribute management; RFID; state and local outreach; secure OS and application configuration specifications; personal identity verification compliance test generation; authentication effectiveness metrics; technology-specific security guideline development; automated combinatorial testing

DHS: Protected Repository for the Defense of Infrastructure Against Cyber Threats (PREDICT), library of network datasets for use by security developers; R&D in emerging threats (e.g., virtual machine environment, next-generation crimeware, botnet command and control); SBIRs; next-generation technologies (vulnerability prevention, discovery, and remediation; network attack forensics; technologies to defend against identity theft)

TSWG: Published a study of available software tools for critical infrastructure interdependency modeling; deployed Systems Administrator Simulation Trainer (SAST) with USMC; successfully tested a secure means of data communications between 10K commercial aircraft and air-traffic controllers (S-ACARS)

Human Computer Interaction and Information Management (HCI&IM)

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

HCI&IM focuses on information interaction, integration, and management research to develop and measure the performance of new technologies (e.g., robotic, multimodal), agents, cognitive systems, and information systems that support the hierarchy and refinement of data from discovery to decision and action by both humans and computers working together and separately. HCI&IM capabilities support U.S. national priorities such as leading-edge scientific research, national defense, homeland security, economic competitiveness, emergency planning and response, education and training, health care, space exploration, weather forecasting, and climate prediction.

President's 2008 Request

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

Information integration: To support complex human thought, analysis, and timely decision-making, disparate forms of raw information must be managed, fused, and made accessible to the user in understandable formats. Next-generation methods, technologies, and tools are needed to fully integrate and efficiently manage massive stores of distributed, heterogeneous information (e.g., science and engineering research data, Federal records). Key research issues include:
  – **Information standards:** Data interoperability and integration of distributed data; usability; provenance and integrity (metadata); generalizable ontologies; accessibility
  – **Decision support:** Timeliness of and access to data; user-oriented techniques and tools for summarization, synthesis, analysis, and visualization of information for decision-making; measurement and management of human responses to data
  – **Information management (IM):** Efficient integration, maintenance, and access to complex, large-scale collections of heterogeneous data; scalable technologies; integration of policies (differential sensitivity, security, user authentication) with data; integrated distributed data repositories; long-term curation, data preservation; testbeds for evaluating approaches; sustainability and validation of complex models
Multimodal interfaces and data: HCI capabilities enabling rapid, easy access to (e.g., without a keyboard) and communication and understanding of heterogeneous information (e.g., audio and text in diverse languages, video, images) for national defense and national security applications and assistive devices
Systems that know what they are doing: Systems that learn, reason, and automatically adapt and respond to new and unforeseen events; robotic devices for emergency-response and hazardous environments

Highlights of Request
Cyber-enabled Discovery and Innovation (CDI): New focus area to address the limitations of current understanding of and tools for managing complex, ultra-scale, multidimensional data in high-performance scientific computing environments, (e.g., knowledge extraction, federation, preservation, curation, access) – NSF
Cognitive systems: Create a new generation of systems to dramatically reduce workforce requirements; extend the capabilities of commanders, warfighters; provide decision-support systems/tools; improve performance (autonomy, trustworthiness, reliability) of automated and robotic systems – DARPA, ARL, NASA, NIST, ONR
Global Autonomous Language Exploitation (GALE): Software technologies to transcribe, translate, and distill huge volumes of speech and text in multiple languages, automatically and efficiently providing relevant actionable information to military personnel – DARPA, NIST, CENTCOM, DLI, other agencies
Multimodal language recognition and translation: Improve multilingual language technology performance in areas such as speech-to-text transcription, spontaneous two-way communications translation, text retrieval, document summarization/distillation, automatic content extraction, speaker and language recognition, multimodal interfaces, usability – DARPA, NIST, NSF, DTO, with NARA, other agencies
Biomedical informatics infrastructure: Infrastructure, tools, and data to facilitate biomedical discovery, enhance interdisciplinary communication, and improve health care – NIH
Biomedical imaging: Technologies for detection, diagnosis, monitoring, image-guided therapies – NIH, NIST, NSF
Information integration, accessibility, and management: Technologies for secure management; modeling,

integration, analysis, visualization techniques and tools; ontologies and metadata; efficient data access and transmission; integration, exploitation of heterogeneous data; automated integration, image understanding; compute- and data-grid management – NSF, ARL, ONR, NIH, NASA, NIST, AHRQ, NOAA, EPA, NARA

Humans in the loop: HCI and systems integration; decision-support systems and tools; distributed collaboration and knowledge management; computational cognitive process modeling and measurement; cognitive triage and automation; interactive user interfaces – NSF, ARL, ONR, DARPA, NASA, NIST, NOAA, EPA

Text Retrieval Conference (TREC): Evaluation of information-discovery technologies – DTO, NIST, NSF, NARA

Planning and Coordination Supporting Request

Access to Scientific Data - Technical Challenges, Opportunities: Workshop plans – EPA, other HCI&IM agencies

Joint Workshop on Medical Devices: Planning phase – HCI&IM and HCSS coordinating group agencies

IM I/O bounds: IM issues that are architecture-related – NARA, other HCI&IM agencies

Cognitive triage and adaptive automation: Active HCI to monitor for cognitive and sensory overload events prior to failure and to activate mitigation strategies – ARL, other HCI&IM agencies

Visualization and Analysis: Interdisciplinary research to provide a principled approach to synthesis through visualization to promote discovery for science and national defense – NSF, other HCI&IM agencies

Workshop on information integration R&D: Identified key areas of research needed to advance the utility of heterogeneous, multimodal information environments – NSF, AHRQ, EPA, NARA, NIST, ONR

Drug information standards for patient safety: Build, approve system of standardized drug definitions in standardized formats and transmit to Federal Web sites, including clinical vocabularies and coding systems mapped to clinical terminology adopted by HHS, VA, and DoD, metadata registry of data standards terms, and a landscape of U.S. health data standards activities – AHRQ, NIH, NIST, FDA, HHS (CMS), other agencies

Earth System Modeling Framework: Information interoperability and reuse in Earth science applications – DOE/SC, NASA, NOAA, NSF, OSD and DoD Service research organizations, other agencies

Multidomain informatics: Collaborations on data integration, presentation, standards – EPA, NIH, NSF

Additional 2007 and 2008 Activities by Agency

NSF: Academic research in information privacy; intelligent robots, vision technology; universal access; IM aspects of Plant Genome Cyberinfrastructure Center; science and engineering informatics; digital government

ARL: Manned robots – intelligent driving navigation, computer communications; intelligent imaging, virtual reality, real-time processing/prediction of complex data; command and control, collaboration and coalition

ONR: Persistent surveillance including autonomous systems (e.g., robots, unattended vehicles) and information exploitation; tools for mitigating misperceptions, improving situational awareness; portable bi-directional language translator; MURI in handling uncertainty

NIH: Biomedical data registries and analysis tools; acquisition, curation, analysis of biomedical and clinical research data collections; development of standard vocabularies, ontologies, knowledge environments

DARPA: Develop technologies that enable individual cognitive agents to work together as a team to provide cooperative decision, situation, and reconnaissance support in complex military situations

NASA: Continue efforts on decision-support systems, cognitive and perceptual modeling, and multimodal interface development, collaborative systems, data and text mining, and data exploration systems

NIST: Evaluation and standards for biometrics (fingerprint, face recognition, multimodal biometrics for identification and verification); evaluation methodology for multimedia (video retrieval, motion image quality, audio and video analysis, and content extraction and standards); standards for software usability reporting; user-centered evaluation of interactive, intelligent systems; ontologies for information integration in manufacturing, commerce; semantic Web and health-care informatics

AHRQ: Continue health IT patient safety and quality improvement program to reduce medical errors in ambulatory care settings and promote safe use of medications, personal safety, and care delivery that achieves the highest-quality outcome; patient safety health care IT data standards program; and rural/non-rural/regional projects including health information exchange and state information networks

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

EPA: Environmental databases, approaches to large-scale data distribution; architectures, tools to explore health and environment linkages; analysis, integration of techniques and technologies to help realize GEOSS vision

NARA: Decision-support technologies, including rules-oriented systems, for high-confidence processing of large collections (e.g., Federal records)

DHS: Efforts in visualization, discrete sciences, and information analysis as elements of broader activities

Large Scale Networking (LSN)

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

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

President's 2008 Request

Strategic Priorities Underlying This Request
Large-scale data transfers: Enable near-real-time petabyte and above data transfers, by 2008, to support science cooperation and modeling in high-energy physics, bioinformatics, weather, astrophysics, and other areas, overcoming scalability limitations of current technology and the Internet Protocol (IP)
New architectures: Develop future Internet architectures that are flexible, trustworthy (secure, reliable, ensuring privacy), and able to support pervasive computing using wireless access and optical light paths, networked sensors, and innovative applications (e.g., applications on the fly and large-scale information dissemination)
End-to-end performance measurement: Develop visibility into the interior of networks to enable optimization of application performance over networks; implement standard measurement instrumentation, standard protocols, and cooperation across domain boundaries to allow end-to-end application performance tuning

Highlights of Request
Optical network testbeds (ONTs): Evaluate lessons learned from NSF's CHEETAH and DRAGON networks, DOE/SC's UltraScience Net; and coordination with OMNInet, OptiPuter, Internet2, NationalLambda Rail, and regional ONTs; develop the second generation of GMPLS, QoS, agile circuit-switching, and interdomain control plane protocols, tools, services, and management (e.g., resource reservation, security) – NSF, DARPA, DOE/SC, NASA
Innovative network architectures: Global Environment for Network Investigations (GENI) support of R&D for a large-scale experimental facility for new scalable, flexible, trustworthy, usable Internet architectures; develop facility concepts that allow researchers to encompass in their visions high-impact emerging technologies, such as quantum cryptography – NSF, with DARPA, DOE/SC, NASA, NIST, NSA
Network security research: Provide network security for R&D networks, applications, and infrastructure – NSF, OSD, DARPA, DOE/SC, NIST
End-to-end agile networking, QoS, GMPLS: Develop robust capability and technologies to provide on-demand networking and assured bandwidth for advanced networking applications – NSF, DARPA, DOE/SC, NASA, other agencies
Wireless and sensor networking: Advance capabilities for highly distributed, ubiquitous networking – NSF, DARPA, NIST, other agencies
Large-scale data flows: Develop InfiniBand and single-stream flows over WANs, high-speed data transport protocols – NSF, NRL, DOE/SC, NASA
IPv6 and cyber security implementation: Roll out IPv6 onto research networks and establish DNSSEC prototyping in research networks in response to OMB requirements – All
End-to-end network performance monitoring and measurement: Identify intrusions and bottlenecks and isolate faults – NSF, OSD (HPCMP), DARPA, DOE/SC, NSA, NASA
International coordination: Leverage investments in federated security regimes and optical networking transparency with international partners – NSF, DOE/SC

Planning and Coordination Supporting Request
Federal Plan for Advanced Networking Research and Development: Develop a vision and plan for coordinated, multiagency Federal networking R&D activities in networking architecture, technologies, services, and applications to promote U.S. leadership in next-generation networks – All LSN agencies

Co-funding: NSF networking research projects receive support from DARPA, DOE/SC, NSA

Workshops: Annual government/private sector ONT workshop to provide input into coordinated Federal activities for R&D and promote technology transfer; NSF GENI workshops to coordinate research on new architectures, experimental infrastructure, and control plane technology; academia/industry/government workshop to identify networking R&D needs – Multiple agencies

Coordination by LSN Teams:

– **Joint Engineering Team (JET): DOE/SC, NASA, NIH, NIST, NOAA, NSA, NSF, OSD (HPCMP), USGS, with participation by academic organizations (CAIDA, CENIC, Internet2, ISI, MAX, NLANR, StarLight), national labs (ANL), supercomputing centers (ARSC, MCNC, PSC), universities (FIU, IU, UIC, UMd, UNC, UW), and vendors –** ONTs; engineering research networks (JETnets); security best practices; applications testbeds (IPv6, IPv6 multicast, performance measurement); metrics and monitoring: interdomain, end-to-end, internal network visibility; tool sharing and data exchange; 9,000-byte MTU recommendation; international coordination; transit and services cooperation

– **Middleware and Grid Infrastructure Coordination (MAGIC) Team: DOE/SC, NIH, NIST, NOAA, NSF, 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; applications; coordinated certificate authorities for security and privacy; collaboration infrastructure; standards development; international coordination (e.g., federated certificate authorities under Americas Policy Management Authority)

Information exchange: Multiagency LSN participation in review panels, informational meetings, principal investigator (PI) meetings; tactical coordination among program managers with common interests; coordination of JET meetings with DOE ESSC and Internet2 Joint Techs Meetings; GMPLS forum coordinating development of interdomain signaling in agile optical networks

Additional 2007 and 2008 Activities by Agency

NSF: University-based fundamental networking research in broad-area networking topics, including future Internet design, wireless networks, sensor networks, and infrastructure research (create, test, harden next-generation systems); middleware development and dissemination

OSD (HPCMP): IP end-to-end performance measurement, network monitoring tools, IPv6 pilots and IPv6 multicast, network security (IPsec, VPN portals, attack detection tools, filters, encryption), automated management, disaster recovery planning, research network high-speed access to Hawaii and Alaska

NIH: R&D on data and computational grids in support of biomedical research, including Biomedical Informatics Research Network (BIRN) and cancer Biomedical Informatics Grid (caBIG); focus on QoS, security, medical data privacy, network management, and collaboratory infrastructure technologies

DARPA: Network technologies that work in and adapt to extreme conditions; distributed networks leveraged for robust network access control; complex mobile RF networks for actionable situational awareness; and collective technology for dynamic teams of people, software agents, and robots

DOE/SC: Middleware and network research (security, data management, standards-based protocols, advanced reservation and scheduling); Open Science Grid (operational infrastructure for large-scale applications); UltraScience Net (research and engineering prototype); connectivity (ESnet, MANs, collaboration services, trust federations and authentication services)

NSA: Cognitive radio technology (architecture, spectrum management, mesh network testbed), delay-tolerant networking, and Internet performance measurement

NASA: Large-scale data transfers (near-real-time terabyte+ transfers, InfiniBand over WAN); end-to-end performance measurement, agile Lambda switching networking; and end-to-end IPv6 implementation

NIST: Quantum communications; Internet infrastructure protection (Domain Name Service, Internet routing); IPv6 standards and deployment; seamless mobility; modeling of complex systems; public safety communications

AHRQ: Support for networking in activities to improve health data standards and raise the quality and patient safety of hospital and ambulatory care services

DOE/NNSA: Applied research in advanced networking and distance computing

NOAA: Advanced networking infrastructure, including lambda-based networking, IPv6, distributed Web servers; computer and network security; applications (collaboration, grid computing, wireless, remote operation)

High Confidence Software and Systems (HCSS)

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

HCSS R&D supports development of scientific foundations and technologies for innovative systems design, systems and embedded application software, and assurance and verification to enable the routine production of reliable, robust, safe, scalable, secure, stable, and certifiably dependable IT-centric physical and engineered systems comprising new classes of advanced services and applications. These systems, often embedded in larger physical and IT systems, are essential for the operation of the country's critical societal infrastructures, acceleration of U.S. capability in industrial competitiveness, and optimization of citizens' quality of life.

President's FY 2008 Request

Strategic Priorities Underlying This Request

New classes of computationally integrated sensing, communications, and control technologies that are adaptive, distributed, networked, embedded, and real-time are needed to maximize progress towards engineering and deploying high-confidence, high-performance, and efficiently produced IT-centric systems on a large scale for life-, safety-, and mission-critical applications. Research is required to develop:

New scientific foundations for building high-confidence technologies: Innovative theories, methods, and tools including new architectural principles and frameworks – currently not well understood – are necessary to enable systems that are built from the ground up with systematic specialization, integration, and assurance. Such new approaches are needed to replace today's concepts, which have yielded increasingly inefficient, unsound, failure-prone, and frequently dangerous design results. Technical areas include design and engineering methods, distributed sensing and control, measures/metrics to evaluate confidence and assurance

High-confidence, real-time technologies: Composable, configurable real-time embedded systems technology substrate to reduce dependence on an aging and increasingly obsolete technology base (i.e., real-time operating systems [RTOS] designed for single-system applications; middleware [MW] applied atop RTOS for operation of networked systems; virtual machines [VMs] applied atop RTOS as a general purpose fixed architecture)

Next-generation critical societal infrastructures: IT-centric systems based on scientific assurance foundations. Illustrative critical applications for these "systems of systems" or "infrastructures of infrastructures" include: *aviation and air space management* (adaptive avionics, air-traffic control systems); *transportation networks* (intelligent automotive and highway systems that reduce traffic accidents, congestion, air pollution, gas usage); *medical device and electronic health management systems* (dynamically configured, integrated intensive care or emergency transport units; secure nationwide health records system; hospital information systems; home care; assisted living); *beyond supervisory control and data acquisition (SCADA)* (intelligent industrial and home environments with more efficient and real-time water, heating, lighting, and air conditioning generation, distribution, monitoring, and usage); *first responder systems* (reliable systems for emergency responders); *defense systems* (real-time, distributed, embedded systems in a network-centric environment for counterterrorism, missile defense, warfighter protection, reconnaissance, and counterintelligence)

Highlights of Request

Cyber-enabled Discovery and Innovation (CDI): New focus area to address the challenges of large-scale interacting systems, understand their non-linearity of interactions, and their aggregate or emergent phenomena to better predict and deduct capabilities for design, control and decision-making about complex systems – NSF

Cyber-physical systems (CPS): New R&D effort to develop a next-generation real-time technology base for architectures and virtualization (restructuring of OS/MW/VM); high-confidence system service composition; complex cyber-physical systems – NSF, OSD, AFRL, NSA, NASA, NIST, FAA, FDA

High-confidence RTOS: Research to develop next-generation high-confidence RTOS technology base – NSF, OSD, AFRL, ONR, NSA, NASA, with DOE, NIST, FAA, FDA

High-confidence systems and foundations of assured computing: Methods and tools for modeling, measuring, analyzing, evaluating, and predicting performance, correctness, efficiency, and dependability of complex systems; real-time systems; distributed and mobile systems; high confidence platforms for sensing and control; virtualization, architectures, components, composition, and configuration; analysis and testing of software and

hardware; verification and synthesis; programming language semantics and computational models; design and implementation for reliable computing – NSF, OSD, AFRL, NSA, NASA, NIST, FDA

Information assurance requirements: Intelligent, secure, flexible, self-protecting global infrastructure; safe computing platforms that can isolate, measure, and attest to correct operations – NSA

Flight-Critical Systems Software Initiative (FCSSI): New start on mixed criticality architecture requirements for embedded systems platform and integrated tool chain – AFRL, NSF, with NASA, FAA

Illustrative domain research areas for high-confidence, real-time technologies: Medical device, aviation, and critical infrastructures (e.g., power) that operate via SCADA systems – HCSS agencies

Planning and Coordination Supporting Request

Annual National Workshop Series: One cross-cutting and three domain-specific workshops comprising academia, industry, and government stakeholders to identify new R&D and develop roadmaps to build next-generation, real-time high-confidence technologies for life-, safety-, and mission-critical applications including:
  – **High-Confidence Software Platforms for Cyber-Physical Systems:** Comprehensive restructuring of current software and control systems platform designs of complex, IT-centric systems to achieve a more sound and assured technology base that is correct by construction – HCSS agencies
  – **High-Confidence Critical Infrastructures: Beyond SCADA - Networked Embedded Control Systems:** High-confidence device and software technologies for next-generation critical infrastructures that depend on SCADA systems for their operation – NSF, AFRL, NIST, NSA, OSD
  – **Aviation Software Systems for the Second Century of Flight - Design for Certifiably Dependable Systems:** Next-generation high-confidence aviation systems V&V and specifications, design, certification, and testing for aviation software systems – NSF, AFRL, FAA, NASA, NSA
  – **High-Confidence Medical Device Software and Systems:** Next-generation high-confidence medical devices and systems technologies – NSF, FDA, NIST, NSA

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

Seventh Annual HCSS Conference: Showcasing promising research to improve system confidence – NSA, NSF

Static Analysis Methods/Tools Summit: Software security, for vendors, users, academics – NIST, NSA, NSF

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

High-confidence RTOS technology needs assessments: Series of non-disclosure briefings by technology development and systems integration vendors – All HCSS agencies and other agencies

Advancing Software Producibility: NA study and workshop series – OSD, NSF

Sufficient Evidence? Building Certifiably Dependable Systems: National Academies study – NSA, NSF, ONR, with ARO, DARPA, FAA, FDA, NASA, NIST

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

Additional 2007 and 2008 Activities by Agency

NSF: Formal methods (composition, verification); rigorous computation models; compositional software methods

OSD (DDR&E): Software Engineering Institute – quality attribute reasoning; principles, methods, techniques for integration and interoperation and assurance across software components, systems, systems of systems; model-based software engineering for real-time systems; methods for evidence-based assurance

AFRL: Methods, techniques, and tools to enable development of flight-critical systems

NASA: Aeronautics research – enabling V&V technologies for NGATS; integrated vehicle health management, integrated intelligent flight deck, and integrated resilient aircraft control; Exploration – terminate (end of FY 2007) R&D in reliable software technologies

NIST: Security, integrity, usability, and accessibility of voting systems; software diagnostic and conformance testing including cross-enterprise document sharing; computer forensics tool testing; software assurance metrics, tools, and evaluation; vulnerability databases

FAA: Certifiably dependable systems, including incremental certification in traditional safety-critical systems; improved continuous external monitoring of a system's internal vital signs

FDA: Formal methods-based design and assured verification (medical device software/system certification; safety/security/regulatory policy models; forensics analysis, engineering tool foundations); assured platform, middleware, resource management ("black box" data recording, plug-n-play); cyber-physical systems

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

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

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

President's 2008 Request

Strategic Priorities Underlying This Request

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

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

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

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

IT education and training: Support innovative educational approaches to broadening participation in IT careers, and doctoral and post-graduate programs to expand the highly skilled IT workforce in such fields as bio-informatics and computational science

Highlights of Request

Cyber-enabled Discovery and Innovation (CDI): New focus area to address the challenges of distributed knowledge environments that enhance discovery, learning, and innovation across boundaries; better understanding of the design, implementation, and sustenance of large-scale socio-technical systems that integrate humans and cyberinfrastructure to revolutionize the conduct of science and enable innovation in a strong digitally enabled economy; utilization of knowledge environments at all levels of education and integration of computational discovery techniques in the education of scientists – NSF

Creativity and IT: New program emphases on understanding the ecology of IT, creativity, and innovation; information privacy and other human-centered computing priorities; continue broadening participation in IT activities by underserved communities; transform IT education in U.S. universities and colleges; develop a globally aware workforce – NSF

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

Collaborative Expedition Workshops: Sixth year of monthly open workshops exploring cost-effective implementations of emerging technologies for the delivery of services at all levels of government, establishing "communities of practice" among IT implementers across government and the private sector, and developing reference standards for interoperable Federal information sharing – CIO Council, GSA, NSF, with SEW 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 and health care systems – NIH

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

Spread of Wiki technology: Growing use of cost-effective, efficient tool for collaborative work across the Federal government; has fostered:
– **Communities of Practice (CoPs):** More than a dozen groups totaling more than 1,000 participants (e.g., Grants.gov CoPs, IT Performance Management Community, Enterprise Process Improvement, Knowledge Management Working Group, Semantic Interoperability, Spatial Ontology, XML, Federal XBRL, GeoSpatial, Service-Oriented Architecture, Agile Financial Data Services, Health Information Technology Ontology Project). CoPs use the workshops to leverage learning and collaborative prototyping around data and information sharing.
– **Information standards:** Development and implementation of reference models
– **Interoperability:** Increasing Federal emphasis on enterprise-level system interoperability (e.g., incorporation of interoperability models and standards into OMB activities; National Information Exchange model developed by DOJ and DHS; Public Forum for the Federal Enterprise Architecture Model Maintenance Process supported by OMB and the CIO Council)

Additional 2007 and 2008 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; advance human and social dynamics program

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

Software Design and Productivity (SDP)

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

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

President's 2008 Request

Strategic Priorities Underlying This Request

Software design for the 21st century: Generate creative, scientific advances in the design of software artifacts and software-intensive systems through innovative, interdisciplinary research to provide scientific foundations for managing issues of complexity, quality, cost, and human intellectual control of software systems design and development; new approaches that impact design research and education. Priorities include:
– **Adaptation of ideas from other design fields:** Integration of design and systems engineering research streams across software engineering, computer science, engineering, and other scientific fields
– **Testing and validation methods and services:** Application of design science in the understanding, development, and evaluation of software-intensive systems
– **Interoperability:** Use of formal methods; integrated design and operation through software interoperability

Highlights of Request

Design for software-intensive systems: Increased emphasis on interdisciplinary, team projects to adapt and apply design science to the understanding, development, and evaluation of software-intensive systems – NSF

Computing processes and artifacts: Increased emphasis on cyberinfrastructure and computational science to address software engineering challenges for the "e-science" community engaged in software-intensive system development; foundations of computing processes and artifacts (software design and engineering methodologies; tools for software testing, analysis, software understanding, maintenance and evolution, and verification; semantics, design, and implementation of programming languages; software engineering and languages) – NSF, NASA

System information integration and informatics: Increased emphasis on the use of digital forms of information and knowledge in the state of software-intensive systems (issues of information design and integration; digital content of software system state; processes, technologies, and human involvement in creation and use of information and knowledge in software systems) – NSF

Standards validation and testing: Methods and tools for standards development and implementation, with focus on shortening the development, validation, implementation, and testing cycle) – NIST

Biomedical modeling tools: Software for advanced multiscale modeling of biological, biomedical, and behavioral systems – NSF, NIH

Planning and Coordination Supporting Request

Workshop on Interoperable Software (WINS): Explore the role of interoperability in new network-enabled applications. Today's software systems can interact over the Internet, cellular networks, and enterprise networks; such software systems are most easily designed, produced, and maintained when they can use services provided by other networked software systems – NIST, with DOE, NASA, NIH, NSF

Additional 2007 and 2008 Activities by Agency

NSF: University-based research in scalable software architectures; managing complex combinations of requirements, such as meeting real-time constraints and coordinating control in embedded, failure-prone

environments; software system interoperability, robustness, and reliability; productivity of software development; flexibility and agility in software development processes; open-source software development; end-user software development

OSD: Finish defining concept of operations and architecture for a software and system development research support facility that will provide standardized research problems to assess promising technologies, and begin implementation; university and industry research in software technologies for interoperable systems of systems; complete NA study on Advancing *Software-Intensive Systems Producibility*

NIH: Support development of innovative software and tools for modeling, simulation, bioinformatics, and imaging across the range of NIH biomedical research fields

NASA: Modeling frameworks for earth and space science; application modeling and development frameworks; software and data interoperability for Earth System Modeling Framework (with other NITRD and non-NITRD agencies)

NIST: Scientific data integration methods; software security; automated generation of test suites for integration standards; Digital Library of Mathematical Functions (with NSF); supply chain software interoperability; international testbeds for business-to-business solutions; sharable data structures for neutron research; ontological approaches to automate process of integrating supply chain systems; units mark up language; interface standards for interoperability of manufacturing control systems; product representation scheme for interoperability among computer-aided engineering systems; standards for exchange of instrument data and chemical reference data; ontological methods for representation and exchange of mathematical data

Agency NITRD Budgets by Program Component Area (PCA)

FY 2007 Budget Estimates
and
FY 2008 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*
NSF	2007 Estimate	272.4	64.1	67.6	220.9	84.0	51.3	92.9	50.7	903.7
	2008 Request	**303.1**	**67.1**	**69.2**	**225.6**	**106.7**	**57.4**	**109.3**	**55.3**	**993.7**
OSD and DoD Service research orgs.		260.4	6.2	23.9	95.2	133.0	43.0		6.7	568.2
		234.1	**2.0**	**23.3**	**78.7**	**137.4**	**31.5**		**4.3**	**511.4**
NIH		132.5	1.8	1.2	199.6	67.0	8.4	12.2	2.9	425.6
		131.7	**1.8**	**1.2**	**194.5**	**65.4**	**8.2**	**11.9**	**2.9**	**417.6**
DARPA			89.6	93.4	198.6	38.2				419.9
			68.9	**96.9**	**204.3**	**42.4**				**412.5**
DOE/SC		210.0	51.9			43.4		3.5		308.8
		250.5	**67.0**			**47.3**		**5.0**		**369.8**
NSA			36.4	15.8		1.1	22.1			75.4
			60.3	**15.8**		**1.4**	**25.2**			**102.6**
NASA		63.4		0.3	9.5	3.1	5.0		2.0	83.3
		71.4		**0.3**	**8.0**	**1.5**	**3.5**		**2.0**	**86.7**
NIST		2.4	1.8	10.5	8.4	5.3	19.7		5.1	53.2
		2.4	**1.8**	**11.1**	**8.4**	**5.3**	**19.7**		**5.1**	**53.8**
AHRQ					44.9	5.0				49.9
					39.8	**5.0**				**44.8**
DOE/NNSA		10.4	25.9			1.6		5.0	2.9	45.8
		9.9	**17.9**			**1.2**		**4.8**		**33.8**
NOAA		16.4	1.9		0.5	2.9			1.6	23.3
		16.4	**1.9**		**0.5**	**2.9**			**1.6**	**23.3**
EPA		3.3			3.0					6.3
		3.3			**3.0**					**6.3**
NARA					3.5					3.5
					4.5					**4.5**
TOTAL (2007 Estimate)*		971.2	279.7	212.6	784.0	384.6	149.4	113.6	71.9	2,967
TOTAL (2008 Request)*		**1,022.8**	**288.6**	**217.7**	**767.3**	**416.5**	**145.6**	**131.0**	**71.3**	**3,061**

* Totals may not sum correctly due to rounding.

NITRD Program Budget Analysis

Fiscal Year Overview for 2007-2008

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 National Archives and Records Administration (NARA) joined the NITRD Program and is included in the budget table. Further, agencies have continued to work collectively on improving the PCA definitions, as reflected by changes in the definitions outlined in OMB Circular A-11, and individually on improving the classification of investments within the PCAs, resulting in changes in NITRD Program budgets.

2007 Summary

The 2007 NITRD estimate of $2.967 billion is $0.107 billion, or approximately 3 percent, less than the $3.074 billion 2007 President's budget request.[1] The overall change is due to both decreases and increases in individual agency NITRD budgets, which are described below.

2008 Summary

The President's 2008 budget request for the NITRD Program is $3.061 billion, an increase of $0.094 billion, approximately 3 percent, over the 2007 estimate. Contributors to this change are NITRD Program budget increases at DOE/SC, NSA, and NSF, partially offset by decreases within DoD (OSD and DoD Service research organizations), which are explained below, and the addition of NARA. The Administration continues to focus NITRD Program funding increases on the three agencies – DOE/SC, NIST, and NSF – that are part of the American Competitiveness Initiative. The combined 2008 budget request for those three agencies is $151.6 million higher than 2007 spending estimates, an increase of 12 percent.

NITRD Program Budget Analysis by Agency

This section describes changes greater than $10 million either between 2007 requested funding and 2007 estimated spending or between 2007 estimated spending and 2008 requests. Smaller changes are discussed only if they represent shifts in funding focus. Budget numbers are rounded to the nearest million in these descriptions and may result in minor discrepancies in sums due to rounding.

NSF

Comparison of 2007 estimate ($904 million) and 2008 request ($994 million): The 2008 budget request for NSF includes planned investment increases in all of the NITRD PCAs. These include an additional $31 million for HEC I&A, $23 million for LSN, and $16 million for SEW. Increased HEC I&A funding from NSF's Office of Cyberinfrastructure will support software and services for complex science and engineering, including petascale application development as well as support for operations and maintenance of HEC systems, while additional investments from NSF's Mathematical and Physical Sciences Directorate and its Engineering Directorate will support grid computing and other centers and facilities as well as modeling, simulation, analysis, and other applications in several domains. LSN increases will support additional advanced networking research, including NSF's GENI program. The added funding in SEW will provide increases in NSF's Broadening Participation in Computing program and the initiation of an International Workforce effort.

OSD and DoD Service Research Organizations

Comparison of 2007 request ($498 million) and 2007 estimate ($568 million): The 2007 estimate for OSD and the DoD Service research organizations is higher ($70 million) than the request of $498 million due to Congressional add-ons that affect HEC I&A, CSIA, HCI&IM and HCSS.

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[1] The 2007 request figures in this analysis are those reported in the *NITRD 2007 Supplement to the President's Budget.*

Comparison of 2007 estimate ($568 million) and 2008 request ($511 million): The 2008 request for OSD and the DoD Service research organizations is $13 million above the 2007 request but below the 2007 estimate because Congressional add-ons from 2007 are not included in the 2008 request.

NIH

Comparison of 2007 request ($491 million) and 2007 estimate ($426 million): The $65 million decrease is due to the Continuing Resolution that provided less than the full request, resulting in NIH delaying some HEC I&A, HCI&IM, and SDP activities until 2008.

DARPA

Comparison of 2007 request ($466 million) and 2007 estimate ($420 million): The $46 million decrease is the result of Congressional reductions to the President's budget request for HEC R&D and HCI&IM and additional DARPA-imposed HEC R&D reductions due to restructuring of the HPCS program's funding profile to reflect contract requirements; these reductions are partially offset by an increase in LSN funding. The change also reflects a $12 million re-labeling of funding from HEC R&D to CSIA to better match the PCA definitions.

Comparison of 2007 estimate ($420 million) and 2008 request ($413 million): The decrease of $7 million is the result of a decrease of $21 million in HEC R&D due to the HPCS restructuring, partially offset by increases in several other PCAs.

DOE/SC

Comparison of 2007 request ($345 million) and 2007 estimate ($309 million): The $36 million decrease is due to the Continuing Resolution that provided less than the full request, resulting in DOE delaying upgrades to capacity HEC facilities, extending leases for Leadership Computing facilities, and delaying SciDAC partnership activities until 2008. There is also a $105 million shift in funding from HEC R&D to HEC I&A, which reflects a reclassification of DOE/SC's Leadership Computing Facility expenditures as they evolve from research to production.

Comparison of 2007 estimate ($309 million) and 2008 request ($370 million): The $61 million increase is almost wholly due to increases in HEC I&A and HEC R&D, including increased investments in SciDAC applications partnerships, advanced prototypes focused on power-efficient designs that complement HPCS, basic computer science research to enable petascale computers, and applied mathematics research for algorithms for petascale computing.

NSA

Comparison of 2007 request ($118 million) and 2007 estimate ($75 million): The decrease of $43 million is due to a decrease of $26 million in HEC R&D and a decrease of $18 million in HCSS, both of which are the result of actions taken by Congress.

Comparison of 2007 estimate ($75 million) and 2008 request ($103 million): The $28 million increase results mainly from an increase of $24 million in HEC R&D, due to NSA's participation in the DARPA HPCS Phase 3 program.

NIST

Comparison of 2007 request ($43 million) and 2007 estimate ($53 million): Increases are shown primarily in the HCSS PCA, and reflect ongoing activities that have been reclassified as NITRD spending.

AHRQ

Comparison of 2007 request ($57 million) and 2007 estimate ($50 million): LSN funding decreased due to completion of AHRQ Data Standards Program grants. New grants in health-care IT focused on different areas, resulting in an increase in HCI&IM funding that offset some of the decrease. Other funding has shifted into non-IT-related patient safety and quality of care programs, resulting in a net reduction in estimated spending relative to the 2007 budget request.

DOE/NNSA

Comparison of 2007 estimate ($46 million) and 2008 request ($34 million): DOE/NNSA determined that its software design and development investments were more closely related to high-end computing, and has shifted reporting of those investments from the SDP PCA to the HEC R&D PCA. The $12 million decrease is due to reductions in HEC R&D in advanced architecture and systems software development, which are partially offset by the shift in funding from SDP.

NARA

NARA joined the NITRD Program effective with the 2008 budget request.

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 2007 requested funding and 2007 estimated spending and between 2007 estimated spending and 2008 requests.

HEC I&A

Comparison of 2007 request ($884 million) and 2007 estimate ($971 million): The $87 million increase is almost wholly due to increases of $74 million at OSD and DoD Service research organizations and $75 million at DOE/SC, offset by a decrease of $62 million at NIH. These changes are described above.

Comparison of 2007 estimate ($971 million) and 2008 request ($1.023 billion): The $52 million increase is primarily the combined result of increases of $31 million at NSF and $41 million at DOE/SC, partially offset by a decrease of $26 million at OSD and the DoD Service research organizations. These changes are described above.

HEC R&D

Comparison of 2007 request ($440 million) and 2007 estimate ($280 million): The $160 million decrease is primarily the result of decreases of $28 million at DARPA, $109 million at DOE/SC, and $26 million at NSA, which are described above.

Comparison of 2007 estimate ($280 million) and 2008 request ($289 million): The $9 million increase is primarily a combination of increases of $15 million at DOE/SC and $24 million at NSA and decreases of $21 million at DARPA and $8 million at DOE/NNSA. These changes are described above.

CSIA

Comparison of 2007 request ($176 million) and 2007 estimate ($213 million): The $37 million increase is almost wholly due to increases of $23 million at OSD and the DoD Service research organizations and $12 million at DARPA, which are described above.

HCI&IM

Comparison of 2007 request ($825 million) and 2007 estimate ($784 million): The $41 million decrease is almost wholly due to decreases of $40 million at OSD and the DoD Service research organizations and $35 million at DARPA, partially offset by increases of $16 million at NIH and smaller increases at AHRQ and other agencies. These changes are discussed above.

Comparison of 2007 request ($784 million) and 2008 request ($767 million): The $17 million decrease is due to a decrease of $17 million at OSD and the DoD Service research organizations, described above, and smaller increases and decreases at other agencies that offset each other.

LSN

Comparison of 2007 request ($405 million) and 2007 estimate ($385 million): The $20 million decrease is almost wholly due to decreases of $8 million at NIH and $15 million at AHRQ, partially offset by increases at several other agencies. The changes at NIH and AHRQ are described above.

Comparison of 2007 estimate ($385 million) and 2008 request ($417 million): The $32 million increase is due to increases of $23 million at NSF and $4 million at DARPA and smaller increases at several other agencies. The changes at NSF, DARPA, and AHRQ are discussed above.

HCSS

Comparison of 2007 request ($145 million) and 2007 estimate ($149 million): While the 2007 request and the 2007 estimate are approximately level, two agencies had substantial increases and one had a substantial decrease. OSD and the Service research organizations had a $14 million increase; NIST had a $10 million increase; and NSA had an $18 million decrease. The changes at these agencies are described above.

Comparison of 2007 estimate ($149 million) and 2008 request ($146 million): The $3 million decrease is the combination of a decrease of $12 million at OSD and DoD Service research organizations and increases at several other agencies. The change at OSD and DoD Service research organizations is described above.

SEW

Comparison of 2007 request ($114 million) and 2008 request ($131 million): The $17 million increase is due almost entirely to a $16 million increase at NSF, described above.

SDP

Comparison of 2007 request ($86 million) and 2007 estimate ($72 million): The decrease of $14 million is primarily due to a decrease of $15 million at NIH. DOE/NNSA also reclassified programs from SDP to HEC R&D, as described above.

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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

AFRL - DoD's Air Force Research Laboratory

AHRQ - HHS's Agency for Healthcare Research and Quality

ANL - DOE's Argonne National Laboratory

ARC - NASA's Ames Research Center

ARDA - Advanced Research and Development Activity (superseded by the Disruptive Technology Office)

ARL - DoD's Army Research Laboratory

ARO - DoD's Army Research Office

ARSC - Arctic Region Supercomputing Center

ASC - DOE/NNSA's Advanced Simulation and Computing program (formerly ASCI, for Accelerated Strategic Computing Initiative)

BIRN - NIH's Biomedical Informatics Research Network

Black Widow - NSA-supported next-generation system in the massively parallel, vector-processing system line

BLAS - Basic linear algebra subroutine

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

CAREER - NSF's Faculty Early Career Development Program

CDI – NSF's Cyber-enabled Discovery and Innovation program

CENIC - Corporation for Network Initiatives in California

CENTCOM - DoD's United States Central Command

CERDEC – U.S. Army's Communications-Electronics Research, Development, and Engineering Center

CG - Coordinating Group

CHEETAH - NSF's Circuit-switched High-speed End-to-End ArcHitecture network

CIO - Chief information officer

CMS - HHS's Centers for Medicare and Medicaid Services

CoPs - Communities of practice

COTS – Commercial-off-the-shelf

CPS – Cyber-physical systems

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

DARPA - DoD's Defense Advanced Research Projects Agency

DDR&E - OSD's Director of Defense Research and Engineering

DETER - NSF- and DHS-initiated cyber DEfense Technology Experimental Research network

DHS - Department of Homeland Security

DLI - DoD's Defense Language Institute

DNS - Domain Name System

DNSSEC - Domain Name System Security protocol

DOC - Department of Commerce

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

DOT - Department of Transportation

DRAGON - NSF's Dynamic Resource Allocation (via GMPLS) Optical Network

DTO - Disruptive Technology Office (formerly ARDA)

Educause - Non-profit organization promoting advancement of IT in higher education

Eldorado - NSA-supported multithreaded system

EPA - Environmental Protection Agency

ESnet - DOE/SC's Energy Sciences network

ESSC - DOE/SC's Energy Sciences network (ESnet) Steering Committee

FAA - DOT's 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 - HHS's Food and Drug Administration

FIU - Florida International University

FY - Fiscal Year

GALE - DARPA's Global Autonomous Language Exploitation program

GENI - NSF's Global Environment for Network Investigations

GEOSS - Global Earth Observation System of Systems, a cooperative effort of 34 nations, including the U.S., and 25 international organizations to develop a comprehensive, coordinated, and sustained Earth observation system

GMPLS - Generalized MultiProtocol Label Switching

GSA - General Services Administration

GSFC - NASA's Goddard Space Flight Center

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

HECRTF - High-End Computing Revitalization Task Force

HEC-URA - HEC University Research Activity, jointly funded by multiple NITRD agencies

HHS - Department of Health and Human Services

HPCMP - OSD's High Performance Computing Modernization Program

HPCS - DARPA's High Productivity Computing Systems program

IM – Information management

INCITE - DOE/SC's Innovative and Novel Computational Impact on Theory and Experiment program

IETF - Internet Engineering Task Force

InfiniBand - A high-speed serial computer bus, intended for both internal and external connections

INFOSEC – Information security

Internet2 – Higher-education consortium for advanced networking and applications deployment in academic institutions

I/O - Input/output

IP - Internet Protocol

IPsec - IP security protocol

IPv6 - Internet protocol, version 6

ISI - Information Sciences Institute

IT - Information technology

IT R&D - Information technology research and development

IWG - Interagency Working Group

JET - LSN's Joint Engineering Team

JETnets - Federal research networks supporting networking researchers and advanced applications development

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

MAN - Metropolitan area network

MAX - Mid-Atlantic eXchange

MCNC - Microelectronics Center of North Carolina

MIDAS - NIH's Modeling of Infectious Disease Agents Study

MPI - Message-passing interface

MTU - Maximum transmission unit

MURI - Multidisciplinary University Research Initiative

MW - Middleware

NA - National Academies

NARA - National Archives and Records Administration

NASA - National Aeronautics and Space Administration

NationalLambda Rail - Consortium of organizations working to provide an optical network for research

NCAR - NSF-supported National Center for Atmospheric Research

NCBC - NIH's National Centers for Biomedical Computing

NCLS - NASA's National Leadership Computing System

NCO - National Coordination Office for NITRD

NERSC - DOE/SC's National Energy Research Scientific Computing Center

NERSC-5 - DOE/SC NERSC's next-generation platform

NGATS - Federal government's Next-Generation Air Transportation System

NIH - HHS's National Institutes of Health

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 - DoD's Naval Research Laboratory

NRT - LSN's Networking Research Team

NSA - National Security Agency

NSF - National Science Foundation

NSTC - National Science and Technology Council

OMB - White House Office of Management and Budget

OMNInet - Large-scale metro optical network testbed supported by national labs, universities, Canadian organizations, and vendor partners

ONR - DoD's 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

ORNL - DOE's Oak Ridge National Laboratory

OS - Operating system

OSD - Office of the Secretary of Defense

OSTP - White House Office of Science and Technology Policy

PCA - Program Component Area

PF – Petaflop(s), a thousand teraflops

PI - Principal investigator

PNL - DOE's Pacific Northwest Laboratory

PREDICT - DHS's Protected Repository for the Defense of Infrastructure Against Cyber Threats

PSC - NSF-supported Pittsburgh Supercomputing Center

QoS - Quality of service

R&D - Research and development

RF - Radio frequency

ROM - Read-only memory

RTOS - Real-time operating system

S-ACARS - Secure-Aircraft Communication Addressing and Reporting System

SAST - Systems Administrator Simulation Trainer

SBIR - Federal Small Business Innovation Research program

SC - DOE's Office of Science

SCADA - Supervisory control and data acquisition

SciDAC - DOE/SC's Scientific Discovery through Advanced Computing program

SDP - Software Design and Productivity, one of NITRD's eight Program Component Areas

SEW - Social, Economic, and Workforce Implications of IT and IT Workforce Development, one of NITRD's eight Program Component Areas

SpiderWeb - NIH-sponsored effort to create shared informatics infrastructure of clinical, genomic, and molecular data

StarLight - NSF-supported international optical network peering point in Chicago

State - Department of State

SUP - Secure unattended proxy

TF - Teraflop(s), a trillion floating point operations (per second)

Treasury - Department of the Treasury

TREC - Text REtrieval Conference

TRUST - NSF's Team for Research in Ubiquitous Secure Technology

TSWG - Technical Support Working Group

UCAR - University Corporation for Atmospheric Research

UIC - University of Illinois at Chicago

UIUC - University of Illinois at Urbana-Champaign

UltraScience Net - DOE/SC's experimental research network

UMd - University of Maryland

UNC - University of North Carolina

USGS - United States Geological Survey

USMC - U.S. Marine Corps

UW - University of Washington

UWisc - University of Wisconsin

VA - Department of Veterans Affairs

V&V - Verification and validation

VM - Virtual machine

VPN - Virtual private network

WAN - Wide area network

WINS - SDP's Workshop on Interoperable Software

WLAN - Wireless local area network

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