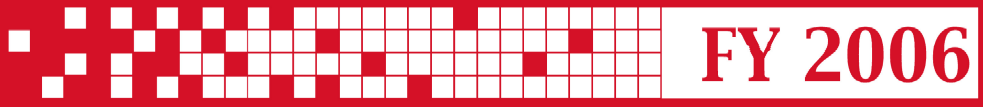

NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT

SUPPLEMENT TO THE PRESIDENT'S BUDGET

FEBRUARY 2005

NETWORKING AND INFORMATION TECHNOLOGY
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FOR

Fiscal Year 2006

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

Committee on Technology
National Science and Technology Council

FEBRUARY 2005

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

February 16, 2005

MEMBERS OF CONGRESS:

I am pleased to forward with this letter the annual report on the multi-agency Networking and Information Technology Research and Development (NITRD) Program. This Supplement to the President's Budget for Fiscal Year 2006 is a description of activities funded by Federal NITRD agencies in the areas of advanced networking and information technologies. Innovations in science and technology derived from NITRD investments are continuing to play an important role in strengthening the Nation's economy and contributing to a secure and prosperous future.

The strength of multi-agency programs like NITRD derives from the power of leveraging funding and research results across many agencies, achieving far more than the investments of any single agency could produce. The effectiveness of the NITRD program depends upon a sound coordinated investment strategy and close interagency cooperation in both planning and execution. This Budget Supplement provides a window into the strong interagency coordination that is occurring through the NITRD Program.

I am pleased to provide to you this timely report.

Sincerely,

John H. Marburger III
Director

Executive Summary

This Supplement to the President's Budget for Fiscal Year 2006 offers a brief technical outline of the 2006 budget request for the Networking and Information Technology Research and Development (NITRD) Program. Now in its 14th year, the NITRD Program is a unique collaborative enterprise of Federal agencies engaged in long-term R&D in information technology (IT) to support Federal missions and help sustain U.S. leadership in cutting-edge science, engineering, and technology. NITRD is the Nation's primary source of fundamental breakthroughs in IT R&D and advanced education and training for the new generations of IT researchers, educators, and entrepreneurs required to maintain U.S. innovation and economic prosperity.

The NITRD agencies coordinate their IT R&D activities in the following major research areas: high-end computing applications and infrastructure; high-end computing research and development; large-scale networking; human-computer interaction and information management; high-confidence software and systems; software design and productivity; and social, economic, and workforce implications of IT and IT workforce development.

The 2006 Supplement provides a two-page review of each NITRD research area summarizing the strategic priorities underlying the budget request, highlights of the request, interagency planning and coordination supporting the request, and an agency-by-agency listing of 2005 and proposed 2006 activities. Coordination highlights for 2006 include joint planning and funding of R&D in software for high-end computing; mutually agreed-upon agency efforts to open Federal HEC resources to wider research communities; collaborative planning and activities in optical networking; a multiagency national workshop on information integration; a joint initiative to create a prototype real-time high-confidence operating system engineered from the ground up to achieve high assurance, security, and reliability; and the open Expedition Workshop series on IT applications to improve government and community services to citizens.

The NITRD Program is coordinated by the Subcommittee on Networking and Information Technology Research and Development, under the aegis of the National Science and Technology Council's Committee on Technology. The National Coordination Office (NCO) for IT R&D provides technical and administrative support for the Program.

NOTE: To assure brevity, abbreviations and acronyms are employed throughout the Supplement and a glossary is included for reference. In conformance with OMB style, references to years in this report are to fiscal years unless otherwise noted.

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

NITRD Agencies: NSF, NIH, DOE/SC, NASA, NIST, OSD, NOAA, EPA, DOE/NNSA

HEC I&A members coordinate Federal activities in advanced computer systems, applications software, and related infrastructure, which have become core necessities for cutting-edge discovery across all scientific and engineering fields. HEC capabilities provide researchers with an unprecedented ability to study the most complex entities and processes in biology, chemistry, environmental sciences, materials science, nanoscale science and technology, physics, and many other fields. In HEC I&A, Federal agencies work collaboratively to extend the state of the art in computing systems, science and engineering applications, and data management. Amid increasing global competition, ongoing improvements in U.S. high-end computing capabilities are needed to keep the Nation at the forefront of 21st century science and engineering advances and to increase our understanding in such critical areas as air and water quality, biological systems at all scales, energy sources and conservation, environmental and human-engineered systems, and weather and climate.

President's 2006 Request

Strategic Priorities Underlying This Request

- Sustaining U.S. scientific and engineering leadership in certain areas that are supported by Federal agencies' science and national security missions will require ongoing investment in Federal HEC facilities and advanced computational applications over the next five years. When extrapolating the recent pace of advances in the use of available computing power to the end of the decade, petascale systems that are more than 100 times more powerful than today's highest-end systems may well be necessary to help meet mission needs and maintain the U.S. at the forefront of computational science innovation. The following critical issues documented in the "Federal Plan for High-End Computing" – developed by the High-End Computing Revitalization Task Force (HECRTF) and presented to Congress by the Administration in May 2004 – are being addressed in HEC agencies' leadership computing and acquisition coordination activities in HEC I&A:
  - *Availability and accessibility of Federal HEC resources for leading-edge scientific researchers.* During 2005 and 2006, new high-end capacity systems will be made available to the scientific research community (e.g., NSF, DOE/SC) that will expand researchers' access to HEC resources.
  - *Next-generation HEC platforms for the largest-scale scientific problems.* A new generation of capability platforms will be provided to the scientific and engineering communities (e.g., NASA, NSF, DOE/SC, DOE/NNSA). An example of a capability platform is NASA's new Columbia system, whose overall high performance enables scientists to execute in a day calculations that would previously have taken months (e.g., the simulations validating the most likely cause of the wing damage that led to the Columbia shuttle disaster).
  - *Coordinated, streamlined mechanisms for benchmarking and procurement of Federal HEC systems.* The agencies are developing mechanisms for opening computing cycles on leadership-class systems to peer-reviewed projects from the broad academic and industrial R&D communities, and are working collaboratively on new performance benchmarks to more accurately predict computing system performance on diverse scientific problems and the total cost of ownership.
- The modeling and simulation of complex scientific systems and engineering problems enabled by high-end computing are now an essential form of research and development. Recent successes, such as NOAA's ability for the first time to accurately predict 72 hours in advance the unusual track of hurricane Charlie in September 2004, saving lives and property, illustrate the great positive impact of computational science on the Nation. Such examples of national impact, many cited in the HECRTF report, motivate HEC I&A priorities.

Highlights of Request

Acquisition of prototype leadership-class machines

- **NSF:** Pittsburgh Supercomputing Center's new 2,000-processor, 10-teraflop Red Storm machine will be available for research by science discipline users requiring orders of magnitude increases in capability
- **DOE/SC (ORNL):** Operation of two 20-teraflop peak capability leadership-class architectures to enable scientific discovery

- **NASA (ARC):** New 10,420-processor, massively parallel processing (MPP) Columbia system will be partly available for research by all science discipline users requiring orders of magnitude increases in capability over today's levels

Applications
- **DOE/SC:** Scientific Discovery Through Advanced Computing (SciDAC) program's achievement in establishing multidisciplinary, multi-institutional teams of computer and disciplinary scientists to develop high-quality software applications in the physical and biological sciences will be extended through re-competition of modeling and simulation applications for scientific discovery
- **DOE/SC:** Competition to select a small number of university-based SciDAC institutes that can become centers of excellence in high-end computational science in areas critical to DOE missions and software centers for high performance computing
- **DOE/SC:** Successful 2004 Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program (providing competitive access to 10 percent of National Energy Research Scientific Computing Center [NERSC] system) will be re-competed in 2006

Planning and Coordination Supporting Request
Infrastructure
- **DOE/SC, NOAA, NSF, OSD:** Connectivity and technology delivery to universities
- **DARPA, NASA, NIST, NSA, NSF:** Standards
- **NASA, OSD:** Acquisition coordination
- **DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD:** Capability community resources

Applications
- **DOE/SC, NASA, NIH, NSF:** Multiscale biological modeling
- **DOE/SC, EPA, NASA, NOAA, NSF, OSD:** Climate and weather applications
- **NASA, NOAA, NSF, OSD:** Weather research and forecasting
- **EPA, NOAA:** Air quality modeling

2005 and 2006 Activities by Agency

NSF: NSF Cyberinfrastructure Framework – supports supercomputing, data resources, and networking needs of the broad scientific community; Extensible Terascale Facility (ETF), with addition of Red Storm at Pittsburgh Supercomputing Center in mid-2005 (this acquisition complements the 25 teraflops already available in the ETF); ETF moves from construction phase to operational phase
NIH: National Centers for Biomedical Computing; Multiscale Modeling Initiative for Bioscience
DOE/SC: New capacity Linux cluster at NERSC; INCITE program; scientific applications pilots; multiscale mathematics, SciDAC re-competition; leadership-class computing
NASA: Ames Research Center – 52-teraflop Columbia system for aerospace and Earth science; funding for 2006 reflects strategic focus on large-scale system and reduction in investments in Grand Challenge Applications
NIST: IMPI; immersive visualization infrastructure; modeling of nanostructure of cement and concrete; fundamental mathematical tools (e.g., basic linear algebra subroutines [BLAS])
OSD (HPCMPO): Additional capacity for the High Performance Computing Centers (four major shared resource centers – ARL, ASC, ERDC, NAVO; 16 distributed centers); software applications support (Common HPC Software Support Initiative [CHSSI], HPC Software Applications Institutes, Programming Environment and Training, Software Protection Center)
NOAA: Facilities – Geophysical Fluid Dynamics Laboratory, Forecast Systems Laboratory, National Center for Environmental Protection; acquire and optimize the use of high-performance scalable systems for research
EPA: Air quality applications – optimization for scalable systems; GEOSS – enhanced environmental codes; metabonomics initiative – shared access to data and results; facilities – Grid deployment
DOE/NNSA: Capability systems – Purple, BlueGene/L, Red Storm; capacity systems – Linux HPC clusters; disruptive technologies – BlueGene/L as a scalable, low-power, low-cost-per-peak-TF computing system

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

NITRD Agencies: NSF, NIH, DOE/SC, DARPA, NSA, NASA, NIST, OSD, NOAA, DOE/NNSA

HEC R&D members coordinate research and development activities to optimize the performance of today's high-end computing systems and to develop future generations of high-end computing systems necessary for meeting critical Federal agency mission and scientific and engineering needs, addressing many of society's most challenging large-scale computational problems, and strengthening the Nation's global leadership in science, engineering, and technology.

President's 2006 Request

Strategic Priorities Underlying This Request

- User requirements for HEC technology in the 2010 timeframe, as documented in the HECRTF report, include achieving high sustained application performance, building and maintaining complex software, managing dramatically increasing volumes of data, and integrating multiscale – in space and time – multidisciplinary simulations. The report laid out a broad R&D agenda and roadmap in hardware (including components and subsystems), software (including tools and languages), and systems (including architectures and programming models), and a set of R&D roadmaps that inform the HEC R&D strategy, priorities, and interagency coordination activities.
- Government, academic, and industry participants in the HECRTF activity highlighted the need for Federal HEC R&D as the essential underpinning for continued U.S. leadership in high-end computing. The report concluded that a revitalized R&D effort is necessary to:
  - *Refill the research pipeline with new ideas and the next generations of highly trained computer scientists.* DARPA, NSF, and DOE/SC have funded HEC University Research Activity (HEC-URA) to support R&D in software for high-end systems.
  - *Preserve U.S. leadership in the development of the world's most robust and innovative high-end systems, with the goals of orders of magnitude increases in U.S. computational capabilities and significantly improved cost-to-performance metrics.* The DARPA High Productivity Computing Systems (HPCS) program is funding research that will enable the next generation of high-end computing systems envisioned in 2010. These will be systems capable of petaflops of sustained operations.
  - *Reduce industry and end-user risk by undertaking the testing and evaluation of early prototype HEC systems and software.* The DARPA HPCS program seeks to minimize the risk to industry by funding research activities leading to next-generation capability systems and by working with the HPCS mission partners to acquire early versions of these systems. NSA's continuing HEC efforts in collaboration with other agencies in development of the Red Storm, X1e, and Black Widow supercomputers helps ensure that these systems also will be available for acquisition by other agencies and companies.
  - *Strengthen R&D in HEC component and software technologies to make HEC systems easier to use.* An HPCS-associated activity is the HPCS productivity effort, which is exploring language and development environments geared to workflows producing high-end applications.
- The HECRTF R&D strategy advances the development of robust and innovative systems and reduces industry and end-user risk by supporting the test and evaluation of HEC systems and software technologies. It calls for integrating hardware and software innovations to enable rapid advances in end-user applications. This approach is key to current and future HEC R&D priorities and activities.

Highlights of Request

- **DOE/SC:** Re-competition of the SciDAC program, which has been successful in establishing multidisciplinary, multi-institutional teams in applied mathematics and computer science that are developing advanced software and computational tools for the physical and biological sciences
- **DOE/SC:** New competitive program to support next generation of Research and Evaluation Testbeds that enable SciDAC teams to evaluate the promise of future computer architectures for their applications
- **DARPA, DOE/SC, NSF:** HEC-URA to fund university research in software specifically for high-end computing (NSA helped plan the activity)

- **DARPA, with DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD:** HPCS Phase III – final, full-scale development phase of DARPA's HPCS program
- **NSA, DOE/SC (SNL and ORNL):** Continue cooperative development of Black Widow and Red Storm systems, leading to introduction in 2006 of a new generation of these systems

Planning and Coordination Supporting Request
- **DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD:** Technical and planning workshops
- **DARPA, DOE/NNSA, DOE/SC, NSA, OSD:** Joint planning memorandum of understanding (MOU)
- **DOE/NNSA, DOE/SC:** NA/CSTB study, "Getting Up to Speed: The Future of Supercomputing"
- **DOE/NNSA, DOE/SC:** Open-source software

Systems architecture activities
- **DOE/SC, NASA, NIST, NOAA, NSF, OSD:** Testbeds
- **DARPA, with DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD:** HPCS Phase II
- **DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD:** Blue Gene/L, Red Storm, Black Widow reviews
- **DARPA, NIST, NSA, NSF:** Quantum information science

Systems software development
- **DARPA, DOE/NNSA, DOE/SC, NSA, NSF (DOE/NNSA participates in proposal reviews):** HEC-URA
- **DARPA, with DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD:** HPCS productivity metrics
- **DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD:** Benchmarking and performance modeling
- **DARPA, DOE/NNSA, DOE/SC:** Scalable visualization and file system

2005 and 2006 Activities by Agency

NSF: Supports university-based research on 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 and next-generation software systems; data-driven science including bioinformatics, geoinformatics, cognitive neuroscience; infrastructure development (create, test, harden next-generation systems); and software and tools for high-end computing
DOE/SC: SciDAC Integrated Software Infrastructure Centers in applied mathematics (applied partial differential equations and terascale tools) and computer science (component technology, scalable systems, engineering of system performance, scientific data management); operating/runtime systems for extreme-scale scientific computation; advanced computing research testbeds (ORNL X1e system)
DARPA: HPCS program – Phase II ends mid-2006 when full-scale development (Phase III) begins; Council on Competitiveness HPC Initiative (with DOE/SC, DOE/NNSA) to promote industry involvement; Polymorphous Computing Architectures program (agile, reconfigurable systems); HEC-URA support (with DOE/SC, NSF)
NSA: Architectures and systems; high-speed switches and interconnects; programming environments; quantum information sciences; vendor partnerships; X1e/Black Widow (extend development of the NSA/OSD X1 system to hundreds of teraflops)
NASA: Multiagency coordination activities in architectures, testbeds, and system performance assessment
NIST: Research in quantum computing and secure quantum communications
NOAA: Development of skills, algorithms, and techniques to fully utilize scalable computing for improved environmental understanding and prediction
DOE/NNSA: Software quality engineering for longevity of codes; verification to ensure accuracy, validation of the problem solution, certification methodology; capability computing, capacity computing; problem solving environments; industry collaboration; tracking requirements

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

NITRD Agencies: NSF, NIH, DARPA, NASA, AHRQ, NIST, NOAA, EPA
Other Participants: AFRL, FAA, ONR

HCI&IM R&D aims to increase the benefit of computer technologies to humans, particularly the science and engineering R&D community. To that end, HCI&IM R&D invests in technologies for mapping human knowledge into computing systems, communications networks, and information systems and back to human beings, all for the benefit of human understanding, analysis, and use. Specific R&D areas are user interaction technologies, cognitive systems, information systems, and robotics.

Highlights of the President's 2006 Request

Strategic Priorities Underlying This Request

- Key national priorities – including national defense, national and homeland security, large-scale scientific research, air-traffic control, emergency planning and response, health care, space exploration, and weather and climate prediction – typically require advanced HCI&IM technologies. Current NITRD work includes:
  - Technologies for multimodal language recognition and translation, multimodal user interfaces, and biometric identification and verification
  - IT capabilities that enable people rapidly to access and understand information that may come from many sources and in many forms (signals and audio, video, and text in diverse languages). Integrating heterogeneous, multimodal data quickly into useful formats remains a major R&D challenge.
  - Robotic vehicles and devices – such as those deployed in Afghanistan, Iraq, space exploration, urban search-and-rescue operations, and human assistive equipment
  - Cognitive systems – those able to "learn," adapt to changing circumstances, and self-heal. HCI&IM agencies' R&D in systems that can adjust to keep functioning under duress is vital for battlefield conditions and for deployability of robotic devices in hazardous or life-critical environments.
- In the information integration area, the NITRD agencies and the weather and climate modeling community are achieving a notable advance that will provide a model for other data-intensive research fields. The unprecedented national ESMF effort to build an interoperable infrastructure of data standards and reusable, user-friendly software tools is enabling all researchers to access and work collaboratively with the vast stores of U.S. climate data. Efforts such as GEOSS (EPA, NASA, NOAA, NSF) will link together strategies and systems, including ESMF, for Earth observation across multiple scientific boundaries. Measurements of air, water, and land made on the ground, from the air, or from space will be fused, manipulated, and mined.

Highlights of Request

- **NSF, other HCI&IM agencies:** National workshop on information integration – will identify key issues such as privacy, security, interoperability, and standards in advancing the utility of heterogeneous, multimodal information environments; goal will be to target R&D areas for coordinated NITRD efforts.
- **NSF:** Continue support for R&D in information integration across scientific disciplines and domains; machine vision, speech recognition, and other robotic technologies
- **DARPA, with NSF:** Continue cognitive-systems work – research supported by NSF and DARPA is used in DARPA's Improving Warfighter Information Under Stress program
- **NASA:** Exploration Systems Mission Directorate will initiate research on mobile agents (human-robotics collaborations)
- **AHRQ:** Continue funding multiagency initiatives to develop critical health data standards (with NLM on medical terminology standards; with NIST on developing a U.S. health standards model and application; with FDA on prescription drug data standards, such as an electronic labeling system)
- **EPA, NOAA, NSF, and other agencies:** Continue work on HCI&IM aspects of ESMF (e.g., data management and interoperability standards; reusable, user-friendly modeling tools and utilities for researchers)

Planning and Coordination Supporting Request

- **NSF, with other HCI&IM agencies:** Planning meeting to develop agenda and structure for 2006 information integration workshop

- **DARPA, NIST, NSA:** Multiyear collaboration on Effective, Affordable, Reusable, Speech-to-text (EARS) and Translingual Information Detection, Extraction, and Summarization (TIDES) programs
- **NASA, AFRL, FAA:** Collaborative work in aviation and aviation safety (NASA projects with FAA on automated vehicle cockpits and air traffic management and risk will continue in 2006)
- **AHRQ, EPA, NIH, NIST, NSF:** Regular information exchanges and R&D collaborations in biomedical research and health care data and information summarization, curation, analysis, and retrieval
- **EPA, NASA, NOAA, NSF:** Ongoing collaboration in climate, weather, and environmental modeling and simulation

2005 and 2006 Activities by Agency

NSF: Supports university-based research on intelligent robots and machine vision technologies to help people of all ages participate as first-class citizens in the information society; automatic multilingual speech-recognition toolkits; systems to recognize spontaneous speech despite disfluencies and multiple speakers; information infrastructure to enable spoken, written, and multimodal communications R&D; information integration, especially domain-specific and general-purpose tools for integrating information from disparate sources; projects to advance understanding of technology to enable scientific discovery and integrate research and education to benefit technical specialists and the general public; SEIII program – an outgrowth of ITR; planning for 2006 workshop on information integration. Participates in IWGEO, the Interagency Working Group for US_GEOSS; planning for NSF observations data to be part of GEOSS.
NIH: Curation and analysis of massive biomedical and clinical research data collections; tools to manage and use massive new databases; tools for building and integrating ontologies; software tools for visualizing complex data sets; curation tools; building nationwide support for standard vocabularies; information integration
DARPA: CAST; EARS; Improving Warfighter Information Intake Under Stress; TIDES
NASA: Multimodal interaction; data visualization and understanding; human-in-the-loop supervisory control (the design of intelligent and intelligible automation, human-robotic interaction); knowledge engineering and capture; risk management; projects in human-centered computing and intelligent data understanding end in 2005
AHRQ: Implement health information technology in rural and small communities and evaluate impact; assess clinical, safety, quality, financial, and organizational effectiveness and efficiency; establish health care data standards to support patient safety technologies; further develop a National Health Information Infrastructure (NHII) that includes an Electronic Health Record System to support health care decisions by allowing authorized users to access patient-level information and appropriate medical knowledge; state and regional demonstration projects of electronic health information exchange using clinical data standards
NIST: Improved performance and measurement in evaluation of technologies for text retrieval, question and answer, EARS, TIDES, TREC, document understanding, topic detection, automatic content extraction, machine translation, meeting transcription, speaker recognition, and language recognition; fingerprint and face recognition standards, interoperability; multimedia standards, video retrieval, visualization and virtual reality for manufacturing, video analysis and content extraction, motion image quality; software usability reporting standard; usability and accessibility of voting systems; roadmap for novel intelligence from massive data; user interface and test arenas for mobile robots; digital library of mathematical functions, accessibility standards; PerMIS conference; testbed for human interaction in smart space environment with microphones and video cameras
NOAA: Methods for cataloging, searching, viewing, and retrieving Web-based NOAA data; exploit geographic information system (GIS) and XML to display and describe data and develop methods to distribute model data; improve access to NWS model data subsets
EPA: Explore potential linkages between air quality and human health; develop collaborative frameworks for shared access to data and results, joint use of applications and visualization tools, and participatory analysis across scientific communities; evaluate distribution, management, and archiving of large data sets and the analytical tools that illuminate the causal relationships among environmental phenomena

ONR: Focus on team collaborative behavior in IT-enabled environments and on the impact of IT on the structure and function of teams. Other areas include: developing low-cost, easy-to-use applications of cognitive models during system design and implementation, information visualization formats to maximize human use of content, and developing user IT support strategies and methods to aid users when interruptions interfere with their work.

Large Scale Networking (LSN)

LSN Agencies: NSF, NIH, DOE/SC, DARPA, NSA, NASA, AHRQ, NIST, OSD, NOAA, DOE/NNSA
Other Participants: DHS, FCC, USGS

LSN members coordinate Federal agency high-performance networking R&D in leading-edge networking technologies, services, and enhanced performance including programs in advanced network components, optical network testbeds, security, infrastructure, and middleware; grid and collaboration networking tools and services; and engineering, management, and use of large-scale networks for scientific and applications R&D.

President's 2006 Request

Strategic Priorities Underlying This Request

- By 2008, science cooperation and model development in high-energy physics, bioinformatics, weather, astrophysics, and other areas will require near-real-time petabyte and above data transfers. Current technology and the Internet Protocol (IP) will not scale to this level. This need is addressed by 2006 LSN coordination on optical networking testbeds to develop the generalized multi-protocol label switching (GMPLS) protocol, interdomain resource reservation and management, and optical networking protocols and switches.
- Secure interdomain cooperation and collaboration is hindered by lack of a scalable authentication, authorization, and accounting protocol (AAA). In 2006, the LSN agencies will cooperatively develop an AAA interagency testbed with the aim of later expanding the AAA protocols to larger-scale networks. They are also developing security best practices and new technologies such as automated intrusion response.
- Optimizing application performance over networks is severely constrained by lack of visibility into the interior of networks. Joint Engineering Team (JET) members are coordinating implementation of standard measurement boxes and standard protocols allowing end-to-end tuning of application performance.

Highlights of Request

Promote development and coordination of Optical Networking Testbeds (ONTs): NSF's CHEETAH and DRAGON networks, DOE/SC's UltraScience Net, and coordination with OMNInet, NationalLambda Rail, and regional ONTs. These testbeds are developing GMPLS, agile circuit-switching, and interdomain control plane tools, services, and management (e.g., resource reservation, security). Collaborative activities include:

- **All:** Coordination of network backup during times of stress, outage, or national emergency
- **All:** Coordination on OMB's call for cybersecurity implementation
- **DOE/SC, NSF:** End-to-end agile networking
- **DOE/SC, NSF:** High speed transport protocol
- **DOE/SC, NSF, others:** End-to-end QoS/GMPLS
- **DARPA, NSA, NSF, OSD:** End-to-end network performance measurement
- **DARPA, NSF, FCC:** Programmable wireless networking (ProWin) and networking of sensor systems (NOSS)
- **DHS, DOE/SC, NSF, OSD:** Network security research

Planning and Coordination Supporting Request

- **Co-funding:** NSF networking research projects (e.g., cyber security, fundamental network research) receive support from DARPA, DHS, DOE/SC, and NSA
- **Workshops:** Follow-up meeting on 2004 JET Roadmap Workshop co-sponsored by DOE/SC, NSF to plan joint activities; LSN ONT Workshop, August 2004 to plan 2005-06 activities; 2005 NSF Cybersecurity Follow-on Workshop; DOE/SC National Collaboratories Workshop to plan 2005-06 programs
- **Coordination by LSN Teams:**
    - **Joint Engineering Team (JET): DOE/SC, NASA, NIH, NIST, NOAA, NSA, NSF, OSD, USGS, with national labs, universities, and vendors (ANL, ARSC, CAIDA, Cisco, CSC, FIU, Internet2, ISI, IU, Juniper, MAX, NLANR, Qwest, StarLight, UIC, UMd, UNC, UW) –** 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;

recommendations: 9,000-byte MTU; international coordination
    - **Middleware and Grid Infrastructure Coordination (MAGIC) Team: DOE/SC, NIH, NIST, NOAA, NSF, with national labs, universities, and vendors (ANL, Boeing, Cisco, Educause, Fairfield Technology, HP, IBM, Internet2, ISI, LANL, Level3, LBL, Microsoft, PNL, UCAR, UIUC, UMd, UWisc) –** middleware and Grid tools and services; collaboration infrastructure; applications; security, privacy (coordinate certificate authorities); standards development; international coordination
    - **Networking Research Team (NRT): DARPA, DOE/SC, NASA, NIST, NSA, NSF –** basic research (technology and systems); prototyping/testing optical networks (dynamic provisioning, GMPLS-based control plane); applications; wireless, nomadic networking (ad hoc, mobile); education and training
- **Information exchange:** Multiagency LSN program manager participation in review panels, informational meetings, principal investigator (PI) meetings; monthly LSN, JET, MAGIC, and NRT meetings; tactical coordination among program managers with common interests; DOE ESSC meetings coordinated with Internet2 Joint Techs Meetings; GMPLS working group coordinating development of inter-domain signaling in agile optical networks

2005 and 2006 Activities by Agency

NSF: Sponsorship at universities of fundamental networking research (architectures, fundamental design, control and management, innovative technologies, extensible networks, strategic research); networking of sensor systems (network programming, hardware/software, architecture, privacy/security, protocols, and algorithms); programmable wireless networks (dynamic spectrum management, topology discovery, robust/secure architecture, applications development, management); CAREER awards for networking research; network security (intrusion/attack detection and prevention, network forensics, critical systems protection, survivable designs and protocols); infrastructure development (create, test, and harden next-generation systems); optical networking testbeds (DRAGON, CHEETAH, applications development, security, GMPLS, interdomain services, bandwidth on demand)
NIH: Testbed projects to demonstrate QoS, security and medical data privacy, nomadic computing, network management, collaboratory infrastructure technology; Biomedical Informatics Research Network (BIRN)
DOE/SC: Middleware and network research (on-demand bandwidth, Grid security, transport protocols, control plane signaling [optical networking], guaranteed end-to-end bandwidth); and network testbeds (Grid3 currently operational); UltraScience Net (research and engineering prototype); QoS/MPLS Testbed (ESnet production network)
DARPA: Self-aware collective systems (resilient, scalable, self-diagnosing, self-healing collections of assets); cognitive networking (self-aware, self-managing networks)
NSA: Wired and wireless location-based services; optical routing and control; quantum communications and quantum key distribution; high-speed information security; pricing models in networking and information assurance
NASA: Space communications and networking (backbone networks and ad hoc networking, energy-efficient integrated communications/networking, data and link layer applications); networking for supercomputing support; projects in Grid computing and space communications end in 2005
NIST: Complex systems (Web service/global information systems, self-managing systems, wireless protocols for healthcare, IP telephony): trustworthy networking (cryptographic standards and applications, smart card security, quantum communications, next-generation protocol architecture, Internet infrastructure protection); networking for public safety: protocols for public safety communications, indoor localization
OSD (HPCMPO): IP end-to-end performance measurement, measurement tools, IPv6 pilots, network security (WAN firewalls and encryption), automated management, IPv6 multicast, and broadband access to Hawaii and Alaska
NOAA: Advanced networking infrastructure including distributed Web servers; computer and network security; applications (collaboratories, Grid computing, storm-scale simulations, wireless, remote operation)

High Confidence Software and Systems (HCSS)

NITRD Agencies: NSF, NIH, DARPA, NSA, NASA, NIST, OSD
Other Participants: AFRL, ARO, DHS, FAA, FDA, ONR

HCSS activities focus on the basic science and information technologies necessary to achieve affordable and predictable high levels of safety, security, reliability, and survivability in U.S. national security- and safety-critical systems. These activities are essential in domains such as aviation, health care, national defense, and infrastructure.

President's 2006 Request

Strategic Priorities Underlying This Request

- Assuring the security, safety, and highly dependable performance of systems and software in critical applications and U.S. infrastructures is one of the most significant and difficult challenges in computing and networking R&D. The technical complexity of these systems continues to grow rapidly in two directions – ever-larger systems of systems involving many millions of lines of code and ever-smaller embedded systems and networks of such systems. As of 2005, the NITRD research community is in the third year of an intensive focus on software and systems assurance arising not only from the new national security climate but also from the rapid emergence of embedded sensor applications in industry; the growing need for secure, reliable IT systems in health care informatics and medical devices; and the increasing complexity of large-scale systems of systems such as the U.S. financial system.
- Agencies' 2006 plans reflect their search for new science-based concepts, technologies, and tools that can revolutionize not only the engineering processes for construction, testing, and certification of software, but also the overall engineering of systems to incorporate high assurance levels at every stage of system design – a new concept in IT R&D. The new area of hybrid and embedded systems such as medical devices offers a rare opportunity to instantiate high assurance from the beginning, not just re-engineer legacy systems.

Highlights of Request

- **NSF:** Develop a new Computer Systems Research program in basic and technology research for high-confidence embedded systems, hybrid control, distributed systems; continue Cyber Trust and Science of Design themes across the divisions of CISE Directorate
- **NSF, DHS:** Continue DETER/EMIST network testbed and experimental framework for network security research launched in 2004
- **DARPA, NSF:** Continue four jointly funded, multi-university projects in Cyber Trust that are developing methods for demonstrating that large software systems are free from flaws
- **NSA, NSF, with NASA, NIST, and other HCSS participants:** Initiate a jointly funded research project on assured and composable, secure, real-time operating systems and middleware. The project will develop an integrated systems and verification technology base for assured systems that are component-oriented, configurable, and coordinated. The goal is to enable future distributed, real-time, embedded systems that have security and assurance built in "from the ground up."
- **NSA, NSF, with other HCSS agencies:** Verification Grand Challenge Workshop planning
- **NIST:** New activity in high-confidence methods for voting and vote counting

Planning and Coordination Supporting Request

- **HCSS CG and agencies:** Two-part High Confidence Medical Device Software and Systems (HCMDSS) activity – November 2004 workshop planning meeting; June 2005 national workshop on improving design, certification, and operation (by both health care professionals and consumers) of medical device software and systems that will result in better and more cost-effective medical care
- **HCSS CG, FAA:** Aviation workshop planning meeting and workshop to address safety issues in certification of autonomous vehicles and air traffic management; goal is to formulate a research agenda that addresses safety and security and is compatible/compliant with civilian processes.

- **DARPA, NIST, NSF, FAA, ONR:** Support for NA/CSTB Cyber Security study
- **NSA, NSF, ONR, with participation by DARPA, NASA, NIST, ARO, FAA, FDA:** NA/CSTB study on "Sufficient Evidence? Building Certifiably Dependable Systems" to assess current practices for developing and evaluating mission-critical software, with an emphasis on dependability
- **NSA, NSF, with NASA, NIST, other HCSS participants:** Collaborative study and planning for 2006 initiative for a real-time research operating system using open systems technologies
- **NSA, NSF, with HCSS agencies:** Planning workshop for Software Verification Grand Challenge conference
- **NSA, with participation by other HCSS agencies:** Fifth annual HCSS conference in Spring 2005 to showcase recent technical accomplishments, promising research activities, and future research directions, all focused on improving the confidence of software and systems
- **NIST, with participation by other HCSS agencies:** Workshop on Software Assurance Metrics and Tools Evaluation
- **FDA:** Collaborations on medical device safety, including with NSF on proton beam and with NSA on unintended function checker

2005- 2006 Activities by Agency

NSF: Cyber Trust – cyber security foundations, network security, systems software, information systems; Science of Design – assured design for software-intensive computing, information, and communications systems; ITR – IT and high-confidence hybrid control systems for critical infrastructures such as the power grid, open source/open verification technology; Computing Processes and Artifacts and Computing Systems Research – assured platforms and software, and distributed, real-time, embedded computing; computational models and assurance methods for safety-critical systems
DARPA: Self-Regenerative Systems effort to develop systems able to function fully in spite of attacks; Security-Aware Critical Software program (new in 2005) to create software that provides a comprehensive picture of security properties and current status, presenting this information at multiple levels of abstraction and formality
NSA: R&D in trusted development (ways to achieve assured software and system designs with assured development techniques throughout the software lifecycle) and containment (mitigating risks of systems whose components are not assured); research in transparency (development of critical architectures and components necessary to support information assurance) and high-assurance platform (supporting promising partnerships through the development of new platform-level containment mechanisms and measurement capabilities)
NASA: Automated mathematical techniques for high-confidence software development; Highly Dependable Computing Platform (HDCP) Testbed (evaluating real-time in-flight software demands); Mission Data Systems reusable software infrastructure for 2005 Mars mission; R&D in software engineering, assurance, and verification and validation techniques for mission-critical applications. Some aviation safety and security projects end in 2005, including efforts in flight-critical systems; 2006 projects currently being planned. The AuRA project is exploring advanced technologies for autonomous aircraft, including efforts to ensure integrity of underlying computational capabilities.
NIST: Continue work in e-commerce, e-health, computer forensics, test method research, security technologies, systems and network security, management and assistance, and security testing and metrics; lead DHS and DoD efforts to create studies and experiments to validate existing software assurance metrics and develop new metrics

AFRL: Developing the safety and security certification requirements for future Air Force applications of unmanned aerial vehicles; forming multi-technical directorate team to participate in and contribute to a national investment strategy plan; workshop planning meeting and full workshop anticipated in 2005
FAA: Developing a rapid quarantine capability; testing biometrics single sign-on; testing behavior-based security; developing an information systems security architecture; establishing an integrity and confidentiality lab to test wireless information systems security; extending COCOMO II (COnstructive COst MOdel II) to include security; validating Web data mining to find FAA vulnerabilities
FDA: Research projects include: proton beam therapy device (safety and modeling); software for an infusion pump with a control loop, which led to an initiative of similar control loop software for a ventilator device (certification); blood-bank software regulation (certification); reverse engineering of C programs to look for inconsistencies and errors in radiation treatment planning systems used in tumor treatment (forensics); unintended function checker (forensics)

Software Design and Productivity (SDP)

NITRD Agencies: NSF, NIH, DARPA, NASA, NIST, OSD, NOAA, DOE/NNSA
Other Participants: FAA, ONR

SDP activities will lead to fundamental advances in concepts, methods, techniques, and tools for software design, development, and maintenance that can address the widening gap between society's need for usable and 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 and the economics of software management across all IT domains including the emerging areas of sensor networks, embedded systems, autonomous software, and highly complex, interconnected systems of systems.

President's 2006 Request

Strategic Priorities Underlying This Request

- Developing, upgrading, and maintaining software has become the most costly, time-consuming, labor-intensive, risky, and frustrating aspect of IT deployment for Federal agencies and indeed all sectors of the economy. Certifying the correct functionality, reliability, and security of products and processes that include software adds costs and delays the deployment of new and improved capabilities. SDP R&D focuses on cost-effective methods to overcome this pervasive problem at the core of computing and networking technologies.
- Because high-quality software is mission-critical for SDP agencies, they are both individually and collaboratively creating frameworks and environments to more efficiently develop and certify such software. The goal is to find next-generation software engineering methods, tools, and techniques that reduce the cost, risk, and difficulties of software development and increase the reliability, security, interoperability, and even reusability, of software components.
- The commonality of agencies' software issues, recent advances in computer science such as aspect-based programming, and the need for interoperability (which is facilitated by data standards) make several topics ripe for enhanced information sharing and coordination. The capability to conduct multiscale modeling and simulation of complex physical systems such as the Earth, the human body, and manufactured products is needed across all science and engineering domains, but developing the necessary software is costly and technically difficult. The SDP workshop activity will assess the state of the art and identify research needs to advance interdisciplinary modeling techniques and tools that many communities could share.

Highlights of Request

- **DOE/SC, NOAA, NSF:** ESMF (component architecture with libraries and utilities to increase portability, reusability, and performance of Earth science software applications)
- **DOE/SC, NIH, NIST, NSF:** Data Uniformity and Standards for Structural Bioinformatics
- **DARPA, NSF:** Embedded Systems Consortium for Hybrid and Embedded Research (ESCHER)
- **NASA, NSF:** Highly Dependable Computing and Communications Systems Research (HDCCSR)
- **NASA, NIST:** Systems Engineering Program

Planning and Coordination Supporting Request

- Planning for a 2006 workshop on multiscale modeling and simulation of complex physical systems
- Briefings by Federal IT user agencies about issues in developing their critical large-scale software applications

2005 and 2006 Activities by Agency

NSF: Supports basic research on foundations of computing processes and artifacts (advanced computational research, software engineering, and languages), science of design (scientific study of the design of software-intensive systems including their complex interdependencies); computer systems research (distributed systems, embedded and hybrid systems, new-generation software); HDCCSR to advance the design, testing, implementation, and certification of highly dependable software-based systems (with NASA)

NIH: Support four National Centers for Biomedical Computing to develop, disseminate, and train users of biomedical computing tools and user environments; encourage collaboration between "big" and "small" science at these Centers; create and disseminate curriculum materials to embed quantitative tools in undergraduate biology education

NASA: Advanced software engineering technologies for modular and reusable flight software, software verification and validation technologies for autonomous systems, and increased reliability for critical flight control software; software systems for autonomy and intelligence; advanced software health management technologies for fault detection, diagnosis, prognostics, information fusion, and degradation management; advanced capabilities in modeling, simulation, and visualization; multi-agent technologies for self-scheduling systems, distributed decision-support systems and other autonomous environments; advanced capabilities to support management of technology; systems design and engineering analysis tools including simulation modeling environments, system models, discipline-oriented analysis tools, parametric-based risk analysis tools, and probabilistic risk analysis models; projects in autonomy and engineering for complex systems end in 2005

NIST: Automated design, procurement, and operation through software (mostly data) interoperability; automated generation of test suites for XML schema; Digital Library of Mathematical Functions (with NSF); manufacturing supply chain software interoperability; standards for ebXML; international testbeds for business-to-business solutions; interoperability of databases for bioinfomatics, chemical properties, and properties of inorganic materials; sharable data structures for neutron research; ontological approach using formal logic to automate process of integrating manufacturing enterprise UnitsML; interface standards and associated conformance tests for interoperability of manufacturing control systems architectures with security; semantically based validated product representation scheme for seamless interoperability among computer-aided design (CAD) systems and with systems that use CAD data; standards for exchange of instrument data and NIST Chemical Reference Data; standards for physical and chemical product data interchange; anthropometric data standards for accurate 3-D representation of human measurement (with the U.S. Air Force for cockpit design); ontological methods for representation and exchange of mathematical data; 3-D representation of schema models; tools for validation and testing of schemas

OSD (HPCMPO): Applications software development (physics-based design, modeling, simulation, testing); institutes on battlespace topics; PET Program tools and techniques (benchmarking, remote visualization, debugging and optimization, interactive computing environments for large datasets)

NOAA: Develop atmospheric, ocean, and coupled climate models for climate projection studies using the FMS programming structure; ESMF; Development Test Center (with NSF/NCAR and the university community)

DOE/NNSA: Deploy software user environment for Advanced Simulation and Computing (ASC) Program's Red Storm system at SNL; deploy and test software components and environment for Purple and Blue Gene/L systems at LLNL; develop high-performance open-source Linux-based environment, initially targeting capacity computing; execute performance-related analysis of interconnects, ASC computational workload, Linux software stacks, and capacity platforms; plan and prepare for software infrastructure of future ASC systems

FAA: Focus on developing secure, dependable software-based systems and the ability to produce them in a timely, predictable, and cost-effective manner

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

SEW Agencies: NSF, NIH, DOE/SC, NASA, DOE/NNSA
Other Participant: GSA

SEW activities focus on the nature and dynamics of IT impacts on technical and social 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 transfer the results of IT R&D to the policymaking and IT user communities in government at all levels and the private sector. The goal of SEW research and dissemination activities is to enable individuals and society to better understand and anticipate the uses and consequences of IT, to inform social policymaking, IT designs, and broadened participation in IT education and careers.

President's 2006 Request

Strategic Priorities Underlying This Request

- The President's Information Technology Advisory Committee (PITAC) noted in 1999 that the societal implications of the digital revolution were not yet clear and required examination. Six years later, the revolution continues to sweep us rapidly forward, and understanding the implications so that society can make informed choices remains a necessity. As the only NITRD agency funding basic research on the social and economic implications of IT, NSF has already contributed significant R&D findings: explaining the productivity paradox; expanding understanding of Internet use in the home, global e-commerce, and design principles for scientific collaboratories; and prototyping ways to embed principles of trust in e-commerce protocols and mechanisms.
- The NITRD Program is the Nation's primary resource for addressing the education and training of new generations of advanced IT researchers and technical professionals. In addition to the support for U.S. graduate students that flows with NITRD grants to universities, the SEW agencies sponsor targeted education and training in computational science, IT security, biomedical informatics, K-14 science subjects, and IT for underserved communities. The Collaborative Expedition Workshop series plays a related role, connecting people who have developed advanced IT implementations with those who are seeking to learn how to apply these capabilities to improve government and community services – with an emphasis on open standards, reusable components to maximize cost-effectiveness, and interoperability.

Highlights of Request

- **NSF:** Continue multiyear 2005 ITR projects in SEW topic areas (selected awards include infectious disease informatics; globalization and the distribution of knowledge work; socio-technical systems for management of biohazardous emergencies); new program in Broadening Participation for Underserved Communities in IT Activities
- **NSF, with EPA, NASA, USGS:** Support for projects in eco-informatics and government decision-making
- **NSF, Library of Congress:** Continue 2005 initiative in digital archiving/long-term preservation
- **DOE/NNSA, DOE/SC:** Continue support for Computational Science Graduate Fellowship Program
- **CIO Council and GSA, with SEW:** Continue monthly Collaborative Expedition Workshop series

Planning and Coordination Supporting Request

As the only NITRD area focused on the implications of IT for society at large, for education, and for IT workforce development, SEW functions as a crossroads between the IT R&D community and the larger arena of policymakers and IT implementers. In the last several fiscal years, GSA has helped SEW expand its outreach to other communities by co-sponsoring with the Federal CIO Council a monthly open workshop series to foster collaboration among government and community implementers of IT and to demonstrate promising IT capabilities emerging from Federal research. NSF co-sponsors these events and invites researchers to give academic talks on selected topics in an attempt to bridge the gap between research and policy. The Collaborative

Expedition Workshops draw participants from Federal, state, and local government, nongovernmental organizations, and IT developers and researchers. The focus is on emerging technologies for application 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 initiative. Through this activity, SEW's Universal Access Team has forged communication links with many other Federal IT implementation efforts.

2005 and 2006 Activities by Agency

NSF: SEW-related R&D under ITR program; research in collaboration in the sciences and for emergency preparedness, advancing knowledge and the knowledge economy, socio-technical issues in intelligence informatics; collaborations with the European Commission Information Society Technologies Programme; broadening participation for underserved communities in IT activities; and expanded opportunities for innovative education and curriculum development projects

NIH: Graduate and postdoctoral fellowship programs in bioinformatics

DOE/SC and DOE/NNSA: Computational Science Graduate Fellowship Program

NASA: Learning Technologies Project. No SEW activities reported for 2006.

GSA: Collaborative Expedition Workshop series

Agency NITRD Budgets
By Program Component Area
2005 Budget Estimates and **2006 Budget Requests**
(Dollars in Millions)

Agency		High End Computing Infrastructure & Applications (HEC I&A)	High End Computing Research & Development (HEC R&D)	Human-Computer Interaction & Information Management (HCI & IM)	Large Scale Networking (LSN)	High Confidence Software & Systems (HCSS)	Software Design & Productivity (SDP)	Social, Economic, & Workforce (SEW)	**Total**
NSF	2005 Estimate	198.9	101.8	167.4	96.2	66.7	66.4	97.5	795
NSF	**2006 Request**	**201.8**	**105.0**	**168.5**	**94.5**	**76.0**	**65.4**	**92.1**	**803**
NIH		133.8	66.6	173.4	84.8	12.3	26.3	12.3	509
NIH		**135.1**	**67.3**	**171.0**	**76.6**	**12.3**	**26.4**	**12.0**	**501**
DOE/SC[1]		98.2	107.3		43.9			3.5	253
DOE/SC		**105.7**	**82.0**		**36.2**			**3.5**	**227**
DARPA[2]			64.3	61.2	17.2				143
DARPA[2]			**81.0**	**74.4**	**20.8**				**176**
NSA			53.9		1.5	57.2			113
NSA			**36.9**		**1.5**	**62.2**			**101**
NASA[2]		53.7	1.7	39.2	29.6	17.9	14.1	6.7	163
NASA[2]		**34.0**		**14.5**	**13.0**	**12.8**			**74**
AHRQ[2]				45.0	35.0				80
AHRQ[2]				**38.0**	**30.0**				**68**
NIST		3.4	0.6	7.6	4.6	18.0	4.8		39
NIST		**5.4**	**0.6**	**8.6**	**4.6**	**18.0**	**4.8**		**42**
OSD						2.4	19.2		22
OSD						**2.5**	**20.0**		**22**
NOAA		12.9	1.8	0.4	2.7		1.5		19
NOAA[2]		**13.7**	**1.8**	**0.5**	**2.8**		**1.5**		**20**
EPA		2.3		2.0					4
EPA		**3.3**		**3.0**					**6**
Subtotals		503.2	398.0	496.2	315.5	174.5	132.2	120.0	2,140
Subtotals		**499.0**	**374.6**	**478.5**	**280.0**	**183.8**	**118.1**	**107.6**	**2,041**
DOE/NNSA[2]		31.4	34.5		13.3		32.9	4.7	117
DOE/NNSA[2]		**33.1**	**30.5**		**14.3**		**31.6**	**4.4**	**114**
TOTALS[2]		534.6	432.5	496.2	328.8	174.5	165.1	124.7	2,256
TOTALS[2]		**532.1**	**405.1**	**478.5**	**294.3**	**183.8**	**149.7**	**112.0**	**2,155**

[1] For comparability to current characterizations, the 2005 DOE/SC LSN number includes $16.4 million for National Collaboratory Tools and Pilots, which had been previously included in HCI&IM.

[2] These totals supersede numbers released with the President s 2006 Budget. Discrepancies resulted from rounding and late shifts in estimates.

NITRD Budget Analysis

The President's 2006 Budget continues the Administration's strong support for the NITRD Program. The total request of $2.15 billion supports cutting-edge research, development, and education by the NITRD agencies, working in close collaboration, in: high-end computing infrastructure, applications, research, and development (HEC I&A and HEC R&D respectively); human-computer interaction and information management (HCI&IM); large-scale networking (LSN); high-confidence software and systems (HCSS); software design and productivity (SDP); and social, economic, and workforce aspects of information technology (SEW).

Analysis of NITRD Investments by Agency

The President's 2006 request for NSF is increased by $8 million over 2005. Both HEC I&A and HEC R&D are increased, consistent with the recommendations of the HECRTF. HCSS is also increased to support NSF's Cyber Trust Program and other important cyber security research. These increases are balanced by slight decreases in LSN and SEW.

The 2006 request for NIH shows a slight decrease from 2005 due to completion of testbed projects exploring medical applications of advanced networks.

In 2006, DOE/SC will operate the two leadership-class architectures acquired in 2004 and 2005 at ORNL, with with a limited number of very large allocations open to the scientific community. Major elements of the DOC/SC SciDAC portfolio will be re-competed in 2006, including competitive establishment of new SciDAC academic centers to focus on computational science areas critical to DOE missions, resulting in an increase in HEC I&A funding. Reduction in HEC R&D funding reflects completion of the initial leadership-class system acquisition. Funding for LSN is reduced as current efforts in Networking Research and Collaboratory Tools and Pilots are consolidated into an integrated Distributed Network Environment focusing on basic research in computer networking and middleware to serve DOE mission needs. Although the total DOE/SC 2006 NITRD request shows a decrease from the 2005 enacted level, it is $1 million above the President's 2005 request.

The request for DARPA is increased $28 million above 2005. HEC R&D is increased by $17 million to support Phase III of the High Productivity Computing Systems program, consistent with the recommendations of the HECRTF. HCI&IM is increased $13 million for research aimed at improving information access and analysis for warfighters. LSN is increased by $3 million for research to improve network reliability and resilience for military needs.

The 2006 request for NSA contains two significant budget changes. The reduction of $17 million in HEC R&D reflects the winding down of developmental support for the Black Widow computer system. The $5-million increase for HCSS funds the NSA part of an inter-agency effort on secure real-time operating systems and associated middleware.

In 2006, NASA's Vision for Space Exploration and mission needs for Return to Flight will affect its participation in the NITRD Program. NASA will continue operating the 52-teraflop Columbia computer acquired in 2004 and 2005 for science and engineering simulation, including providing access to this world-class resource for the scientific community. Funding for Grand Challenge Applications will be reduced, and HEC technology research will be completed, reducing its HEC I&A participation and ending NASA's HEC R&D participation. NASA will continue interagency coordination activities in architectures, testbeds, and system performance assessment. Funding for research in intelligent systems and grid computing has been redirected to more directly address time-critical agency mission needs related to Return to Flight and the Vision for Space Exploration, reducing NASA participation in HCI&IM and LSN. NASA investments in autonomous systems and robotics are no longer counted as part of SDP, and NASA funding similarly is no longer counted as part of SEW. As a result of these reductions and redirections, NASA overall funding for NITRD activities changes from $162.9 million in 2005 to $74.3 million in 2006.

The AHRQ request is $12 million below 2005 but $25 million above 2004. Under this request, AHRQ supports the President's goal of driving better information technology into health care by supporting creation of regional health information networks and developing standards for interoperable health information. AHRQ's funding decrease results from transferring to the new Office of the National Coordinator for Health Information Technology (ONCHIT) responsibility for the maturing regional collaborations that assist health care providers in the deployment of standards-based interoperable Electronic Health Records systems.

Although NIST, NOAA, and EPA have modest funding levels relative to other NITRD agencies, they leverage their investment through collaboration with the other NITRD agencies. Reflecting the benefits of these collaborations, NIST, NOAA, and EPA all show funding increases in HEC I&A to support scientific applications for the agencies' mission needs. Similarly, these agencies are increasing their efforts in HCI&IM, reflecting their collaborations in information management research for their mission needs.

OSD has been restored to the NITRD crosscut. The OSD request is constant from 2005 to 2006, focusing on HCSS and SDP.

The DOE/NNSA request is slightly below 2005. The primary change is a shift from HEC R&D toward HEC I&A, reflecting NNSA priorities to better support the computational needs of its scientists and engineers.

Analysis by Program Component Area (PCA)

HEC I&A is almost constant from 2005 to 2006, with reductions in NASA offset by increases in all of the other participating agencies.

HEC R&D is decreased by $38 million from 2005 to 2006. This results from decreases in specific DOE/SC and NSA projects described above, though these decreases are partly offset by an increase in the DARPA HPCS program. Long-range HEC technology research will continue at approximately the same level in 2006 as in 2005. Collaboration among agencies to carry out the HECRTF recommendations will continue in both HEC I&A and HEC R&D.

HCI&IM funding is down $18 million from 2005 to 2006. The decrease at NASA is partly balanced by increases in DARPA and other agencies. The AHRQ decrease from 2005 actually sustains a substantial increase over 2004.

LSN funding decreases $29 million from 2005 to 2006. While LSN funding increases at DARPA and DOE/NNSA, LSN funding decreases at NSF (completion of projects), NIH (completion of testbeds for network applications), DOE/SC (consolidation of middleware activities), NASA (redirection for new missions), and AHRQ (reduction of regional networking).

HCSS funding increases by $9 million from 2005 to 2006, reflecting multiagency focus on cybersecurity and on more secure, reliable, and resilient systems. Notable are NSF's lead in basic cybersecurity research and the multiagency effort on a real-time research operating system.

SDP funding decreases $15 million from 2005 to 2006, almost entirely due to NASA's shifts to address its time-critical mission needs. The participating agencies will benefit from the increased involvement of OSD, which has set a high priority on improvement of software quality.

SEW funding decreases $13 million from 2005 to 2006 because of reductions and redirections, primarily at NASA and NSF.

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Human-Computer Interaction and Information Management (HCI&IM) Coordinating Group
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Software Design and Productivity (SDP) Coordinating Group
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Michael Foster, NSF

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

Universal Accessibility Team
Chair
Susan B. Turnbull, GSA

Participation in Federal NITRD Activities

The following are criteria developed by the multiagency IT research program that agencies considering participation can use to assess whether their research activities fit the NITRD profile.

NITRD Goals

- Assure continued U.S. leadership in computing, information, and communications technologies to meet Federal goals and to support U.S. 21st century academic, industrial, and government interests
- Accelerate deployment of advanced and experimental information technologies to maintain world leadership in science, engineering, and mathematics; improve the quality of life; promote long-term economic growth; increase lifelong learning; protect the environment; harness information technology; and enhance national security
- Advance U.S. productivity and industrial competitiveness through long-term scientific and engineering research in computing, information, and communications technologies

Evaluation Criteria for Participation

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

Technical/Scientific Merit
The proposed agency program must be technically/scientifically sound and of high quality and must be the product of a documented technical/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/scientifically timely for one or more of the Program Component Areas.

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

AAA - Authentication, authorization, and accounting protocol
AFRL - 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
ARL - Army Research Laboratory
ARSC - Arctic Region Supercomputing Center
ASC - DOE/NNSA's Advanced Simulation and Computing program
ASC- U.S. Air Force's Aeronautical Systems Center
BIRN - NIH's Biomedical Informatics Research Network
Black Widow - See X1e
Blue Gene - an IBM supercomputing project dedicated to building a new family of supercomputers optimized for bandwidth, scalability and the ability to handle large amounts of data while consuming a fraction of the power and floor space required by today's fastest systems.
Blue Gene/L - Scalable experimental new supercomputing system being developed by IBM in partnership with DOE/SC and DOE/NNSA; expected to achieve 300-teraflops+ processing speeds
C - C programming language
CAD - Computer-aided design
CAIDA - Cooperative Association for Internet Data Analysis
CAREER - NSF's Faculty Early Career Development program
CAST - DARPA's Compact Aids for Speech Translation program
CHEETAH - NSF's Circuit-switched High-speed End-to-End ArcHitecture network
CIO - Chief Information Officer
CISE - NSF's Computer and Information Science and Engineering Directorate
CMS - HHS's Centers for Medicare and Medicaid Services
COCOMO II - FAA's COnstructive COst MOdel II (to include security)
CSC - Computer Science Corporation
CSR - NSF's Computer Systems Research program
CSTB - Computer Science and Telecommunications Board of the National Academies
DARPA - DoD's Defense Advanced Research Projects Agency
DETER - NSF's cyber DEfense Technology Experimental Research network
DHS - Department of Homeland Security
DOC - Department of Commerce
DoD - Department of Defense
DOE - Department of Energy
DOE/NNSA - DOE/National Nuclear Security Administration
DOE/SC - DOE/Office of Science
DOT - Department of Transportation
DRAGON - NSF's Dynamic Resource Allocation (via GMPLS) Optical Network
EARS - DARPA/NIST Effective, Affordable, Reusable Speech-to-text program
ebXML - electronic business Extensible Markup Language
EMIST - NSF/DHS Evaluation Methods for Internet Security Technology project
EPA - Environmental Protection Agency
ERDC - U.S. Army's Engineering Research and Development Center
ESCHER - Embedded Systems Consortium for Hybrid and Embedded Research, a joint effort of DARPA and NSF
ESMF - Earth System Modeling Framework
ESnet - DOE/SC's Energy Sciences network
ESSC - DOE/SC's Energy Sciences network (ESnet) Steering Committee
ETF - NSF's Extensible Terascale Facility
FAA - DOT's Federal Aviation Administration
FCC - Federal Communications Commission
FDA - HHS's Food and Drug Administration
FIU - Florida International University
FMS - NOAA's Flexible Modeling System
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 to help societies understand and address global environmental and economic challenges
GMPLS - Generalized multi-protocol label switching
Grid3 - Project funded by NSF, DOE/SC, and universities that uses the Internet to combine the computational resources of 26 universities and national laboratories to serve the computing needs of more than 10 research groups in particle physics, astrophysics, bioinformatics, and computer science
GSA - General Services Administration
HCI&IM – Human-Computer Interaction and Information Management, one of NITRD's seven Program Component Areas

HCMDSS - HCSS's High Confidence Medical Device Software and Systems activity
HCSS - High Confidence Software and Systems, one of NITRD's seven Program Component Areas
HDCCSR - Highly Dependable Computing and Communications Systems Research program, a joint effort of NASA and NSF
HDCP - NASA's Highly Dependable Computing Platform program
HEC - High-end computing
HEC I&A - HEC Infrastructure and Applications, one of NITRD's seven Program Component Areas
HEC R&D - HEC Research and Development, one of NITRD's seven Program Component Areas
HECRTF - High-End Computing Revitalization Task Force
HEC-URA - HEC University Research Activity, funded by DARPA, DOE/SC, and NSF
HHS - Department of Health and Human Services
HP - Hewlett Packard
HPC - High-performance computing
HPCMPO - OSD's High Performance Computing Modernization Program Office
HPCS - DARPA's High Productivity Computing Systems program
IMPI - NIST's interoperable message-passing interface
INCITE - DOE/SC's Innovative and Novel Computational Impact on Theory and Experiment program
IP - Internet protocol
IPv6 - Internet protocol, version 6
IRS - Internal Revenue Service
ISI - Information Science Institute
IT - Information technology
ITR - NSF's Information Technology Research program
IT R&D - Information technology research and development
IU - Indiana University
JET - LSN's Joint Engineering Team
JETnets - Federal research networks supporting networking researchers and advanced applications development
LANL - DOE's Los Alamos National Laboratory
LBL - DOE's Lawrence-Berkeley National Laboratory
LLNL - DOE's Lawrence Livermore National Laboratory
LSN - Large Scale Networking, one of NITRD's seven Program Component Areas
MAGIC - LSN's Middleware and Grid Infrastructure Coordination Team
MAX - Mid-Atlantic Exchange
MOU - Memorandum of understanding
MPLS - Multi-protocol label switching
MPP - Massively parallel processing
MTU - Maximum transmission unit
NA - National Academies
NASA - National Aeronautics and Space Administration
NAVO - U.S. Navy's Naval Oceanographic Office
NCAR - NSF-supported National Center for Atmospheric Research
NCSA - NSF-supported National Center for Supercomputing Applications
NERSC - DOE/SC's National Energy Research Scientific Computing Center
NHII - National Health Information Infrastructure
NIH - HHS's National Institutes of Health
NIST - DOC's 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
NNSA - DOE's National Nuclear Security Administration
NOAA - DOC's National Oceanographic and Atmospheric Administration
NOSS - Networking of Sensor Systems
NRT - LSN's Networking Research Team
NRT - NSF/CISE's Networking Research Testbed program
NSA - National Security Agency
NSF - National Science Foundation
NSTC - White House National Science and Technology Council
NWS - NOAA's National Weather Service
OMB - White House Office of Management and Budget
OMNInet - Large-scale metro optical network testbed supported by national labs, universities, Canadian organizations, and vendor partners
ONR - Office of Naval Research
ONT - Optical Networking Testbeds
OSD - Office of the Secretary of Defense
ORNL - DOE's Oak Ridge National Laboratory
OSTP - White House Office of Science and Technology Policy
PCA - Program Component Area
PerMIS - NIST's Performance Metrics for Intelligent Systems
PET - HCPMPO's Programming Environment and Training program

PNL - DOE's Pacific Northwest Laboratory
ProWin - Programmable Wireless Networking
Purple - DOE/NNSA ASC's 100-teraflops IBM SMP supercomputing platform under development, in tandem with Blue Gene/L, at LLNL
QoS - Quality of service
R&D - Research and development
Red Storm - DOE/NNSA ASC's 40-teraflops Cray system under development at SNL
SC - DOE's Office of Science
SciDAC - DOE/SC's Scientific Discovery through Advanced Computing program
SDP - Software Design and Productivity, one of NITRD's seven Program Component Areas
SEIII - NSF's Science and Engineering Information Integration and Informatics program
SEW - Social, Economic, and Workforce Implications of IT and IT Workforce Development, one of NITRD's seven Program Component Areas
SMP - Symmetric multiprocessing
SNL - DOE's Sandia National Laboratory
SSA - Social Security Administration
StarLight - NSF-supported international optical network peering point in Chicago
TF - Teraflop(s), a trillion floating point operations (per second)
TIDES - DARPA/NIST's Translingual Information Detection, Extraction and Summarization program
TREC - The DARPA/NIST Text Retrieval Conference
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
UnitsML - XML schema for encoding units of measurement
USGS - United States Geological Survey
UW - University of Washington
UWisc - University of Wisconsin
X1 - Cray, Inc., scalable, hybrid scalar-vector high-end computing system developed with support from NSA and OSD
X1e - NSA-supported next generation of Cray X1 known as Black Widow; under development now, is expected to be available in 2006
XML - Extensible markup language

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