

**COMPUTER AND INFORMATION SCIENCE AND ENGINEERING**

**\$574,000,000**

The FY 2008 Budget Request for the Computer and Information Science and Engineering (CISE) Directorate is \$574.00 million, an increase of \$47.31 million, or 9.0 percent, over the FY 2007 Request of \$526.69 million.

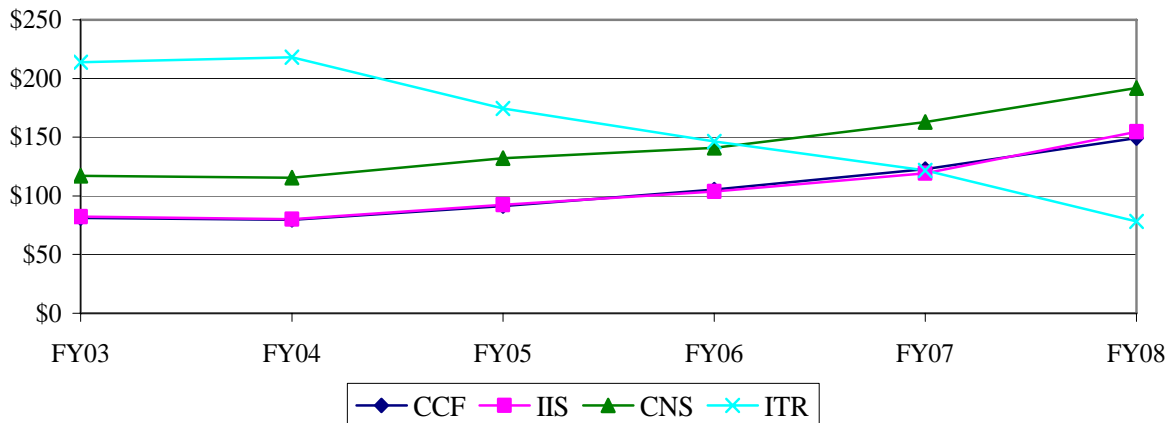
**Computer and Information Science and Engineering Funding**  
(Dollars in Millions)

|   | FY 2006<br>Actual | FY 2007<br>Request | FY 2008<br>Request | Change over<br>FY 2007 Request |             |
|---|-------------------|--------------------|--------------------|--------------------------------|-------------|
|   |                   |                    |                    | FY 2007 Request<br>Amount      | Percent     |
| <b>Computing and Communication</b>        |                   |                    |                    |                                |             |
| Foundations (CCF)                         | \$105.30          | \$122.82           | \$149.15           | \$26.33                        | 21.4%       |
| Computer and Network Systems (CNS)        | 141.07            | 162.98             | 191.98             | 29.00                          | 17.8%       |
| Information and Intelligent Systems (IIS) | 103.78            | 119.30             | 154.63             | 35.33                          | 29.6%       |
| Information Technology Research (ITR)     | 146.20            | 121.59             | 78.24              | -43.35                         | -35.7%      |
| <b>Total, CISE</b>                        | <b>\$496.35</b>   | <b>\$526.69</b>    | <b>\$574.00</b>    | <b>\$47.31</b>                 | <b>9.0%</b> |

Totals may not add due to rounding.

The mission of the CISE Directorate is to enable the U.S. to uphold a position of world leadership in computer, communications, and information science and engineering; to promote understanding of the principles and uses of advanced computer, communications, and information systems in service to society; and to contribute to universal, transparent, and affordable participation in an information-based society. CISE supports investigator-initiated research in computer science and engineering and related fields, contributes to the education and training of computing professionals and, more broadly, prepares a workforce with the computing competencies essential to success in an increasingly competitive global market.

**CISE Subactivity Funding**



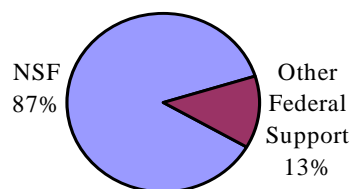
Note: The chart indicates that, with the completion of the ITR priority area in FY 2004, CISE ITR investments are being redirected to prominent IT research challenges and opportunities in core CISE activities in CCF, CNS, and IIS.

The CISE Directorate is in a unique position to help realize the goals and objectives outlined in the American Competitiveness Initiative (ACI). CISE research and education outcomes are vital to the Nation's economic future in two important ways: through the economic robustness the IT industry itself generates and through IT-enabled discovery and innovation across all sectors of the economy, including healthcare, manufacturing, and many other enterprises.

## RELEVANCE

NSF is the principal source of federal funding for university-based basic research in computer science, providing the vast majority – 87 percent – of total federal support in this area. In recent years, the fruits of basic research investments in computer science and engineering – information technology (IT) – have provided unsurpassed value to the U.S. economy. As the President's Council of Advisors in Science and Technology (PCAST) recently noted, IT has served both *as the basis for innovation and economic growth, and as a technology enabler for increased productivity that provides an additional avenue of economic benefit to the Nation across a wide range of sectors.*

**Federal Support for Basic Research in Computer Science at Academic Institutions**



Essentially all practical applications of IT are based on ideas and concepts that emerged from basic research investments – often made many years before – in computer science and engineering. These fundamental ideas and concepts have enabled innovative product and application developments that now permeate all areas of modern life. IT not only forms a sizeable portion of the economy in its own right, but drives discovery and innovation in many other areas, including advanced scientific research, healthcare, national and homeland security, organizational effectiveness, and governmental efficiency. Innovation in IT will remain an essential and vital force in productivity gains and economic growth for many years to come, positioning CISE as a central and essential actor in realizing the goals of the American Competitiveness Initiative.

The CISE Directorate continues to play a leadership role in the multi-agency Subcommittee on Networking and Information Technology Research and Development (NITRD), which is co-chaired by the Assistant Director of NSF for CISE. Consistent with the Administration's NITRD priority, in FY 2008 CISE will continue to advance the computing frontier, stimulating research advances in new computing software, hardware, systems, and algorithms. CISE will continue to increase investments in networking and distributed systems to address issues of security, reliability, and integration of new technologies that prevent the full exploitation of the current Internet and related technologies. CISE also will support fundamental research in new hardware and software architectures for high performance computing (HPC) in support of NSF's cyberinfrastructure vision. The Administration's Homeland Security priority will be addressed with investments in areas such as cybersecurity, machine translation, artificial intelligence, computer vision, and technologies for collaboration and information retrieval. CISE will contribute to the National Nanotechnology Initiative via exploratory and interdisciplinary work on novel nano-based devices and architectures that promise to form the basis of future computing and communication systems.

As a result of the increasingly important role of computing in society, the number of new scientific opportunities and challenges presented by the field far exceeds CISE’s ability to fund them. While CISE has always received many more quality proposals than can be funded, proposal funding rates have declined dramatically since FY 2000 as a consequence of growth in the field. CISE was able to fund 32 percent of the proposals received in FY 2000; in FY 2007, a success rate of 21 percent or less is projected.

NSF is the principal source of federal support for strengthening STEM education across all levels and is uniquely positioned to lead the Nation in STEM education due to its focus on STEM education research. CISE's education programs are responsive to the directorate’s mission and goals, increase American competitiveness in the global economy, and support NSF’s underlying strategy of integration of research and education.

**Summary of Major Changes by Division** *(Dollars in Millions)*

**FY 2007 Request, CISE.....\$526.69**

**Computing and Communication Foundations (CCF) +\$26.33**

Increased support will lead to the development of revolutionary software and hardware architectures that improve the raw performance of computing systems, potentially by orders of magnitude; contribute to improved security, reliability, and manageability of computing systems; and support the exploration of emerging computing paradigms including quantum and bio-computing. In addition, increased support will lead to new understanding of both the limits and optimal methods of computation and communication in our increasingly mobile and interconnected world.

**Computer and Network Systems (CNS) +\$29.00**

Increased funding will be used for the design and pre-construction development associated with the Global Environment for Networking Innovations (GENI) program. GENI is a facility concept currently being explored by the computing community. Using GENI, researchers will be able to explore a “clean-slate” reinvention of the Internet to build in security and robustness and to create new applications capabilities. If not addressed successfully, limits on the current Internet will severely impede innovation, defense, and economic activity within the next ten years. The GENI facility will enable experimental research in computing and networked systems at scale, and will support Homeland Security activities related to Critical Infrastructure Protection.

In addition, CNS will increase support for projects aimed at making significant breakthroughs in the design and implementation of robust and secure systems software. Improving the security of computing and communications systems is of vital national importance and is an essential component in the division’s programs.

**Information and Intelligent Systems (IIS) +\$35.33**

Increased support will target the development of transformative projects that tackle the challenges of creating comprehensively intelligent systems that master and integrate multiple cognitive tasks. The new visions for reliable and secure distributed computer networks targeted by GENI must be developed in lockstep with new visions for the future-generation in formation systems what will live on them. IIS will support research on next-generation networked information systems, tackling such questions as: What will information systems look like when they reside in new generations of networks with nodes

of greatly heterogeneous capability, mobility, and use? How can information be provided not only based on content but also context? IIS will build research capacity in areas foundational to homeland security such as machine translation, artificial intelligence, computer vision, and robotics.

**Information Technology Research (ITR)** -\$43.35

Funds are redirected to prominent IT research challenges and emerging scientific opportunities in CCF, CNS, and IIS. For example, redirected funds will be used to support research on Cyber Trust and to support the broader category of cybersecurity research. ITR funds will also be used to increase core funding rates in the core CISE disciplines.

Remaining ITR funds will support new research in computing fundamentals and research supporting larger, experimental projects that promise IT systems that are more reliable and robust, have better and more predictable performance, provide useful new services, and exploit the potential of emerging technologies.

Subtotal, Changes +\$47.31

**FY 2008 Request, CISE.....\$574.00**

***Summary of Major Changes in Directorate-wide Investments*** *(Dollars in Millions)*

**FY 2007 Request, CISE..... \$526.69**

The CISE FY 2008 budget contributes directly to the goals of the American Competitiveness Initiative and to other Administration priorities including advanced networking and high-end computing. CISE will refocus its Discovery Research for Innovation portfolio to exploit emerging opportunities at the frontier. The directorate also will increase investment in the preparation of a U.S. workforce with the core computing skills essential to their effective participation in an increasingly competitive global environment. Finally, CISE is increasing investments in Transformational Facilities and Infrastructure, supporting the further design of a state-of-the-art networking facility, the Global Environment for Networking Innovations (GENI), that will provide new and unique basic research opportunities in networking and distributed systems while promising significant potential for shorter-term innovation.

Discovery Research for Innovation +\$27.15

CISE will refocus its investments in high-risk, high-return computing research essential to innovation and economic competitiveness in IT. Just as research advances in IT have made unsurpassed contributions to the Nation's technological, economic, and security posture over the past ten years, so future CISE research investments are designed to both deepen and accelerate computing contributions to the Nation's competitive position.

- *Computing Fundamentals and Research (+\$50.0 million).* At a level of \$50.0 million, CISE will support new research in computing fundamentals and research supporting larger, experimental projects that promise IT systems that are more reliable and robust, have better and more predictable performance, provide useful new services, and exploit the potential of emerging technologies. CISE-funded research projects will also shed new light on the

complex interdependencies of social and IT systems, focusing on those areas that have the potential to transform learning and discovery, contribute to U.S. competitiveness and ACI goals and objectives, and enhance the quality of life for all people.

- *Software Design and Productivity (+\$10.0 million)*. CISE will make new investments in software design and productivity at a level of \$10.0 million. The focus will be on development of innovative theories, methods, and tools to address the limitations in the technologies developed over the last 50 years. New computational models for software will be incubated with focused funding and supportive demonstration environments. While much of the software development research in the first 50 years of computing was focused on correct syntax-directed computation of details for computer execution, future efforts will shift to semantics-directed computation of correct abstractions for human understanding and manipulation.
- *Cyber-enabled Discovery and Innovation (+\$20.0 million)*. Computing concepts, tools, and methodologies play a central role in NSF's new investment in Cyber-enabled Discovery and Innovation (CDI), and simultaneously contribute to the goals of the ACI. CISE will contribute 38 percent (\$20.0 million) of the agency's overall investment of \$51.98 million. CISE research investments will contribute in fundamental ways to all five CDI conceptual areas - knowledge extraction, interacting elements, computational experimentation, virtual environments, and education for computational discovery. CISE-supported CDI outcomes will deepen computational thinking in all fields supported by NSF, stimulating innovation across the science and engineering frontier.
- *CAREER (+\$2.0 million)*. CISE will provide an additional \$2.0 million, for a total of \$40 million in FY 2008, in support for the CAREER program to enhance opportunities for early career faculty.
- *Industry/ University Cooperative Research Centers (+\$750,000)*. Additional support of \$750,000, for a total CISE contribution of \$2.0 million, will be provided for Industry/ University Cooperative Research Centers (I/UCRCs). CISE-supported I/UCRCs contribute directly to the goals of the ACI by nurturing industry-university partnerships, thus speeding the transfer of basic research outcomes in computing into IT products and services.
- *Other Changes (-\$55.60 million)*. Increases in Discovery Research for Innovation discussed herein are offset mainly through conclusion of ITR program activities.

Preparing the Workforce of the 21<sup>st</sup> Century

+\$10.50

- *International Workforce (+\$10.0 million)*. Through a new internationally focused program funded at \$10.0 million, CISE will contribute to the development of a competitive, globally aware workforce. This activity will foster international relationships and cooperative research and education activities that support CISE's mission and maximize the strategic value of its investments.
- *REU (+\$500,000)*. CISE will provide an additional \$500,000, for a total of \$4.0 million, in support for students through the Research Experiences for Undergraduates (REU) program.

Transformational Facilities and Infrastructure +\$8.00

An additional \$10.0 million, for a total of \$20.0 million, will support pre-construction planning activities for the Global Environment for Networking Innovations (GENI). GENI will provide computing researchers with world-class experimental opportunities that will substantively transform research in networking, distributed systems, and eventually many other areas. The GENI facility is expected to increase the quality and quantity of experimental research outcomes supported by CISE and to accelerate the transition of these outcomes into products and services to enhance economic competitiveness and secure the Nation's future. As the GENI effort ramps up, other research resources efforts will be scaled back by \$2.0 million in the short term to accommodate additional funding for GENI.

Subtotal, Changes +\$47.31

**FY 2008 Request, CISE.....\$574.00**

**NSF-WIDE INVESTMENTS**

In FY 2008, the CISE Directorate will support research and education efforts related to broad, Foundation-wide investments in a number of areas, including NSF's multidisciplinary priority areas and the Administration's interagency R&D priorities.

**CISE NSF-wide Investments**

(Dollars in Millions)

|  | FY 2006<br>Actual | FY 2007<br>Request | FY 2008<br>Request | Change over<br>FY 2007 Request |         |
|--|-------------------|--------------------|--------------------|--------------------------------|---------|
|  |                   |                    |                    | Amount                         | Percent |
| Biocomplexity In the Environment             | \$3.00            | -                  | -                  | -                              | N/A     |
| Cyber-enabled Discovery and Innovation       | -                 | -                  | 20.00              | 20.00                          | N/A     |
| Cyberinfrastructure                          | 64.37             | 68.00              | 87.00              | 19.00                          | 27.9%   |
| Human and Social Dynamics                    | 3.02              | 5.00               | 2.00               | -3.00                          | -60.0%  |
| Mathematical Sciences                        | 2.29              | 1.15               | 1.15               | -                              | -       |
| National Nanotechnology Initiative           | 10.42             | 12.87              | 11.00              | -1.87                          | -14.5%  |
| Networking and Information<br>Technology R&D | 496.35            | 526.69             | 574.00             | 47.31                          | 9.0%    |

**Biocomplexity in the Environment:** In FY 2007, BE activities are transitioned into core CISE activities.

**Cyber-enabled Discovery and Innovation:** In FY 2008, CISE provides \$20.0 million for the new CDI investment. CDI research aims to explore radically new concepts, approaches and tools at the intersection of computational and physical or biological worlds. CDI will provide the new concepts and tools that are needed to address the challenges posed by a world of petascale computers, massive data flows and databases, and an economy dependent on digitally enabled activity.

**Cyberinfrastructure:** A total of \$87.0 million, an increase of \$19.0 million, will support an increase in research on computing and communication techniques and systems that will be part of the cyberinfrastructure of the next decade. The challenges of scalability, security, reliability, and

extensibility will be met with research and educational activities in architecture, software, networking, theory, and new underlying technologies. Through increased support for GENI, CISE will provide computing researchers with world-class experimental opportunities that substantively transform research in networking, distributed systems, and other areas.

**Human and Social Dynamics:** A total of \$2.0 million for research in areas such as augmented cognition and the exploration of new interfaces and tools that allow people to make informed and rational decisions in spite of human limitations and biases.

**Mathematical Sciences:** With the conclusion of this priority area in FY 2007, the FY 2008 funding reflects spending for continuing awards made in prior years. Other components of this investment will return to core programs for continued support.

**National Nanotechnology Initiative:** A total of \$11.0 million will support research in areas such as fundamental nanoscale phenomena and processes; nanoscale devices and systems; nanomanufacturing; and research facilities and instrumentation. Within CISE, these general categories encompass architecture, design, and fabrication of information systems based on nanoelectronics, representation of quantum and classical information in nanostructures, and the national infrastructure needed to support such research.

**Networking and Information Technology R&D:** CISE's entire request of \$574.0 million is included in NITRD activities supporting fundamental research and related education in information technology and networking.

## **QUALITY**

CISE identifies the highest quality research through the use of a competitive, merit-based review process. The percent of research funds that were allocated to projects that undergo external merit review was 97 percent in FY 2006, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, CISE convenes Committees of Visitors (COVs), composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. In December 2005, CISE convened a COV for the IIS Division. COVs also were convened for the CNS Division in March 2006 and for the CCF Division in June 2006.

CISE also receives advice from the Advisory Committee for Computer and Information Science and Engineering (CISEAC) on such issues as: the mission, programs, and goals that can best serve the scientific community; the promotion of quality graduate and undergraduate education in the computer and information science and engineering sciences; and priority investment areas in computer and information science and engineering research. The CISEAC meets twice a year with members volunteering their time to serve on subcommittees for three additional days per year. Members from both academe and industry represent a cross section of the computer and information science and engineering field, with representatives from many different sub-disciplines within the field. The CISEAC includes a balanced representation of women, underrepresented minorities, and individuals from a range of geographic regions and institutions.

## PERFORMANCE

NSF's FY 2008 budget is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

### Computer and Information Science and Engineering By Strategic Outcome Goal (Dollars in Millions)

|                         | FY 2006<br>Actual | FY 2007<br>Request | FY 2008<br>Request | Change over<br>FY 2007 Request |             |
|-------------------------|-------------------|--------------------|--------------------|--------------------------------|-------------|
|                         |                   |                    |                    | Amount                         | Percent     |
| Discovery               | \$428.30          | \$452.97           | \$480.12           | \$27.15                        | 6.0%        |
| Learning                | 31.04             | 36.73              | 47.23              | 10.50                          | 28.6%       |
| Research Infrastructure | 29.53             | 31.08              | 39.08              | 8.00                           | 25.7%       |
| Stewardship             | 7.48              | 5.91               | 7.57               | 1.66                           | 28.1%       |
| <b>Total, CISE</b>      | <b>\$496.35</b>   | <b>\$526.69</b>    | <b>\$574.00</b>    | <b>\$47.31</b>                 | <b>9.0%</b> |

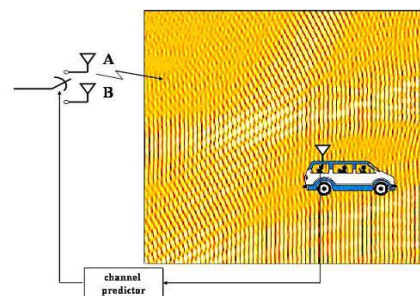
Totals may not add due to rounding.

CISE will continue its commitment to education, training, and increasing diversity within the computing field. The support for Learning reflects this commitment and represents CISE investments in the Broadening Participation in Computing (BPC) program, which encourages projects to work with local Centers of Research Excellence in Science and Technology (CREST), the Alliances for Graduate Education and Professoriate (AGEP) program, and the Louis Stokes Alliances for Minority Participation (LSAMP). Prominent IT research challenges and opportunities in the CISE Divisions of CCF, CNS and IIS are also targeted in FY 2008. At the same time, the FY 2008 Request seeks to optimize funding rates and to emphasize crosscutting research and education opportunities in computing.

### Recent Research Highlights

#### ► New tools improve quality of service for wireless customers:

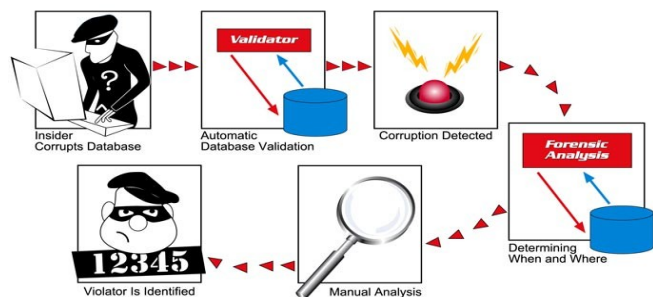
Researchers at North Carolina State University have developed a suite of adaptive tools that can improve both the capacity and quality of wireless communication service. Since channels change rapidly in mobile radio communications, most transmitters and receivers today are not optimized for the channel conditions they encounter from instant to instant. Accordingly, the devices fail to exploit the full potential of the wireless channel. These new adaptive tools predict information about a fading wireless channel – information that allows more efficient use of power and frequency. By collaborating with an industry partner, the researchers were able to validate the tools using realistic modeling and field measurements. In 2005, more than one billion consumers worldwide owned and used wireless telephones – the majority of those users being in North America, Western Europe and the Asia-Pacific region. The tremendous growth in demand for wireless communication capacity has created a need for new transmission and receiving methods to enhance user quality of service. (CCF)



New wireless communication tools will improve the quality of service for consumers.  
Credit: Alexandra Duel Hallen.



► **Detection and Forensic Analysis of Database Tampering:** Computer scientists at the University of Arizona have developed new techniques to detect instances of unauthorized access and tampering with electronic databases – even when the intruders are insiders. Imagine, for example, that a corporate accountant splits a transaction, after the fact, into multiple transactions to hide the magnitude of a questionable action. Or imagine that an administrator at a medical facility changes the date of a confidentiality signature after learning that some personal health data had been revealed erroneously to a third party. Conventional defenses, which try to protect the data with software and hardware "fences," simply do not work in such situations: the intruders are already inside the fences.



Researchers have developed new methods for detection and subsequent forensic analysis of database corruption. *Credit: Created by Cheryl Ryan and Richard T. Snodgrass, 2006*

However, the newly created analysis techniques can identify these data manipulations. Moreover, they can provide a sophisticated forensic analysis of the crime, identifying when the corruption took place, verifying the original date of the corrupted data and indicating which data were changed. The techniques will also verify when large volumes of data in a database have not been corrupted. The payoff: an increase in people's trust in such systems. (IIS)

► **New Wi-Fi Network Brings Eye Care to Thousands in India:** Thousands of villagers in India are receiving quality eye care for the first time, thanks to new technology for low-cost rural connectivity developed by NSF-funded researchers at the University of California Berkeley, and the Intel Research Berkeley lab. Based on "Wi-Fi" wireless networks, the new technology allows eye specialists to interview and examine patients in five remote clinics via a high-quality videoconference that uses simple, inexpensive software and hardware.

The system provides villages with a high-bandwidth connection to computer networks in cities as far as 50 miles away. The researchers implemented the Technology and Infrastructure for Emerging Regions (TIER) pilot program in 2005. Because of the initial success, TIER will soon expand to include five hospitals linked to 50 clinics that will annually serve an expected half a million patients in the southern Indian state of Tamil Nadu. (IIS)



In this satellite map graphic of the Aravind network, green lines indicate links from the central hospital to rural vision centers in five rural towns. All distances are in kilometers. *Credit: Graphic by Sonesh Surana.*

► **Compressive Sampling Technique Promises Improved Healthcare Imaging:** In a finding by researchers at the California Institute of Technology that contradicts the conventional wisdom in their field, NSF-funded computer scientists have proved that it is possible to reconstruct a high-resolution digital image or signal using a comparably small number of measurements. The new theory, called Compressive Sampling (CS), could have widespread practical impact, with applications ranging from completely new data acquisition algorithms to dramatically new compression and error-correction schemes. In the field of medical imaging, for example, CS could enable new technologies such as high-

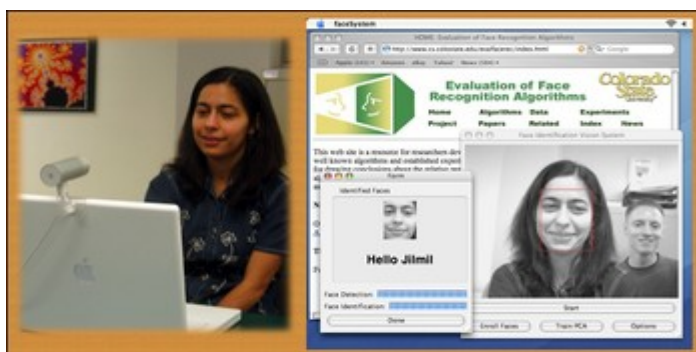
speed magnetic resonance angiograms. In the field of communications, CS could help meet the growing challenge of processing wideband radio frequency signals. (CCF)



This image, from the game Unreal Tournament 2004, requires 6,768,766 depth comparisons. On average only 7.3 bits out of 32 bits are actually necessary to make the comparison. Our asynchronous comparison takes advantage of this possible optimization and operates 12 times more efficiently than conventional synchronous circuits. *Credit: Epic Games.*

clockless method is more than 10 times more efficient than conventional, clocked systems. Resultant energy savings significantly extend battery life. (CCF)

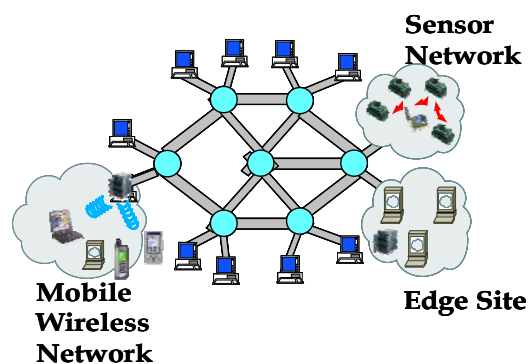
► **Human Face Detection:** Researchers at Colorado State University (CSU) have developed a face detection and recognition algorithm, and have integrated it into a new real-time system. The new software is being prepared for release as part of a CSU face recognition software package. The current CSU Face Identification Evaluation System has been downloaded over 10,000 times by people from all over the world for use as a teaching and research tool. The release later this year of an open-source, real-time face recognition system will make the CSU software even more useful and appealing, particularly to students seeking hands on experience with a fully interactive face recognition system. (IIS)



Colorado State University's face detection and identification system is being prepared for release as part of their Evaluation of Face Recognition Algorithms package. The system both identifies and recognizes the individual in the foreground. *Credit: J. Ross Beveridge, Colorado State University, 2006*

► **Global Environment for Networking Innovations:**

Last year three CISE-funded projects, Emulab, Planetlab, and DETER, provided thousands of researchers working on hundreds of research projects to experiment with large-scale distributed systems and networks. This suite of experimental platforms, used together or separately, have permitted CISE investigators to explore solutions to increase the stability and security of advanced networks and distributed systems. Use of these platforms is informing the research community's design of a larger-scale experimental facility with greatly increased functionality and versatility – a facility called GENI, the Global Environment for Networking Innovations that will support exploration of revolutionary systems architectures that will lead to reinvention of the "Internet" as it is known today. (CNS)



The goal of GENI research is to overcome the limitations of today's internet and create new network architecture for the 21st Century. *Credit: Computer and Network Systems Division, CISE, NSF*

**Other Performance Indicators**

The tables below show the number of people benefiting from CISE funding, and trends in the award size, duration, and number of awards.

**Number of People Involved in CISE Activities**

|                               | FY 2006<br>Estimate | FY 2007<br>Estimate | FY 2008<br>Estimate |
|-------------------------------|---------------------|---------------------|---------------------|
| Senior Researchers            | 5,040               | 5,200               | 5,450               |
| Other Professionals           | 706                 | 720                 | 750                 |
| Postdoctorates                | 285                 | 295                 | 310                 |
| Graduate Students             | 5,042               | 5,200               | 5,450               |
| Undergraduate Students        | 731                 | 750                 | 790                 |
| <b>Total Number of People</b> | <b>11,804</b>       | <b>12,165</b>       | <b>12,750</b>       |

**CISE Funding Profile**

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|   | FY 2006<br>Estimate | FY 2007<br>Estimate | FY 2008<br>Estimate |
|---|---------------------|---------------------|---------------------|
| <b>Statistics for Competitive Awards:</b> |                     |                     |                     |
| Number                                    | 1,281               | 1,200               | 1,270               |
| Funding Rate                              | 26%                 | 21%                 | 24%                 |
| <b>Statistics for Research Grants:</b>    |                     |                     |                     |
| Number of Research Grants                 | 1,003               | 950                 | 1,000               |
| Funding Rate                              | 22%                 | 18%                 | 20%                 |
| Median Annualized Award Size              | \$116,000           | \$116,000           | \$116,000           |
| Average Annualized Award Size             | \$146,000           | \$158,000           | \$158,000           |
| Average Award Duration, in years          | 3.0                 | 3.0                 | 3.0                 |

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**COMPUTING AND COMMUNICATION FOUNDATIONS**

**\$149,150,000**

The FY 2008 Budget Request for the Division of Computing and Communication Foundations (CCF) is \$149.15 million, an increase of \$26.33 million, or 21.4 percent, over the FY 2007 Request.

**Computing and Communication Foundations Funding**

(Dollars in Millions)

|  | FY 2006<br>Actual | FY 2007<br>Request | FY 2008<br>Request | Change over<br>FY 2007 Request |              |
|--|-------------------|--------------------|--------------------|--------------------------------|--------------|
|  |                   |                    |                    | Amount                         | Percent      |
| <b>Computing and Communication Foundations</b> | <b>\$105.30</b>   | <b>\$122.82</b>    | <b>\$149.15</b>    | <b>\$26.33</b>                 | <b>21.4%</b> |
| Major Components:                              |                   |                    |                    |                                |              |
| Research & Education Grants                    | 97.30             | 114.82             | 141.15             | 26.33                          | 22.9%        |
| Science and Technology Centers                 |                   |                    |                    |                                |              |
| STC for Embedded Networked Systems             | 4.00              | 4.00               | 4.00               | -                              | -            |
| STC for Ubiquitous Secure Technology           | 4.00              | 4.00               | 4.00               | -                              | -            |

**About CCF:**

CCF addresses current and emerging areas of computing and communication foundations: theory and incubation of computing and communication; processes and artifacts for computing and communication; signals, communication and interaction; and foundations of systems in use. Within and across these areas, CCF supports research and education activities that explore the foundations of computing and communication devices and their usage. Research and education projects supported promote advances in computing and communication theory, algorithms for computer and computational sciences, architecture and design of computers and software, and investigations of revolutionary computing paradigms such as bio-inspired computing. CCF projects also integrate education with research to prepare future generations of computer science and engineering professionals.

In general, 58 percent of the CCF portfolio is available for new research grants. The remaining 42 percent is used primarily to fund continuing grants made in previous years.

*Science and Technology Centers*

CCF supports the Science and Technology Center for Embedded Networked Sensing (CENS) at the University of California at Los Angeles. CENS is exploring embedded networked sensing systems, large-scale, distributed systems, composed of smart sensors and actuators embedded in the physical world. CCF also supports the Science and Technology Center for Ubiquitous Secure Technology at the University of California at Berkeley (TRUST). TRUST is addressing a parallel and accelerating trend of the past decade--the integration of secure, robust computing and communications capabilities across critical infrastructures, in areas such as telecommunications, finance, energy distribution, and transportation.

**CCF Priorities for FY 2008**

*Cyber-enabled Discovery and Innovation*

In support of the American Competitiveness Initiative, CCF plans a large effort in Cyber-enabled Discovery and Innovation. Computation has revolutionized science, engineering, and daily life through massive computation, simulation, and other algorithmic processes. Computers are tools that provide new

ways of probing and shaping our world through simulation utilizing massive data capture. Computers are also tools for performing more abstract tasks, ranging from the automation of mathematical proof to the secure use of ecommerce, banking, and credit cards. Computer and information science now promises a second revolution through a new way of understanding nature and engineered artifacts. Cyber-enabled discovery, the use of algorithmic and computing insights to recast the core concepts of science and engineering, is at the heart of this revolution. These insights will increase our understanding of complex processes that arise in many fields of science and engineering. Examples are the mechanisms by which the cell processes proteins to generate other proteins, by which the neurons in the brain learn, or by which companies incorporate current prices and market behavior into their strategies. With better understanding, improvements in the products and processes that underlie American competitiveness will be realized.

*Hardware and Software Frontier Areas*

CCF support of American competitiveness is also exemplified by an emphasis on the architecture and software of computer systems. The multi-core chip architectures that are now appearing on the market are merely the first wave of chips that will eventually include hundreds or thousands of processors. The overall architecture of such large chips raises many new research questions, as does the design of software for them. In addition, a broad and diverse workforce must be prepared with skills in the design, programming, and use of multi-core processors. CCF will emphasize research and education in software frontier areas, such as software architectures, components, and dynamics. An enhanced ability to produce and design software-intensive systems will ensure American competitiveness.

*Foundational Research in Visual Analytics*

Visual approaches to understanding information extend beyond traditional computer graphics. These approaches are crucial to new scientific and engineering discovery and to the competitiveness and well being of the Nation. Foundational and applied research is needed into how humans learn from complex visual presentations, and how they sense, reason and respond to produce a seamless flow of hypothesis, evaluation and discovery. CCF will emphasize foundational research in this area of visual analytics.

*Scientific Foundations for Internet's Next Generation*

CCF will continue its emphasis on the Scientific Foundations for Internet's Next Generation (SING). This topic merges elements of the theoretical foundations of computing, communications, signal processing, and network science into a foundation for a clean-slate redesign of the Internet. This coordinates well with NSF's construction of the GENI facility. The resulting increase in connectivity will both increase American competitiveness and broaden participation in this enterprise to more sectors of our population.

**Changes from FY 2007:**

The FY 2008 request for CCF includes an increase of \$26.33 million directed toward core research and education. Disciplinary and interdisciplinary research in the CCF core will be allocated to activities like those described above and will help maintain a consistent proposal funding rate.

**COMPUTER AND NETWORK SYSTEMS**

**\$191,980,000**

The FY 2008 Budget Request for the Division of Computer and Network Systems (CNS) is \$191.98 million, an increase of \$21.0 million, or 17.8 percent, over the FY 2007 Request of \$162.98 million.

**Computer and Network Systems Funding**

(Dollars in Millions)

|                                     | FY 2006<br>Actual | FY 2007<br>Request | FY 2008<br>Request | Change over<br>FY 2007 Request |              |
|-------------------------------------|-------------------|--------------------|--------------------|--------------------------------|--------------|
|                                     |                   |                    |                    | Amount                         | Percent      |
| <b>Computer and Network Systems</b> | <b>\$141.07</b>   | <b>\$162.98</b>    | <b>\$191.98</b>    | <b>\$29.00</b>                 | <b>17.8%</b> |
| Major Components:                   |                   |                    |                    |                                |              |
| Research & Education Grants         | 112.44            | 132.40             | 153.40             | 21.00                          | 15.9%        |
| Computing Research Resources        | 28.63             | 30.58              | 38.58              | 8.00                           | 26.2%        |

**About CNS:**

The CNS Division addresses four areas: computer systems, network systems, computing research infrastructure, and education and workforce. Within and across these areas, CNS supports research and education activities related to the development of new computing and networking technologies and to the exploration of new ways to make use of existing technologies. The division seeks to develop a better understanding of the fundamental properties of computer and network systems through analysis, prototyping, and experimentation, and to create better abstractions and tools for designing, building, analyzing, and measuring future systems. The division also supports the development and use of computing research infrastructure, which is required to enable state-of-the-art computer science research and education, and it coordinates cross-divisional activities that foster the integration of research, education, and workforce development to prepare future generations of computer science and engineering professionals.

In general, 47 percent of the CNS portfolio is available for new research grants. The remaining 53 percent is used primarily to fund continuing grants made in previous years.

**CNS Priorities for FY 2008**

The focus of the FY 2008 request for CNS is to initiate new and emerging research areas related to Cyber-enabled Discovery and Innovation, increase funding for the Global Environment for Networking Innovations (GENI) activity, and strengthen existing programs such as Computer Systems Research (CSR), Cyber Trust, CPATH, and Broadening Participation in Computing.

*Cyber-enabled Discovery and Innovation*

In support of the American Competitiveness Initiative, CNS will participate in Cyber-enabled Discovery and Innovation. High-performance, seamless, robust networks are essential to the conduct of cyber-enabled science and engineering to work. Research challenges include identification and mitigation of failures and performance issues, timely integration of new technology into the network infrastructure, and evaluation and development of next- and future-generation innovations.

*Global Environment for Networking Innovations (GENI)*

CNS support of American competitiveness is also exemplified through the continued support of the design of the GENI facility. Experiments on this facility will lead to a future Internet that meets the demands of the 21<sup>st</sup> century, including increased security, the use of large-scale, distributed societal applications, and the inclusion of wireless and sensor systems in end-to-end networking solutions. Research challenges and opportunities include: clean-slate thinking unconstrained by today's Internet; alternative protocols and architectures; and research on new applications and services running as overlays on top of today's network.

*Computer Systems Research*

Computer systems research will focus on: (1) distributed, mobile, and embedded systems; (2) sensing and control systems; (3) dynamically configured, multiple-component systems; and (4) parallel systems. The FY 2008 request will enable a focus on emerging areas, including cross-systems integration, virtualization for configuration and management, and cyber-physical systems.

Cybersecurity research will continue to address threats to the Nation's critical infrastructure. Within this effort, research in Cyber Trust supports a vision of a society in which networked computer systems are more predictable, more accountable, and less vulnerable to attack and abuse; are developed, configured, operated and evaluated by a well-trained and diverse workforce; and used by a public educated in their secure and ethical operation.

*Computing Workforce*

CISE will continue CISE Pathways to Revitalized Undergraduate Computing Education (CPATH), an education and workforce activity that envisions a U.S. workforce with the computing competencies and skills necessary to insure the Nation's health, security and prosperity in the 21<sup>st</sup> century. This workforce includes a cadre of computing professionals prepared to contribute to sustained U.S. leadership in computing in a wide range of application domains and career fields, and a broader professional workforce with knowledge and understanding of critical computing concepts, methodologies and techniques. CISE will also continue its emphasis on Broadening Participation in Computing (BPC), which aims to significantly increase the number of U.S. citizens and permanent residents receiving post secondary degrees in the computing disciplines.

**Changes from FY 2007**

Core Research and Education: +\$21.00

Disciplinary and interdisciplinary research in the CNS core will increase by \$21.0 million. This additional support will be allocated to research priorities such as those described above and will help improve the funding rate in CNS.

Computing Research Resources +\$8.00

An additional \$10.0 million will support pre-construction planning activities for the Global Environment for Networking Innovations (GENI), including support for the GENI Project Office. As the GENI effort ramps up, other research resources efforts will be scaled back by \$2.0 million in the short term to accommodate additional funding for GENI.



**INFORMATION AND INTELLIGENT SYSTEMS**

**\$154,630,000**

The FY 2008 Budget Request for the Division of Information and Intelligent Systems (IIS) is \$154.63 million, an increase of \$35.33 million, or 29.6 percent, over the FY 2007 Request of \$119.30 million.

**Information and Intelligent Systems Funding**

(Dollars in Millions)

|  | FY 2006<br>Actual | FY 2007<br>Request | FY 2008<br>Request | Change over<br>FY 2007 Request |              |
|--|-------------------|--------------------|--------------------|--------------------------------|--------------|
|  |                   |                    |                    | Amount                         | Percent      |
| <b>Information and Intelligent Systems</b> | <b>\$103.78</b>   | <b>\$119.30</b>    | <b>\$154.63</b>    | <b>\$35.33</b>                 | <b>29.6%</b> |
| Major Component:                           |                   |                    |                    |                                |              |
| Research & Education Grants                | 103.78            | 119.30             | 154.63             | 35.33                          | 29.6%        |

**About IIS:**

The Division of Information and Intelligent Systems supports research and education that: 1) increases the capabilities of human beings and machines to create, discover and reason with knowledge; 2) advances knowledge about how computer systems perform tasks autonomously, robustly, and flexibly; 3) advances the state of the art in the application of IT to science and engineering problems; and 4) develops new knowledge about the integration of social and technical systems and capabilities. The division is organized focused on human-centered computing, information integration and informatics, and robust intelligence. IIS activities also focus on the integration of research and education to prepare future generations of computer science and engineering professionals.

In general, 56 percent of the IIS portfolio is available for new research grants. The remaining 44 percent is used primarily to fund continuing grants made in previous years.

**IIS Priorities for FY 2008**

The FY 2008 Request is focused on new and emerging research areas related to Cyber-enabled Discovery and Innovation; on a new internationally focused program that will contribute to the development of a competitive, globally aware workforce; and on strengthening existing programs of research in information and intelligent systems.

*Cyber-enabled Discovery and Innovation*

In support of the American Competitiveness Initiative, IIS plans a significant effort in Cyber-enabled Discovery and Innovation. CDI is based on distinct, but related, conceptual areas that are ripe for advancement and application: knowledge extraction, complex interactions, computational experimentation and virtual environments. These areas comprise computational discovery. The conceptual area of virtual environments will receive the most focus from IIS. Virtual environments are rapidly developing throughout science and engineering (and the rest of the world) as important mechanisms to enhance discovery, learning, and innovation. CDI research in this area will develop new techniques for building and utilizing virtual environments, explore their properties in prototype form, and experiment with them as deployed across a range of scientific and engineering fields, both in discovery and educational settings.

### *International Activities*

Through a new internationally focused program funded at \$10.0 million, CISE will contribute to the development of a competitive, *globally aware* workforce. This program will foster international relationships and cooperative research and education activities that support CISE's mission and maximize the strategic value of its investments.

### *Integrative Intelligence*

Since the earliest pursuits of artificial intelligence scientists have strived for progress by focusing on individual cognitive tasks, such as language, learning, and vision. Many decades of work have seen advances in these individual areas and the development of core methods that span these areas. In FY 2008, IIS will target the development of transformative projects that tackle the challenges of creating comprehensively intelligent systems that master and integrate multiple cognitive tasks.

### *Next Generation Networked Information*

Computer networks are the backbone on which our information-laden society rests. The new visions for reliable and secure distributed computer networks targeted by CISE's investments in Global Environment for Networking Innovations (GENI) must be developed in lockstep with new visions for the future-generation information systems that will live on them. In FY 2008 IIS will support research on next-generation networked information systems, tackling such questions as: What will information systems look like when they reside in new generations of networks with nodes of greatly heterogeneous capability, mobility, and use? How can information be provided not only based on content but also context? What metaphors and models make it possible to provide coherence to the diverse ways users might access information in future networking environments? How can vastly heterogeneous, distributed, and uncoordinated sources of networked information be integrated and made comprehensible and useful for the unforeseen and diverse tasks to which it is relevant?

### *Creative Computer Science and Information Technology*

Information technology is playing an increasing role in enhancing the capability of human creative thinking, problem solving, and innovation. In FY 2008, IIS will support research that capitalizes on the synergies between creativity and information technology, science, engineering, and design research. Anticipated research outcomes include new models of creative cognitive and computational processes, new approaches to education for students that encourage creativity and innovation, new modes of research that include creative professionals, and new tools to support human creativity, both individually and in collaboration.

### **Changes from FY 2007**

The FY 2008 Request for IIS includes an increase of \$35.33 million that will be directed toward the following areas:

|  |          |
|--|----------|
| Core Research and Education:   | +\$25.33 |
| Disciplinary and interdisciplinary research in the IIS core will increase by \$25.33 million.                                      |          |
| This additional support will be allocated to research priorities as described above and will help improve the funding rate in IIS. |          |
| Computing Workforce:   | +\$10.00 |
| CISE addresses ACI education objectives through a new internationally focused program supporting International activities.         |          |

**INFORMATION TECHNOLOGY RESEARCH**

**\$78,240,000**

The FY 2008 Budget Request for the Information Technology Research (ITR) Subactivity is \$78.24 million, a decrease of \$43.35 million, or 35.7 percent, below the FY 2007 Request of \$121.59 million.

**Information Technology Research Funding**

(Dollars in Millions)

|  | FY 2006<br>Actual | FY 2007<br>Request | FY 2008<br>Request | Change over<br>FY 2007 Request |               |
|--|-------------------|--------------------|--------------------|--------------------------------|---------------|
|  |                   |                    |                    | Amount                         | Percent       |
| <b>Information Technology Research</b> | <b>\$146.20</b>   | <b>\$121.59</b>    | <b>\$78.24</b>     | <b>-\$43.35</b>                | <b>-35.7%</b> |
| Major Component:                       |                   |                    |                    |                                |               |
| Research & Education Grants            | 146.20            | 121.59             | 78.24              | -43.35                         | -35.7%        |

**About ITR:**

During FY 2000 - FY 2004, the ITR Subactivity provided for CISE investments in the agency-wide ITR priority area. It provided support for state-of-the-art IT research and related education activities; enhanced support for more focused research in areas of national importance such as cyber security, homeland security, and cyberinfrastructure; and permitted the funding of a larger number of complex, often interdisciplinary, projects.

In general, 71 percent of the ITR portfolio is available to make new research awards in computing fundamentals. The remaining 29 percent is used primarily to fund continuing grants made in previous years.

**ITR Priorities for FY 2008**

Funds redirected from the ITR Subactivity will be used to target IT priorities in the core CISE subactivities of CCF, CNS, and IIS. Remaining funds will target prominent CISE-wide IT research and education priorities as described below.

*Discovery Research for Innovation*

At a level of \$50.0 million, CISE will support new research in computing fundamentals and research supporting larger-scale, experimental projects that promise IT systems that are more reliable and robust, have better and more predictable performance, provide useful new services, and exploit the potential of emerging technologies. Funded projects will permit full development and exploration of fundamental new concepts and ideas in the computing domain, and will promise significant contributions to the American Competitiveness Initiative.

**Changes from FY 2007:**

In FY 2008, CISE will redirect \$43.35 million from the broad category of IT Research to IT priorities in the core CISE subactivities of CCF, CNS, and IIS.

