Innovating for Society: CISE, FY 2011 Budget and FY 2012 Priorities

Farnam Jahanian
CISE Directorate
National Science Foundation

CISE Advisory Committee Meeting
May 6, 2011

Welcome New CISE AC Members

- Term Starting July 2010
  - Jaime Carbonell, Carnegie Mellon University
  - José Fortes, University of Florida
  - Juan Gilbert, Clemson University
  - James Landay, University of Washington
- Term Starting May 2011
  - Henrik Christensen, Georgia Institute of Technology
  - James Kurose, University of Massachusetts, Amherst
  - J Strother Moore, University of Texas, Austin
  - Stefan Savage, University of California, San Diego
- Invitation to AC members whose terms end this summer to continue through the end of 2011
- Indebted to Peter Arzberger for his service to CISE / NSF

CISE Priorities …

- Guided by our mission and core principles
- Informed by our national and global priorities
- Shaped by technological advances and societal trends
- Influenced by current realities

CISE Mission -
Exploring the frontiers of computing

- Promote progress of computer and information science and engineering research and education.
- Promote understanding of the principles and uses of advanced computer, communications and information systems in service to society.
- Contribute to universal, transparent, and affordable participation in an information-based society.

These frontiers have interfaces with all the sciences, engineering, education, and humanities and a strong emphasis on innovation for society.

What's Ahead?

- Computer and Information Science and Engineering (CISE) is at the center of an ongoing **societal transformation** and will be for decades to come.
- The **explosive growth of scientific and social data**, wireless connectivity at broadband speeds for billions of endpoints – which are both people and environmental sensors – and seamless access to computational resources and applications in the "cloud" are transforming the way we work, learn, play and communicate.
- The impact of computing will go **deeper into the sciences and engineering** and will become more **pervasive** throughout society. Policy issues will loom larger as our reliance on technology and computationally-enabled collective intelligence grows.

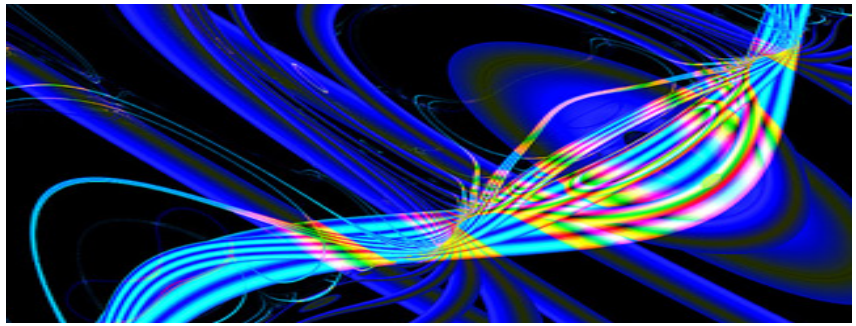


Image Credit: Jack Yaco

Potential for Computing

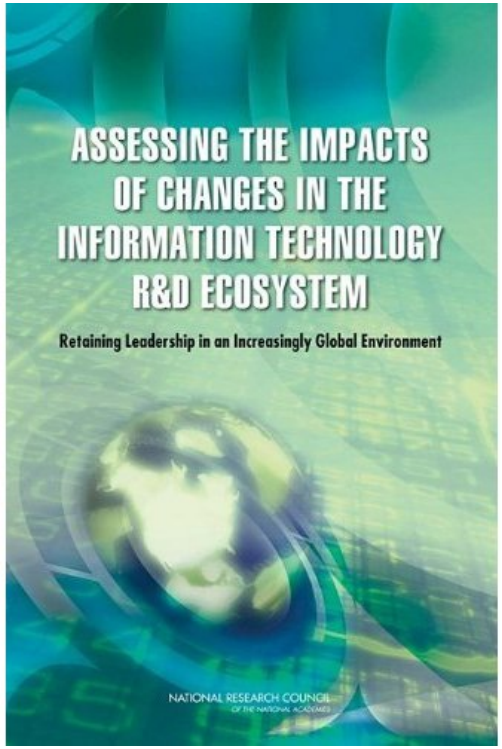
- Computing research and education has the potential to form a pervasive intellectual fabric that connects a wide range of disciplines – recognizing that:
  - Scientific discovery and technological innovations will be **at the core of our response to challenges facing humanity** – from climate change and sustainability, to health care and national security.
  - Many of tomorrow's breakthroughs will occur at **the intersections of diverse disciplines.**

Courtesy of National Institute for Computational Sciences and the University of Tennessee, photo taken by Jason Richards at Oak Ridge National Laboratory

Credit: Kirsty Pargeter

The Impact of Information Technology

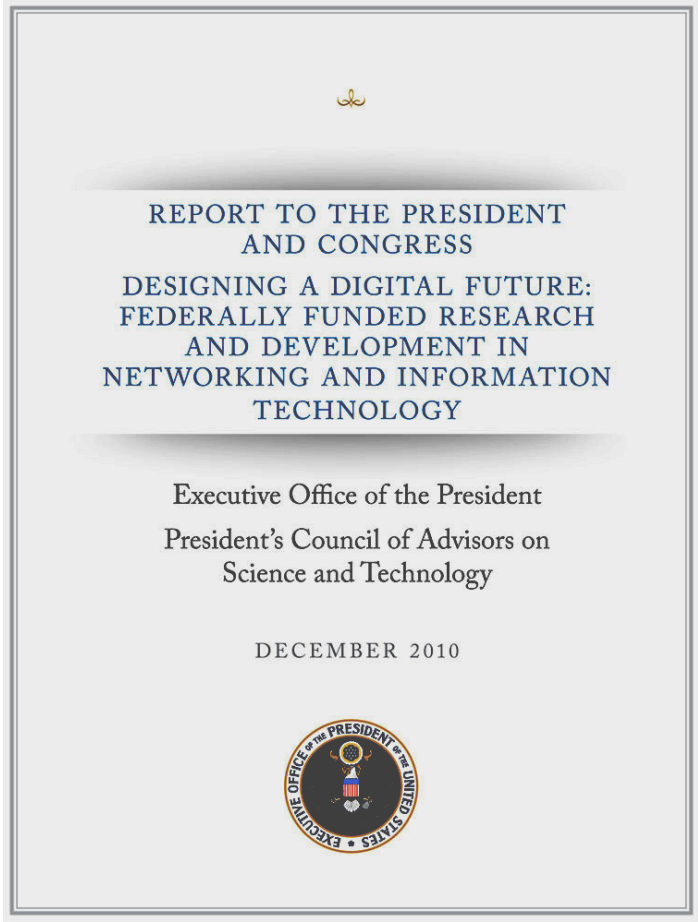
- The enormous global economic impact is not only from the growth of IT industry itself, but to a greater extent from IT-enabled productivity gains from across the entire economy.
- Since 1995, Networking & IT industries accounted for 25% of US economic growth.
- The use and production of IT accounted for “roughly 2/3 of the post-1995 step-up in labor productivity growth.”
- Most investment in basic research comes from the federal government.



A National Imperative

"Recent technological and societal trends place the further advancement and application of NIT squarely at the center of our Nation's ability to achieve essentially all of our priorities and to address essentially all of our challenges."[1] Advances in our discipline:

- are a key driver of economic competitiveness
- are crucial to achieving our major national and global priorities in energy and transportation, education and life-long learning, healthcare, and national and homeland security
- accelerate the pace of discovery in nearly all other science and engineering fields
- are essential to achieving the goals of open government

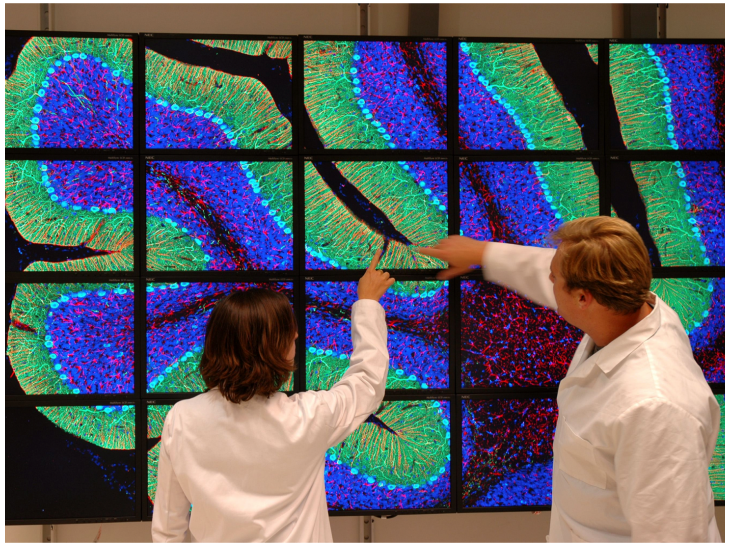


[1] *"Designing a Digital Future" PCAST Report – a periodic congressionally-mandated review of the Federal Networking and Information Technology Research and Development (NITRD) Program.*

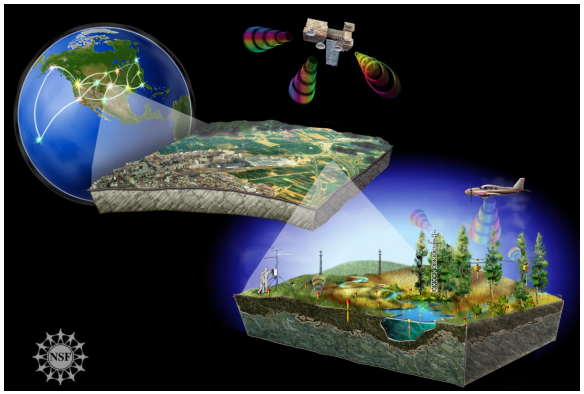
Trends and Advances Shaping the Computing Discipline

Explosive Growth in Size, Complexity and Data Rates

- **Enormous static or streaming data sets** generated by modern experimental and observational methods
- **Infusion of computation into science and engineering** is revolutionizing research
- Shift toward indirect, **automatic extraction of new knowledge** about the physical or biological world continues to accelerate
- **Enabled by data mining and machine learning**, discovery and visualization techniques together with the emergence of multi-core processing and advanced server architectures



Credit: Mark Ellisman and Tom Deerinck, NCMIR/UCSD



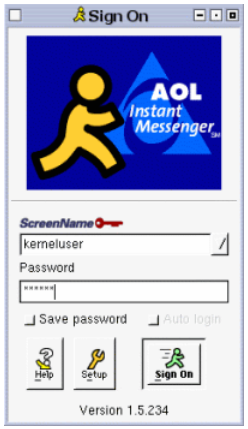
Credit: Nicolle Rager Fuller, National Science Foundation

New Breed of Communications

1988

Remarkable
Pace of innovation

2010

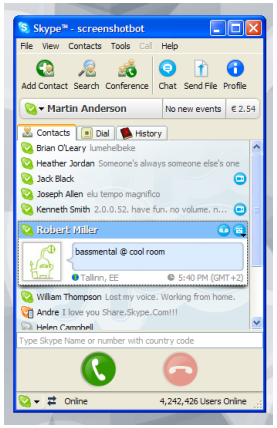


IM

BLOGS

MOBILE

EMAIL



VOIP

VIDEO

Explosive Growth in Volume & Traffic Diversity

VoIP →
663M registered Skype users in March 2011. Represents 20% of long distance minutes world-wide. If Skype were a carrier, it would be the 3rd largest in the world (behind China Mobile and Vodaphone). Largest provider of cross-border communication.

Video →
Recent estimates as high as 60% of internet traffic is video and music sharing via P2P; 35 hours of new videos are uploaded every minute in 2011; 2 billion views per day.

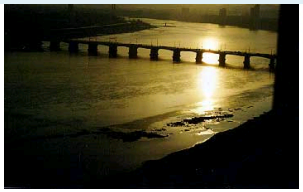
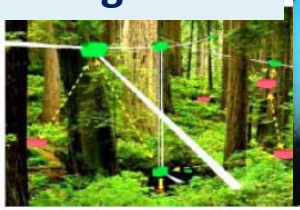
Twitter →
Currently 175 million registered users.

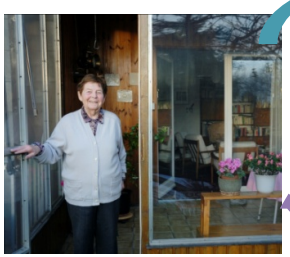
Broadband →
20% of global internet users have residential broadband; 68% in US subscribe to broadband.

Mobile →
5.3 billion mobile phone subscribers; 85% of new handsets will be able to access the mobile web; 1 in 5 has access to fast service, 3G or better; IM, MMS, SMS expected to exceed 10 trillion message by 2013; 300K new mobile applications in 3 years.

The Age of Observation: Smart Sensing, Reasoning and Decision

Environment Sensing



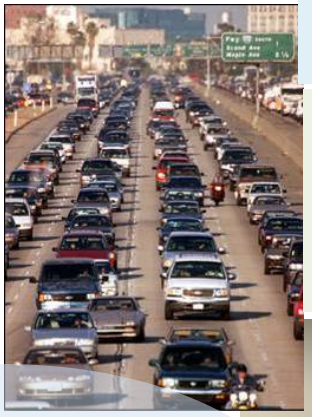

Percepts (sensors)

Agent (Reasoning)

Actions (controllers)

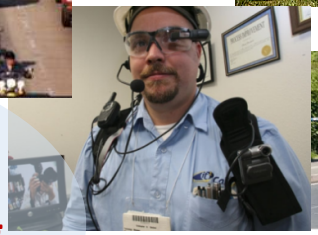
Pervasive Computing

Emergency Response



Credit: Photo by US Geological Survey

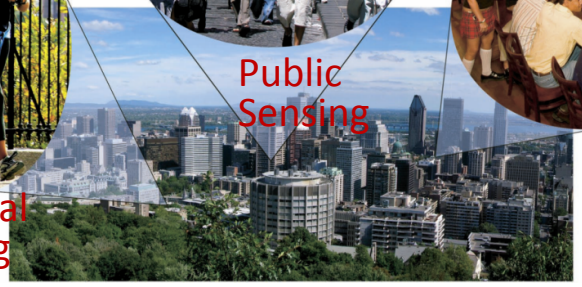
Situation Awareness: Humans as sensors feed multi-modal data streams


People-Centric Sensing

Social



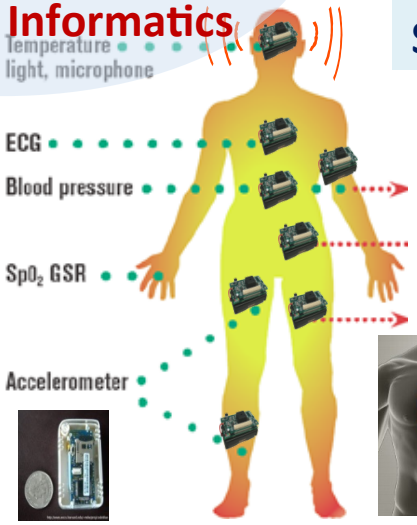



Public Sensing

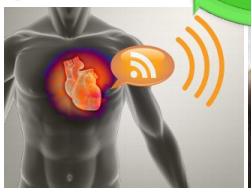
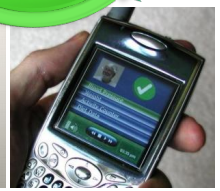
Social Sensing

Personal Sensing

Informatics



Smart Health Care

Source: Sajal Das, Keith Marzullo

Credit: Image courtesy of University of Florida

From the PC Age to the Utility Age

- The idea of providing computing power, like electric power, over a network grid from large-scale utilities has been around for 40+ yrs:
  - Time-share system in 70s
  - ADP's computing jobs as fee-for-service in 80s
  - Grid computing and supercomputing centers
  - Application service providers (ASP), thin clients, and software-as-a-service in 90s

  The Underlying concept goes back to the 1960s:
  - "Computation may someday be organized as a public utility." [John McCarthy]

Credit: Courtesy Pittsburgh Supercomputing Center

The Era of Cloud Computing

- Major public cloud service providers like Amazon are now able to provide vast computing resources to organizations … the interest in such services is staggering.
- Each day Amazon adds enough computing resources to power one whole Amazon.com circa 2000.
- Gartner Inc. believes the cloud computing market place will grow substantially from about $60B in 2010 to $149 billion by 2014.
- A whole generation of Internet companies wouldn't be here today without the cloud: Netflix's video-on-demand service runs on it; Zynga uses it to handle spikes.
- The one constant in computing has been the explosion of data. The cloud is making data analytics available to small companies; a technology that was once available only to the largest companies in the world.
- Everybody is playing in this arena:
  - One Camp: Amazon, Google, Microsoft, and salesforce.com
  - Other Camp: all the traditional software and hardware infrastructure companies IBM, HP, Cisco, Juniper, EMC/VMWare, Dell, AT&T and Verizon
- Compelling New Business Models: Mindset shift from asset ownership to a utility-based model and economies of scale gained through multi-tenancy.

Challenges and Opportunities

- Programming parallel applications with hundreds of threads – need for new programming abstractions and tools for software synthesis and dynamic analysis
- Placement strategies and load balancing algorithms
- Architectures, systems, network support: Can clouds become as reliable as the power grid? Achieving 99.999% uptime?
  - Amazon service outage last week
  - Gmail multi-hour outage in 2009
  - Amazon Web Services failure in 2008
  - Rackspace massive outage in 2007
  - Application failover
- "Greener" more environmentally sensitive solutions
- Workload-aware and energy-aware approaches to power, cooling, traffic and server management
- Cloud security and privacy: emergence of new threats and managing risks
- New ways to meter and set prices for services (economic models); from most to least cost

Credit: Wifinotes

Least expensive city for data centers = Sioux Falls, SD

Evolution of Cyber Threats

Future security challenges will follow Internet adoption patterns:

Credit: Nicolle Rager Fuller, National Science Foundation

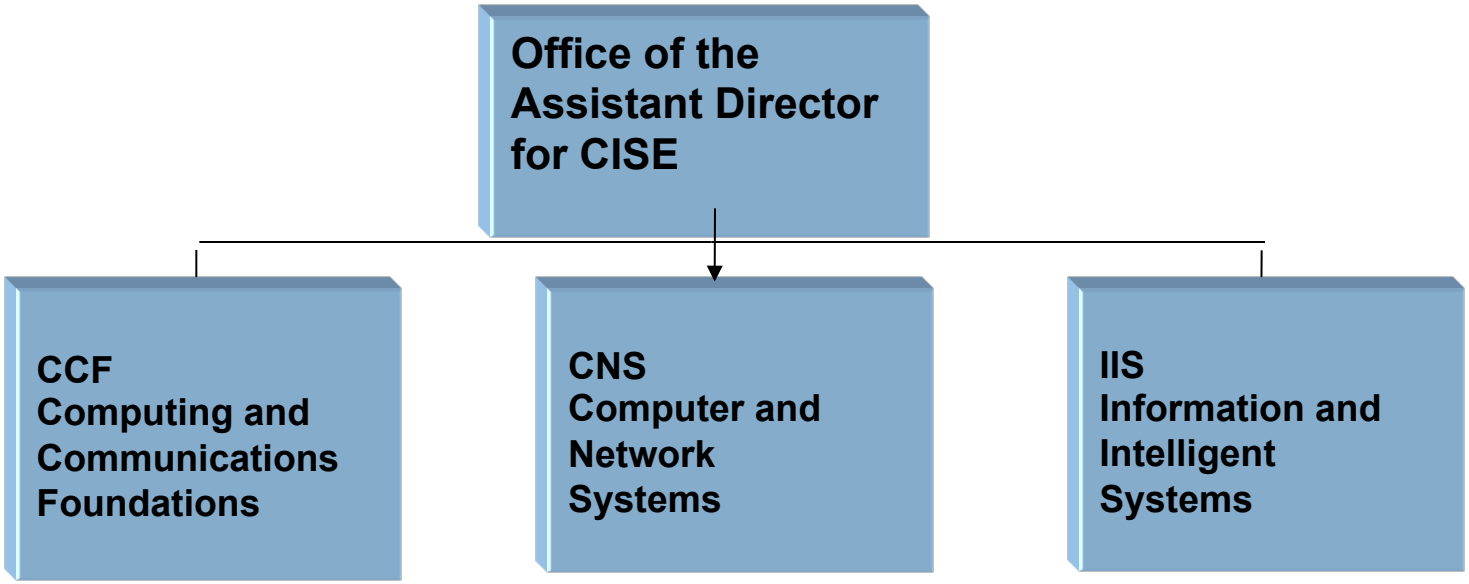
- Proliferation of attacks spurred by financial gains and now political motives.
- Cyber-networks are the new frontier of counterintelligence.
- Distributed attacks increasing in size and sophistication, targeting specific applications.
- Botnets will continue to dominate how attacks are launched; attribution will become increasingly difficult.
- Proliferation of wireless devices and social media platforms open new avenues for hackers and bring evolving security challenges.
- Protecting cloud infrastructure key to long-term adoption.

Networked Society

Clickworkers
Collaborative Filtering
Collaborative Intelligence
Collective Intelligence
Computer Assisted Proof
Crowdsourcing
eSociety
Genius in the Crowd
Human-Based Computation
Participatory Journalism
Pro-Am Collaboration
Recommender Systems
Reputation Systems
Social Commerce
Social Computing
Social Technology
Swarm Intelligence
Wikinomics
Wisdom of the Crowds

CISE Snapshot

CISE Organization and Core Research Programs



CORE PROGRAMS

- Algorithmic Foundations
- Communication and Information Foundations
- Software and Hardware Foundations
- Computer Systems Research
- Networking Technology and Systems
- Education and Workforce
- Human-Centered Computing
- Information Integration and Informatics
- Robust Intelligence

~ 70-75% of CISE Budget in Core Programs

Investment in Cross-Cutting Programs

- Cross-Divisions
  - Trustworthy Computing and Cybersecurity Research
  - Smart Health and Wellbeing
  - Computing Education for the 21st Century (CE21)

- Cross-Directorates
  - Cyber-Physical Systems (CPS)
  - Science and Engineering Beyond Moore's Law (SEBML)
  - Wireless Innovation and Enhancing Access to the Radio Spectrum (EARS)
  - Science, Engineering, and Education for Sustainability (SEES)
  - Cyber Infrastructure Framework for the 21st Century (CIF21)
  - Cyberlearning: Transforming Education (CTE)

Update on CISE Staffing

- 71 FTEs, 28 IPAs
- 58 Science Positions, 41 Administrative Positions
- Acting Deputy AD: Gracie Narcho
- Three New Division Directors
  - Susanne Hambrusch, CCF
  - Keith Marzullo, CNS
  - Howard Wachtler, IIS
- Three New Deputy Division Directors
  - Tracy Kimbrel, CCF
  - Joseph Urban, CNS
  - Deborah Lockhart, IIS
- New Personnel since last AC meeting:
  - CCF: 5 Program Officers, 2 Admin Staff
  - IIS: 6 Program Officers, 6 Admin Staff
  - CNS: 9 Program Officers, 1 Admin Staff

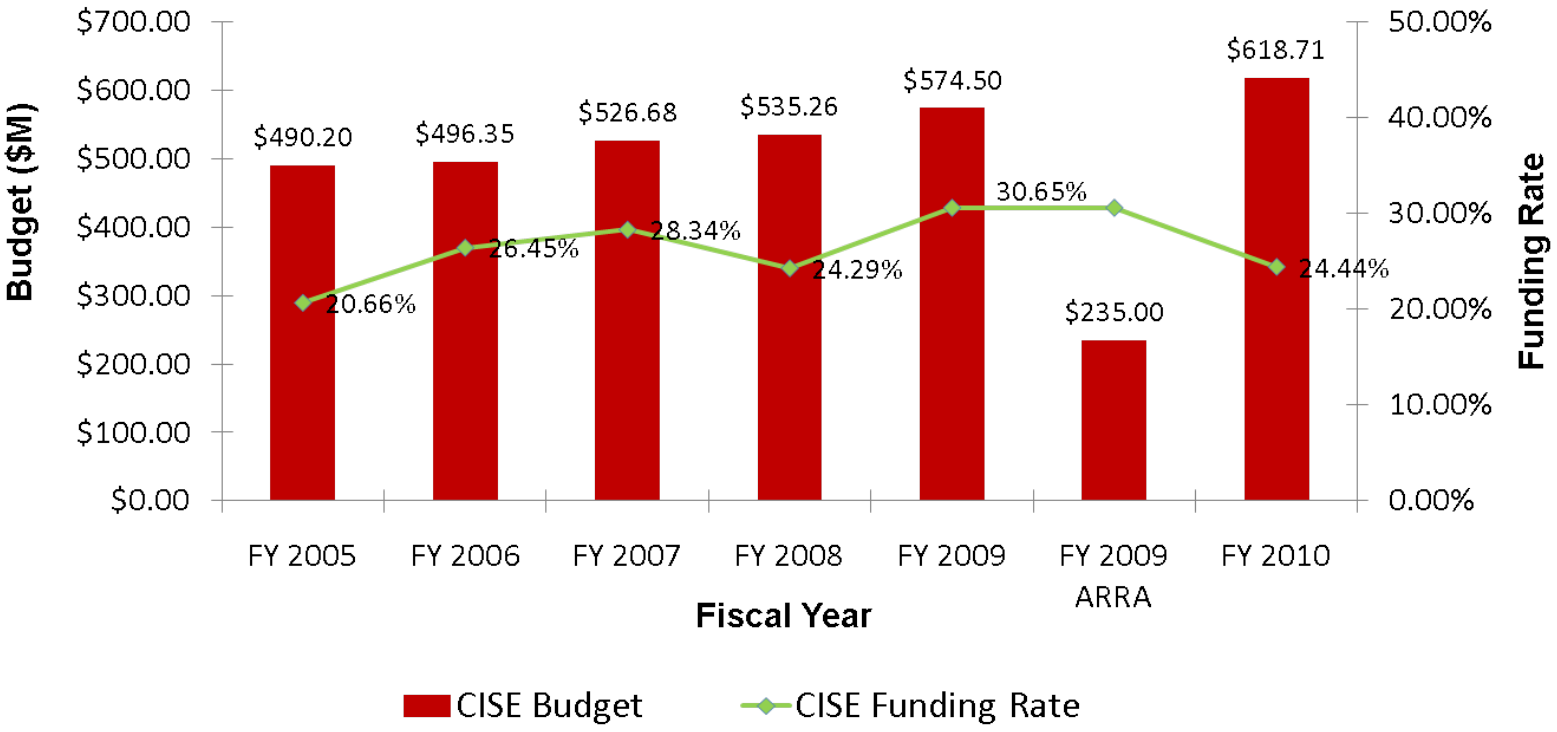
Snapshot of FY 2010 Activities

	CISE	NSF
Research Budget ($M)	$618M	$5,615M
Number of Proposals	6,486	55,559
Number of Awards	1,585	13,015
Success Rate	24.5%	23.5%
Average Award Size	$191K	$200K
Number of Panels Held	247	1500+
Number of People Supported	12,846	291,702

Number of People Involved in CISE Activities – FY2010

	CISE	NSF
Senior Researchers	5,553	53,161
Other Professionals	578	14,194
Postdoctoral Associates	336	6,923
Graduate Students	4,556	39,559
Undergraduate Students	1,823	33,234
K-12 Teachers		59,312
K-12 Students		85,319
Total Number of People	12,846	291,702

CISE Budget and Funding Rate



Expeditions-in-Computing

Inspire bold, transformative research that explores new scientific frontiers that promise disruptive innovations in computing

10 awards made so far ($2M/year per award for 5 years)

Year	Pre-proposals	PI, Co-PI & SP	Institutions	Full Proposals	Awards
2008	75	1000	166	20	4
2009	48	650	161	20	3
2010	23	232	76	16	3
2011	36	328	69		

Expeditions Awards – Overview

Beyond Moore's Law

Variability-aware Software for Efficient Computing with Nanoscale Devices – UCSD, UCLA, UIUC, Stanford, Michigan, 2010

Customizable Domain-Specific Computing – UCLA, UCSB, Rice, Ohio State, 2009

The Molecular Programming Project – CalTech, U Washington, 2008

Sustainability & Environment

Understanding Climate Change: A Data Driven Approach – Minnesota, Northwestern, NC State, NC A&T State, 2010

Computational Sustainability: Computational Methods for a Sustainable Environment, Economy, and Society – Cornell, Oregon State, Bowdoin, 2008

Wireless & Internet

Open Programmable Mobile Internet 2020 – Stanford, 2008

Healthcare & Wellbeing

Computational Behavioral Science: Modeling, Analysis, and Visualization of Social and Communicative Behavior – Georgia Tech, MIT, Boston U, UIUC, USC, Carnegie Mellon, 2010

Next-Generation Model Checking and Abstract Interpretation with a Focus on Embedded Control and Systems Biology – Carnegie Mellon, Stony Brook, NYU, UMD, Pitt, Lehman College, JPL, 2009

Robotics

RoboBees: A Convergence of Body, Brain and Colony – Harvard, Northeastern, 2009

Complexity theory, Quantum Computing & Cryptography

Understanding, Coping with, and Benefiting from Intractability – Princeton, Rutgers, NYU, Institute for Advanced Study, 2008

CISE STCs and SLC

Science and Technology Centers:

- Center for Embedded Networked Sensing (CENS), University of California at Los Angeles(ends in FY11).
- Team for Research in Ubiquitous Secure Technology (TRUST), University of California at Berkeley
  - Focused on the development of cybersecurity science and technology that will radically transform the ability of organizations to design, build, and operate trustworthy information systems.
- The Science of Information, Purdue University
  - Will develop a unifying set of principles to guide the extraction, manipulation, and exchange of information, integrating elements of space, time, structure, semantics and context.

Science of Learning Center

- Robust Learning, Pittsburgh
  - Will leverage cognitive theory and modeling to identify the instructional conditions that cause robust student learning in order to enhance scientific understanding of robust learning in educational settings and create a research facility to support field-based experimentation, data collection, and data mining.

Computing Innovation Fellows (CIFellows)

CHALLENGE:

The impact of economic crisis on graduating doctoral students in CISE; Scarcity of new academic and industrial research jobs due to the downturn

GOAL:

Keep people in research pipeline; forestall permanent loss of research talent

2009: CISE awards CRA $15M for 60 CIFellows

- Response: 521 applications; 135 institutions
- 60 CIFellows from 48 doctoral-granting universities went to 43 host organizations in 2009

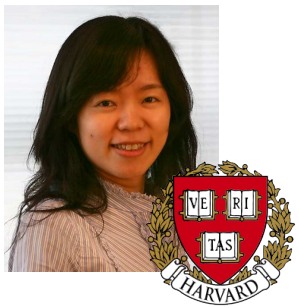
2010: CISE awards CRA $15M for 47 additional CIFellows

- Response: 218 applications
- 47 CIFellows from 33 doctoral-granting universities went to 35 host organizations in 2010

“Cross-flow” Among CIFellows

An objective was to support intellectual diversity in computing fields at U.S. organizations

- 60 CIFellows from 48 Ph.D.-granting universities went to 43 host organizations in 2009
- 47 CIFellows from 33 Ph.D.-granting universities went to 35 host organizations in 2010

CIFellow	Mentor	Current Status
Thomas Schmid UCLA 	**Prabal Dutta** U of Michigan 	THE UNIVERSITY OF UTAH **Assistant Professor** Electrical & Computer Engineering
Jenn Wortman Vaughan UPenn 	**Yiling Chen** Harvard 	 **Assistant Professor** Computer Science
Sitaram Asur Ohio State 	**Bernardo Huberman** HP Labs 	LABS hp **Researcher** Social Computing Lab

Beyond the Statistics …

- *"I view my fellowship as a bridge between graduate school and an academic career... I started working on several exciting projects, which opened up new research avenues for my future. I have already submitted three papers to conferences and workshops. ... Finally... I met and began collaborating with top researchers in my area."*

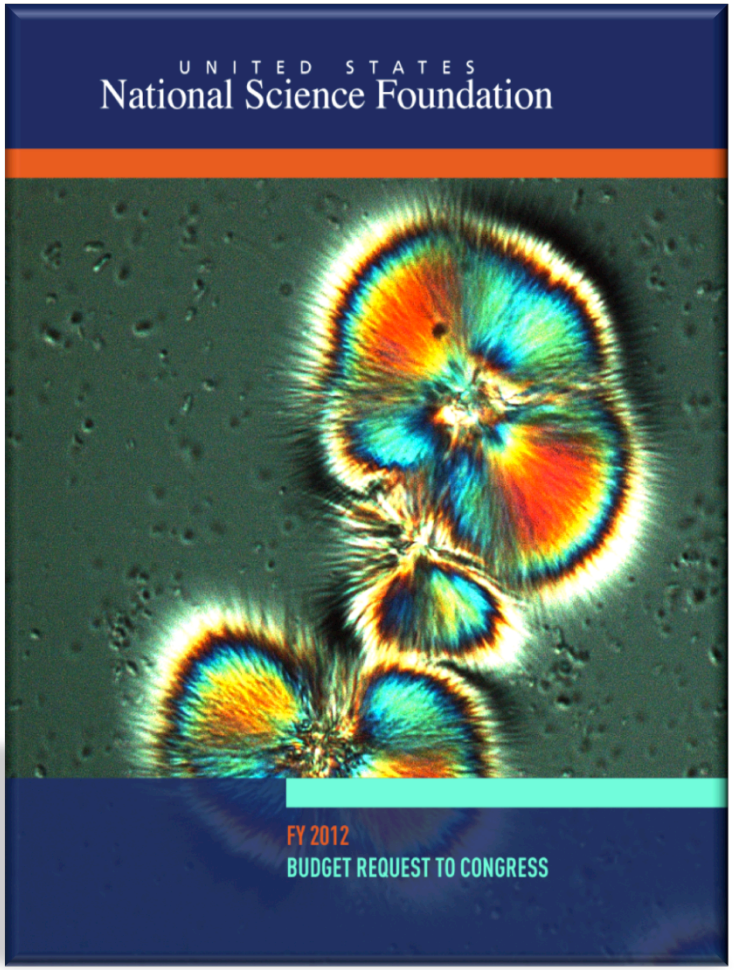
  [2009 CIFellow]

- A "social experiment" for the CISE community!
- Would it really make a difference to the individuals' career opportunities?
- Should it be viewed as a special case? Or Does the experience argue the need for a sustainable multi-year effort?
- The need for a constructive discourse on the postdoc issue as highlighted in the CRA white paper.

NSF FY 2012 Budget Request

TOTAL: $7.767 billion

Increase: 13 percent over 2010 enacted level



CISE FY 2012 Budget Request

FY12 CISE request is $728.42M

Request level is +$109.59M or 17.7%
over FY10 Enacted

Positioning CISE and NSF in FY12:

- Promoting fundamental research
- Innovating for Society
- Partnering in NSF-wide activities
- Advancing computing education and cyberlearning

CISE FY 2012 Major Investments
Addressing National Challenges

Innovating for Society

- Cybersecurity Research, including CNCI
- Cyber-Physical Systems (CPS)
- Science and Engineering Beyond Moore's Law (SEBML)
- National Robotics Initiative (NRI)
- Smart Health and Wellbeing
- Enhancing Access to the Radio Spectrum (EARS)
- Wireless Innovation

Partnering in NSF-wide Activities: OneNSF

- Science, Engineering and Education for Sustainability (SEES)
- Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21)

Advancing Computing Education and Cyberlearning

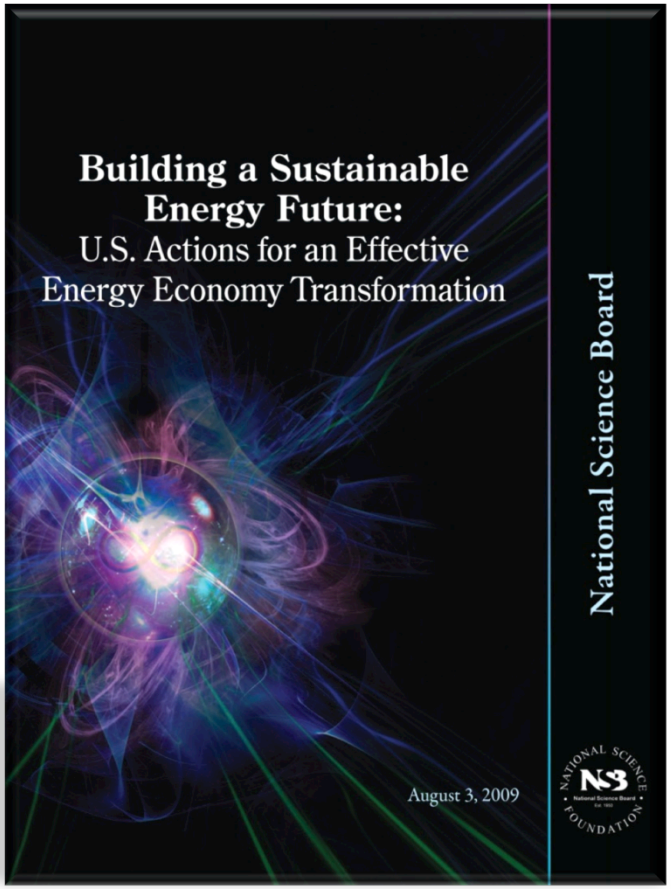
- Computing Education for the 21st Century (CE21)
- Cyberlearning: Transforming Education (CTE)

NSF Program on Science, Engineering, and Education for Sustainability (SEES)

Achieving a sustainable human future in the face of both gradual and abrupt environmental change is one of the most significant challenges facing humanity.

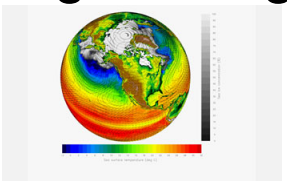
Generating discoveries and building capacity to achieve an environmentally and economically sustainable future.

Established FY10, Planned to continue thru FY15; Involves all NSF research and education directorates and offices.

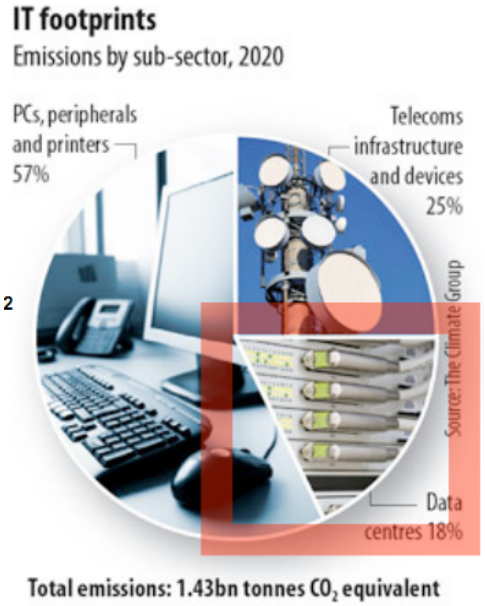


SEES and CISE

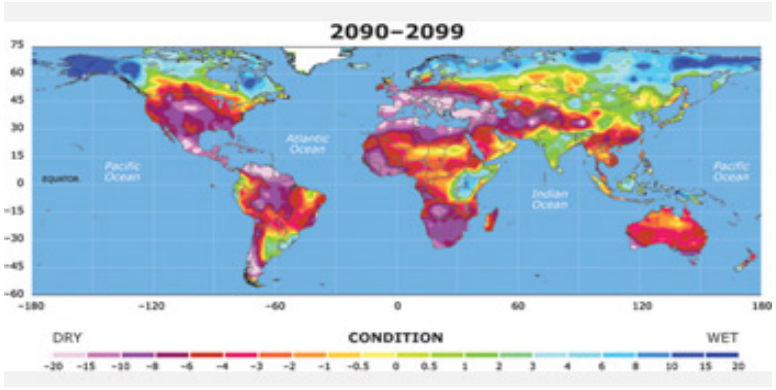
Interdisciplinary research in the areas of environmental & energy science and engineering



Credit: Gary Strand, NCAR



Credit: Climate Group and Molly Webb

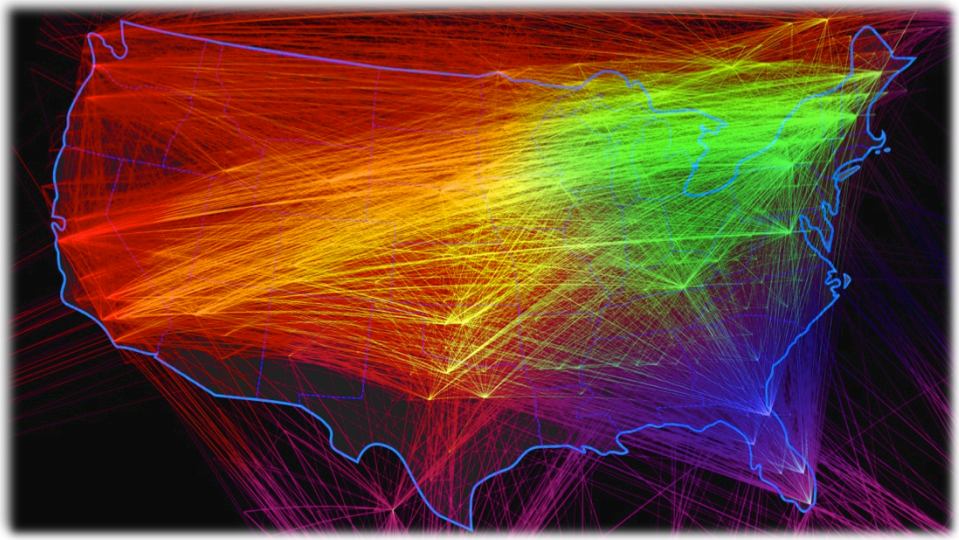


Disciplinary research to develop the foundation of energy-efficient, energy-aware, and sustainable computing and communication

Credit: (c)UNEP

The Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21)

A new, cross-directorate initiative to enable new ways of doing science and education



Credit: Map by Zina Deretsky, National Science Foundation, adapted from maps by Chris Harrison, Human-Computer Interaction Institute at Carnegie Mellon University (http://www.chrisharrison.net).

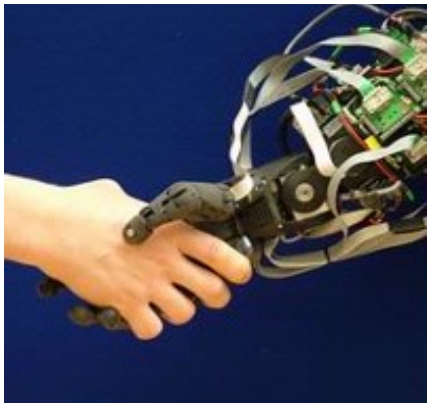
- Data-enabled science & engineering
- New computational infrastructures including software and tools
- Community research networks
- Access and connections to cyber infrastructure facilities

FY 2012 request: $117 million

National Robotics Initiative (NRI)

A concerted cross-agency program to provide U.S. leadership in science and engineering research and education aimed at the development of next generation robotics.

Conceived as robots that work beside, or cooperatively, with people in areas such as manufacturing, space and undersea exploration, healthcare and rehabilitation, emergency response, military and homeland security, education and training.



Credit: Photo Permission by Bristol Robotics Lab

Credit: 2011 Honda Motor Co., Ltd.

Credit: Edwin Olsen, University of Michigan

FY 2012 request: $30 million

Wireless Innovation and Infrastructure Initiative (Wi3)

Spurring novel applications and services that will affect the vast sector of the U.S. economy driven by wireless technology

Nicolle Rager Fuller, National Science Foundation

Computing Education and Learning in the 21st Century

Workforce and Education Initiatives

Human Infrastructure:
Continuing to develop the next generation

- Foundation-wide activity in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and integration of education and research within the context of the mission of their organizations
- Contributes to the development of current and future generations of computing faculty
- Build a firm foundation for a lifetime of scientific leadership and scholarly pursuit

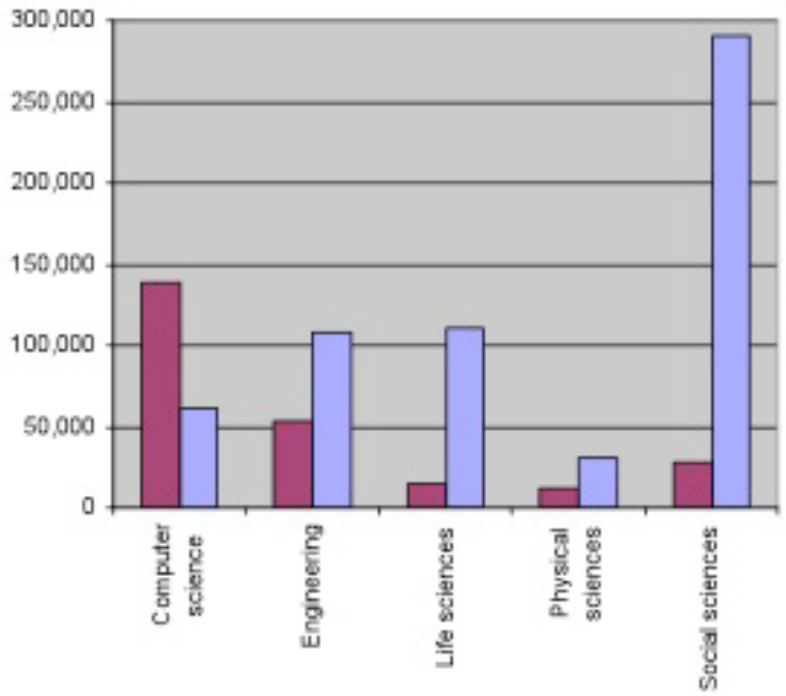
FY 2010	CISE	NSF
Number of Career Proposals	520	3084
Number of Career Awards	127	544
Success Rate	24%	17%
Investment	$42M	$219M

Education Workforce (EWF) Cluster

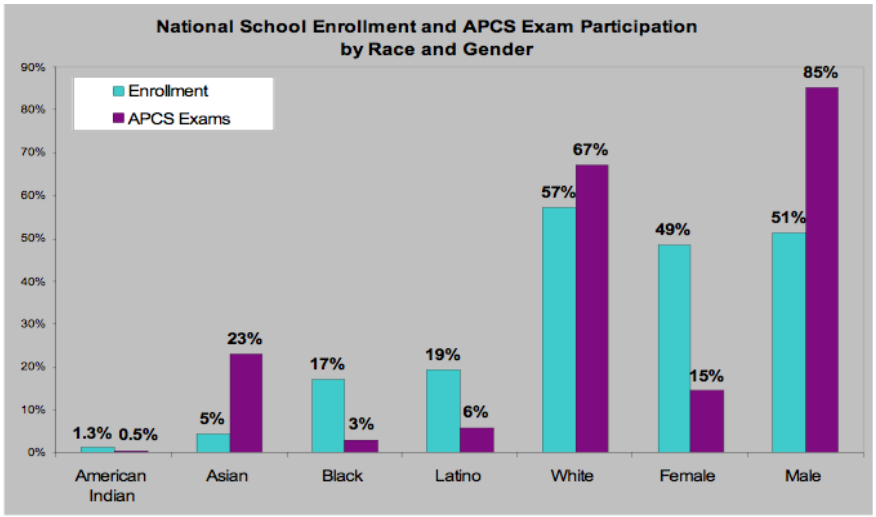
National Challenge:

- Significant underproduction of computing degrees
- Underrepresentation of 70% of the population

Annualized Job Openings (red) vs. Degrees (purple) 2008-2018



AP CS A Demographics



Running On Empty: The Failure to Teach K–12 Computer Science in the Digital Age (ACM and CSTA Report)

- "Computer science and the technologies it enables now lie at the heart of our economy, our daily lives, and scientific enterprise. As the digital age has transformed the world and workforce, U.S. K–12 education has fallen woefully behind in preparing students with the fundamental computer science knowledge and skills they need for future success. To be a well-educated citizen as we move toward an ever-more computing-intensive world and to be prepared for the jobs of the 21st Century, students must have a deeper understanding of the fundamentals of computer science."

- "The report finds that roughly two-thirds of the country have few computer science education standards for secondary school education, and most states treat high school computer science courses as simply an elective and not part of a student's core education."
- Full report: http://csta.acm.org/runningonempty/

Computing Education for the 21st Century (CE21)

AIM

Increase number and diversity of

- K-12 students and teachers with computational competencies
- Early college students with engagement and background to major in computing and computationally-intensive fields
- BPC and CPATH combined into CE21 (engagement and capacity building)

NOTEWORTHY FEATURES

- Spans K-14
- Intertwines broadening participation and education
- Adds educational, EHR-style research component
- Assess with an appropriately rigorous evaluation process
- Partnership with EHR and OCI
- Encourages alignment with CS 10K Project

CE21 investment in FY10 and FY11: $25M NSF, $19M CISE

Cyberlearning: Transforming Education (CTE)

AIM

- Designing and using technologies to aid and understand learning
- Partnership with EHR, SBE and OCI
  - Access to Anytime, Anywhere Learning
  - Personalize Learning Experiences
  - Cyber learning research on how technology can enable new forms of educational practice

CTE potential investment in FY11: $41M NSF, $15M CISE

Opportunities for Community Engagement!

- Join NSF to serve as program officers or division directors
- Visit NSF, get to know your program(s) and program director(s)
- Develop transformational ideas and send your best ideas to NSF
- Participate in NSF-funded and hosted activities, e.g., workshops, COVs, ACs, etc.
- Participate in the CCC/CRA visioning activities
- Develop transitional ideas for how to move from ideas from research to practice
- Work within your institution to support service to the larger computing community around the globe
- Send us your accomplishments; advertise your research to other citizens through local radio or TV, blogs, newspaper articles, etc.

CISE Needs Good People

- Quality of program directors:
  - Affects quality of reviewers chosen for panels and ad hoc reviews
  - Affects quality of reviews PIs receive
  - Affects funding decisions
  - Affects the nature and content of our research
  - Affects the frontiers of our discipline!

Current Vacancies in CISE

- Deputy Assistant Director
- CCF Program Officers
  - Algorithmic Foundations
- CNS Program Officers
  - Networking Technology and Systems (NeTS)
  - Trustworthy Computing
- IIS Program Officers
  - Human-Centered Computing
  - Information Integration and Informatics

Thanks!

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