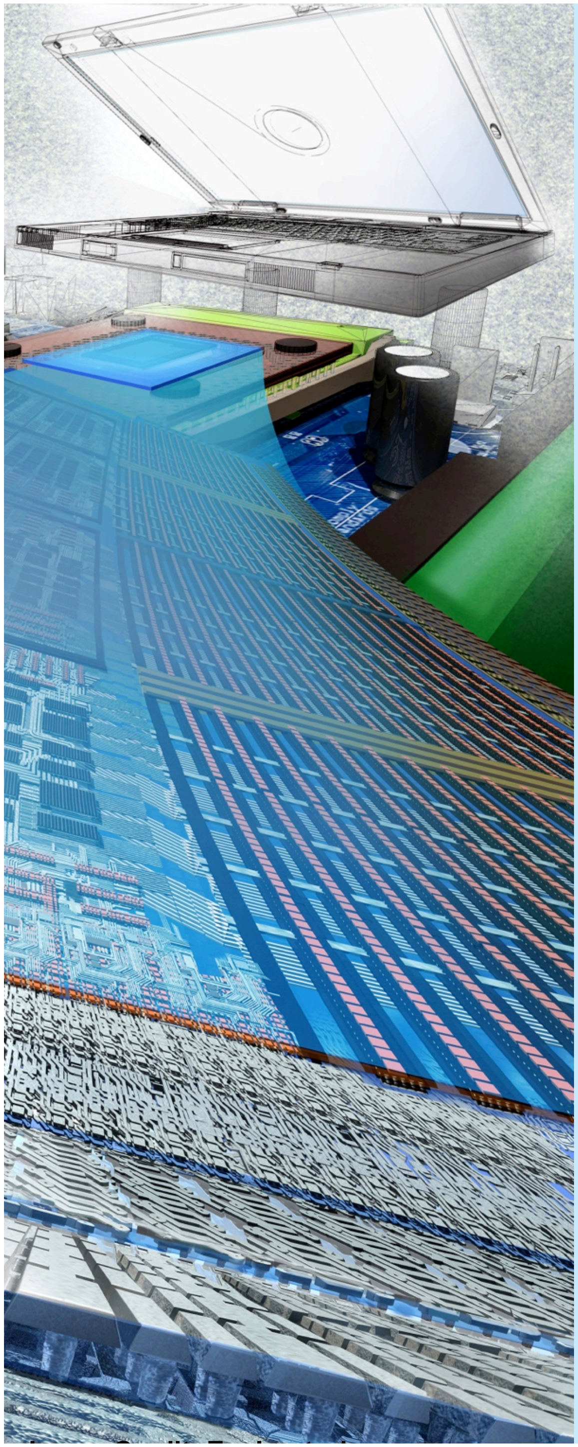


Innovating for Society: Realizing the Transformative Impact of Computing and Communication

Farnam Jahanian
CISE Directorate
National Science Foundation

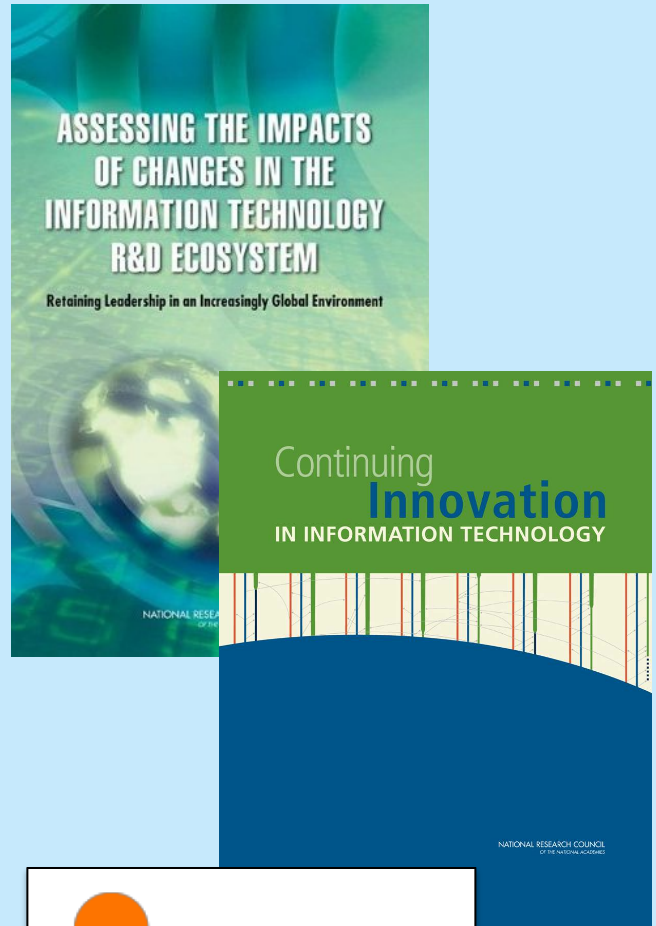
50 Years of Purdue Computer Science
April 2013

Pervasive Impact

- Computing community is at the center of an ongoing societal transformation and will be for decades to come.
- Advances in computing, communications and information technology:
  - Underpin our **economic prosperity and national security**;
  - Serve as a key driver of U.S. **competitiveness** and sustainable **economic growth** in an increasingly global market;
  - **Accelerate the pace of discovery and innovation** in nearly all other fields of inquiry;
  - Are crucial to achieving our major **national and societal priorities**.

Economic Impact of IT

- Growth of IT industry coupled with productivity gains across the entire economy have had enormous impact.
- IT industries accounted for 25% of US economic growth since 1995.
  - In 2010, IT industries grew 16% and contributed 5% to overall US GDP
- Use and production of IT accounted for ~2/3 of the post-1995 growth in labor productivity.
- IT sector generates jobs: IT jobs have grown 125x faster than employment as a whole between 2001 and 2011, and in 2011, IT workers earned 74% more than the average worker.
- IT diversifies regional economies to include idea-driven “creative” industries.



The Information Technology & Innovation Foundation

Sources: NRC (2009). *Assessing the Impacts of Changes in the IT R&D Ecosystem.*; NRC (2012). Continuing Innovation in Information Technology.; ITIF (2012). *Looking for Jobs? Look to IT in 2010 and Beyond.*

Innovations over the past thirty years…

Life Changers

The top innovations of the last 30 years, according to judges at the Wharton School of the University of Pennsylvania.

1. Internet, broadband
2. PC and laptop computers
3. Mobile phones
4. E-mail
5. DNA testing and sequencing
6. Magnetic resonance imaging
7. Microprocessors
8. Fiber optics
9. Office software
10. Laser/robotic surgery
11. Open-source software
12. Light-emitting diodes
13. Liquid crystal display
14. GPS devices
15. E-commerce and auctions
16. Media file compression
17. Microfinance
18. Photovoltaic solar energy
19. Large-scale wind turbines
20. Internet social networking

THE NEW YORK TIMES

THE COUNT

Internet, Mobile Phones Named Most Important Inventions

By PHYLLIS KORKKI
Published: March 7, 2009

In response to the shouted-out question, "What are some of the greatest inventions of all time?," nearby office workers in a recent informal survey gave the following answers: the wheel, the engine, the ballpoint pen, diapers and the cheese Danish.

Life Changers
The top innovations of the last 30 years, according to judges at the Wharton School of the University of Pennsylvania.
1. Internet, broadband
2. PC and laptop computers
3. Mobile phones
4. E-mail
5. DNA testing and sequencing
6. Magnetic resonance imaging
7. Microprocessors
8. Fiber optics
9. Office software
10. Laser/robotic surgery
11. Open-source software
12. Light-emitting diodes
13. Liquid crystal display
14. GPS devices
15. E-commerce and auctions
16. Media file compression
17. Microfinance
18. Photovoltaic solar energy
19. Large-scale wind turbines
20. Internet social networking
THE NEW YORK TIMES

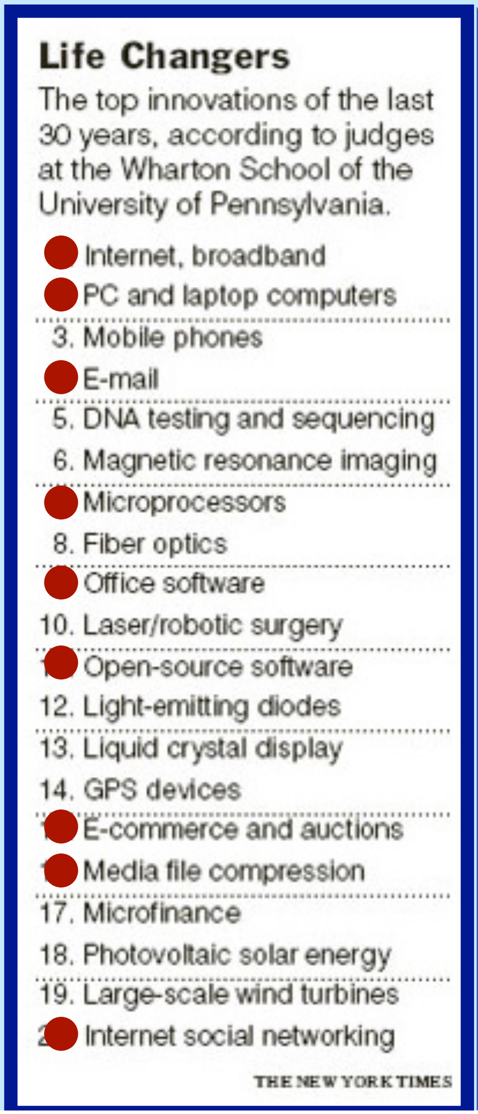
A panel of eight judges from the Wharton School of the University of Pennsylvania was required to go back only 30 years — not to the dawn of history — when asked a similar question. So its answers, of course, were very different.

In the survey, the Internet was voted the biggest innovation of the last three decades, followed by computers, mobile phones and e-mail. The survey was sponsored by Knowledge@Wharton, the school's business publication, and PBS's "Nightly Business Report."

Good, important choices all, but for classic, long-lasting appeal, they still can't beat the wheel. **PHYLLIS KORKKI**

A version of this article appeared in print on March 8, 2009, on page BU2 of the New York edition.

The past thirty years …

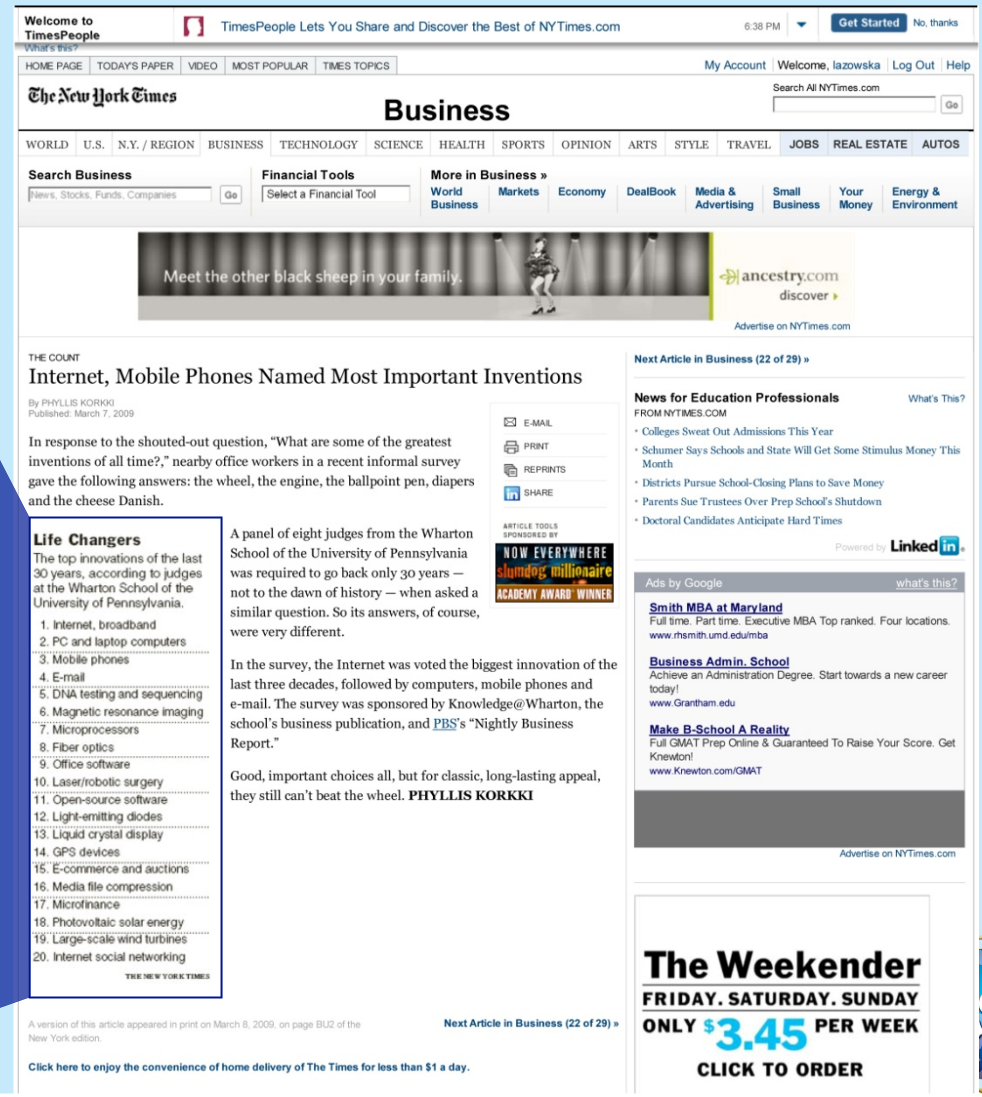


Life Changers

The top innovations of the last 30 years, according to judges at the Wharton School of the University of Pennsylvania.

Internet, broadband
PC and laptop computers
3. Mobile phones
E-mail
5. DNA testing and sequencing
6. Magnetic resonance imaging
Microprocessors
8. Fiber optics
Office software
10. Laser/robotic surgery
Open-source software
12. Light-emitting diodes
13. Liquid crystal display
14. GPS devices
E-commerce and auctions
Media file compression
17. Microfinance
18. Photovoltaic solar energy
19. Large-scale wind turbines
Internet social networking

THE NEW YORK TIMES



Welcome to TimesPeople
TimesPeople Lets You Share and Discover the Best of NYTimes.com
Get Started | No, thanks

HOME PAGE | TODAY'S PAPER | VIDEO | MOST POPULAR | TIMES TOPICS
My Account | Welcome, lazowska | Log Out | Help

The New York Times
Business

WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION | ARTS | STYLE | TRAVEL | JOBS | REAL ESTATE | AUTOS

Search Business | Financial Tools | More in Business »
World Business | Markets | Economy | DealBook | Media & Advertising | Small Business | Your Money | Energy & Environment

THE COUNT

Internet, Mobile Phones Named Most Important Inventions

By PHYLLIS KORKKI
Published: March 7, 2009

In response to the shouted-out question, “What are some of the greatest inventions of all time?,” nearby office workers in a recent informal survey gave the following answers: the wheel, the engine, the ballpoint pen, diapers and the cheese Danish.

A panel of eight judges from the Wharton School of the University of Pennsylvania was required to go back only 30 years — not to the dawn of history — when asked a similar question. So its answers, of course, were very different.

In the survey, the Internet was voted the biggest innovation of the last three decades, followed by computers, mobile phones and e-mail. The survey was sponsored by Knowledge@Wharton, the school’s business publication, and PBS’s “Nightly Business Report.”

Good, important choices all, but for classic, long-lasting appeal, they still can’t beat the wheel. PHYLLIS KORKKI

Life Changers

The top innovations of the last 30 years, according to judges at the Wharton School of the University of Pennsylvania.

1. Internet, broadband
2. PC and laptop computers
3. Mobile phones
4. E-mail
5. DNA testing and sequencing
6. Magnetic resonance imaging
7. Microprocessors
8. Fiber optics
9. Office software
10. Laser/robotic surgery
11. Open-source software
12. Light-emitting diodes
13. Liquid crystal display
14. GPS devices
15. E-commerce and auctions
16. Media file compression
17. Microfinance
18. Photovoltaic solar energy
19. Large-scale wind turbines
20. Internet social networking

THE NEW YORK TIMES

E-MAIL | PRINT | REPRINTS | SHARE

A version of this article appeared in print on March 8, 2009, on page BU2 of the New York edition.

Next Article in Business (22 of 29) »

News for Education Professionals FROM NYTIMES.COM
- Colleges Sweat Out Admissions This Year
- Schumer Says Schools and State Will Get Some Stimulus Money This Month
- Districts Pursue School-Closing Plans to Save Money
- Parents Sue Trustees Over Prep School's Shutdown
- Doctoral Candidates Anticipate Hard Times

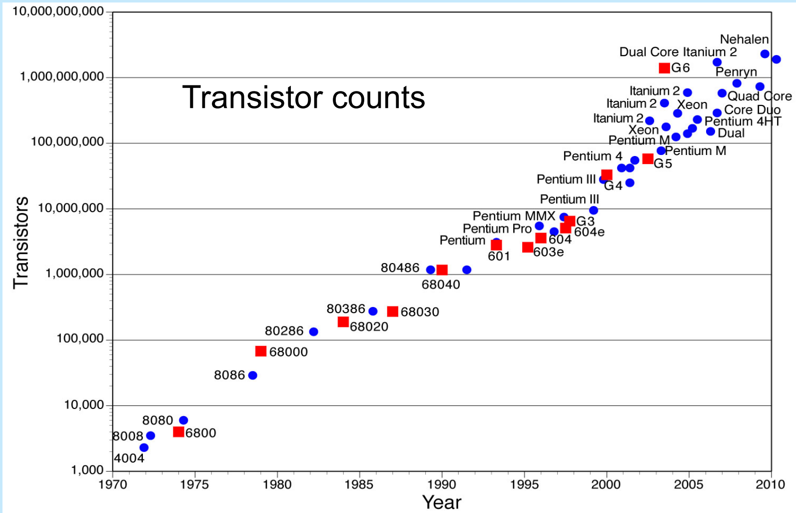
The most recent ten years …

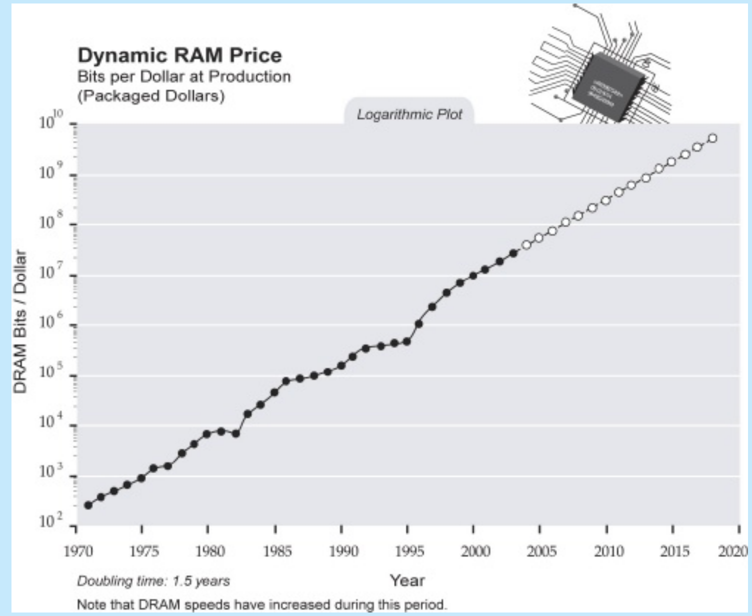
- Search
- Scalability
- Digital media
- Mobility
- eCommerce
- The Cloud
- Social networking and crowd-sourcing

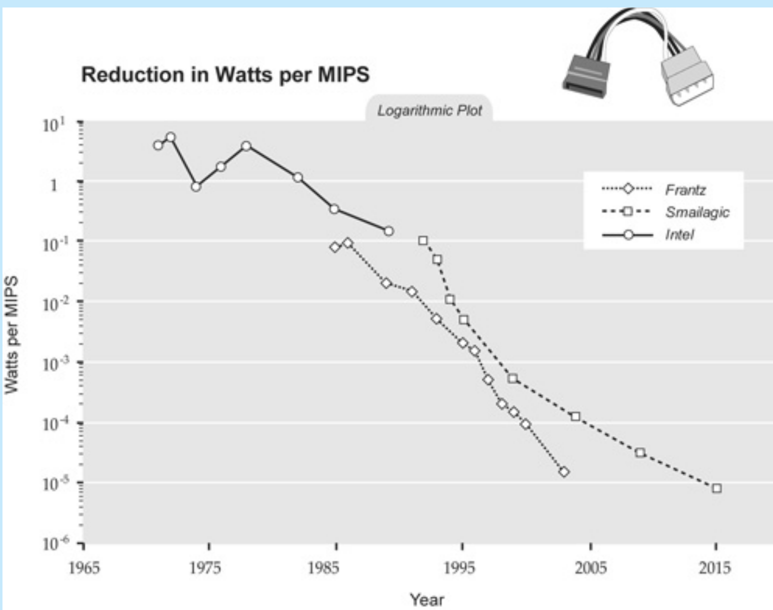
Xconomy

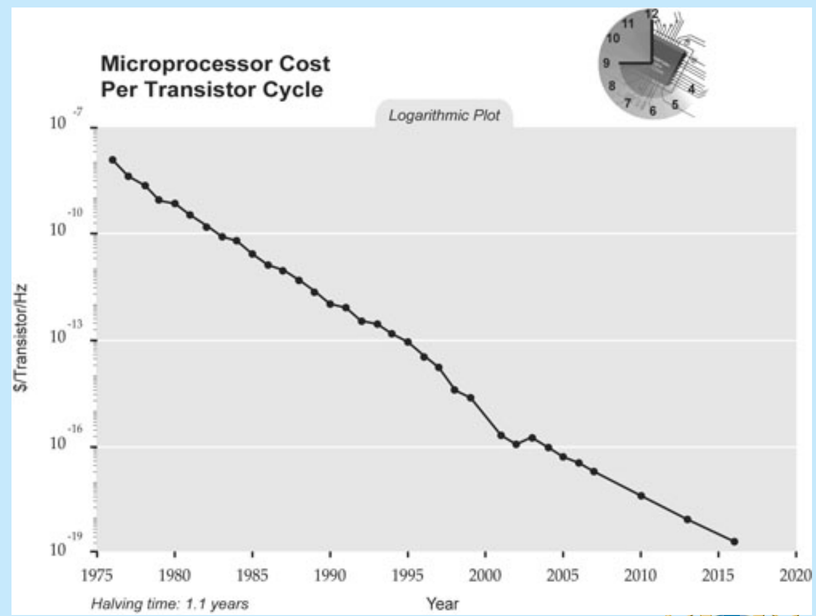
Business + Technology in the Exponential Economy

Technology Push

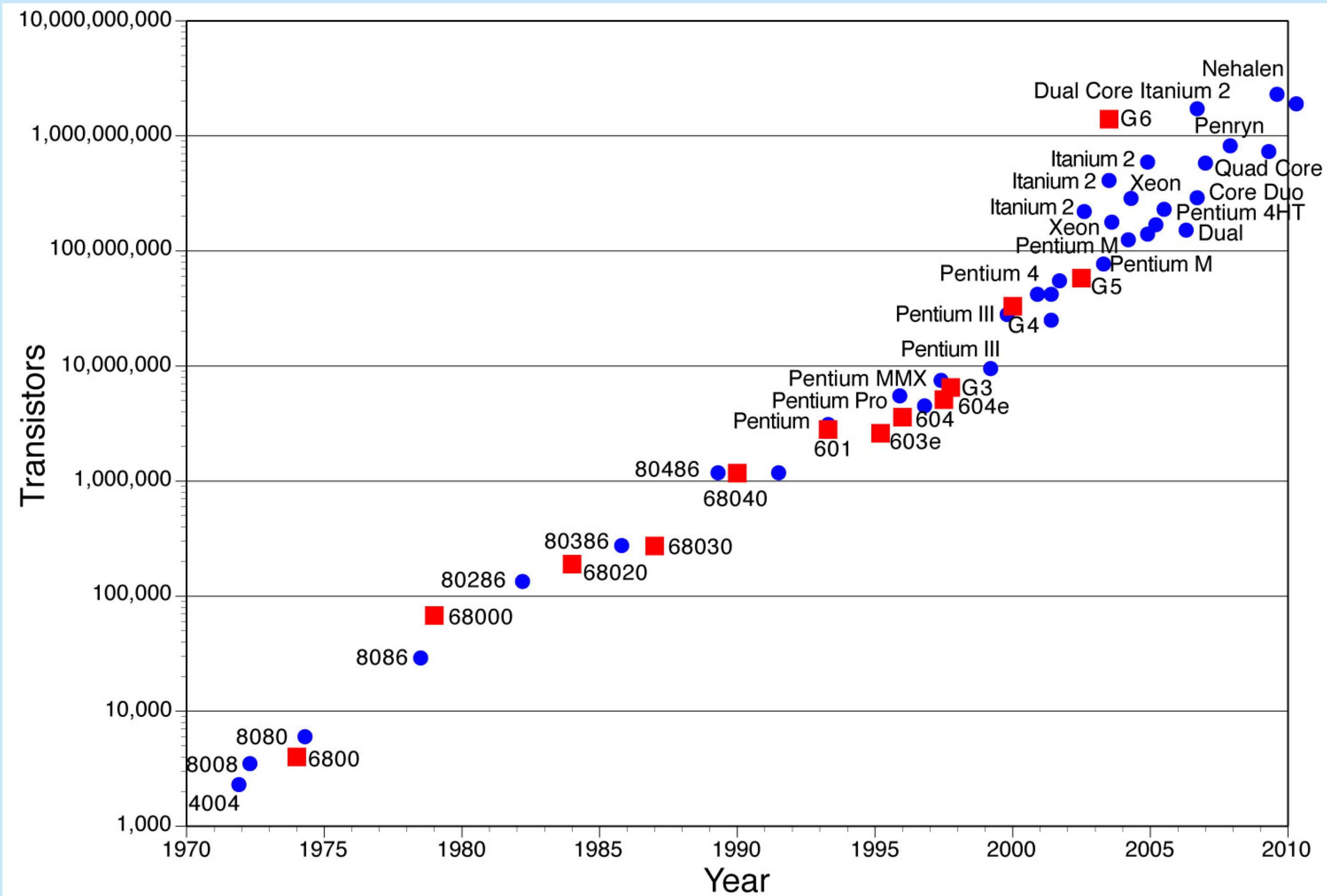




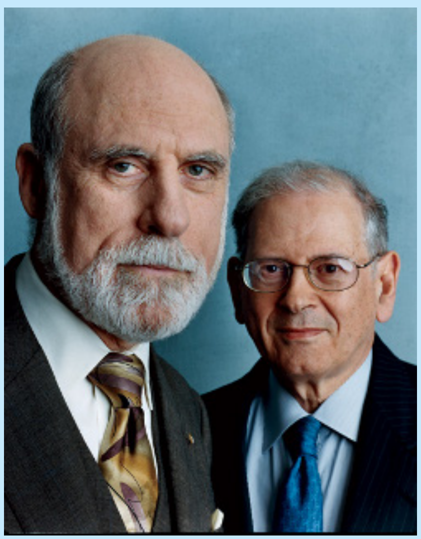


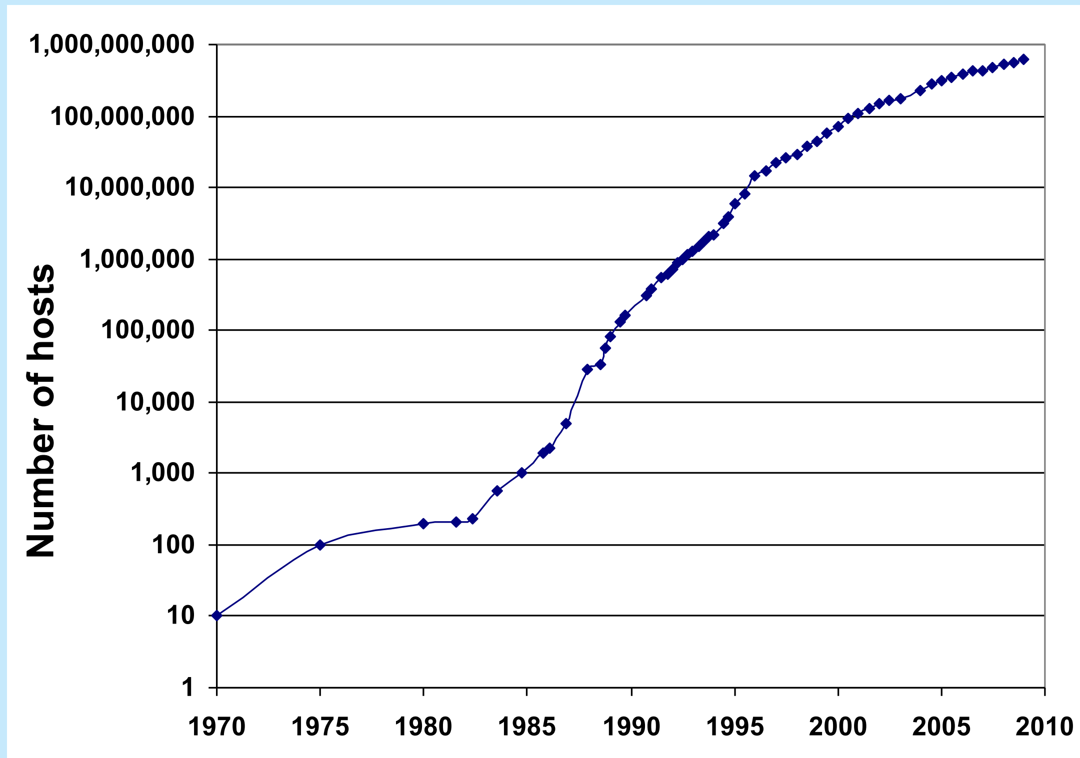


50 years of Moore's Law

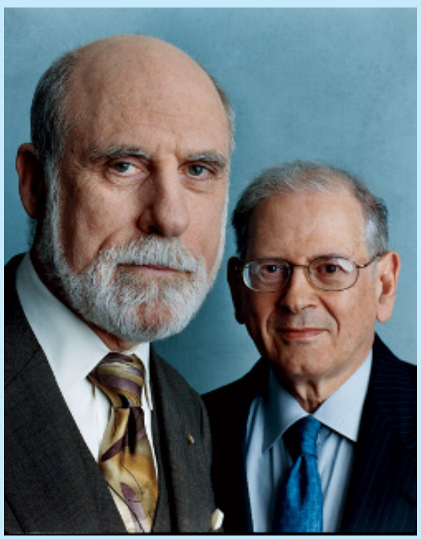


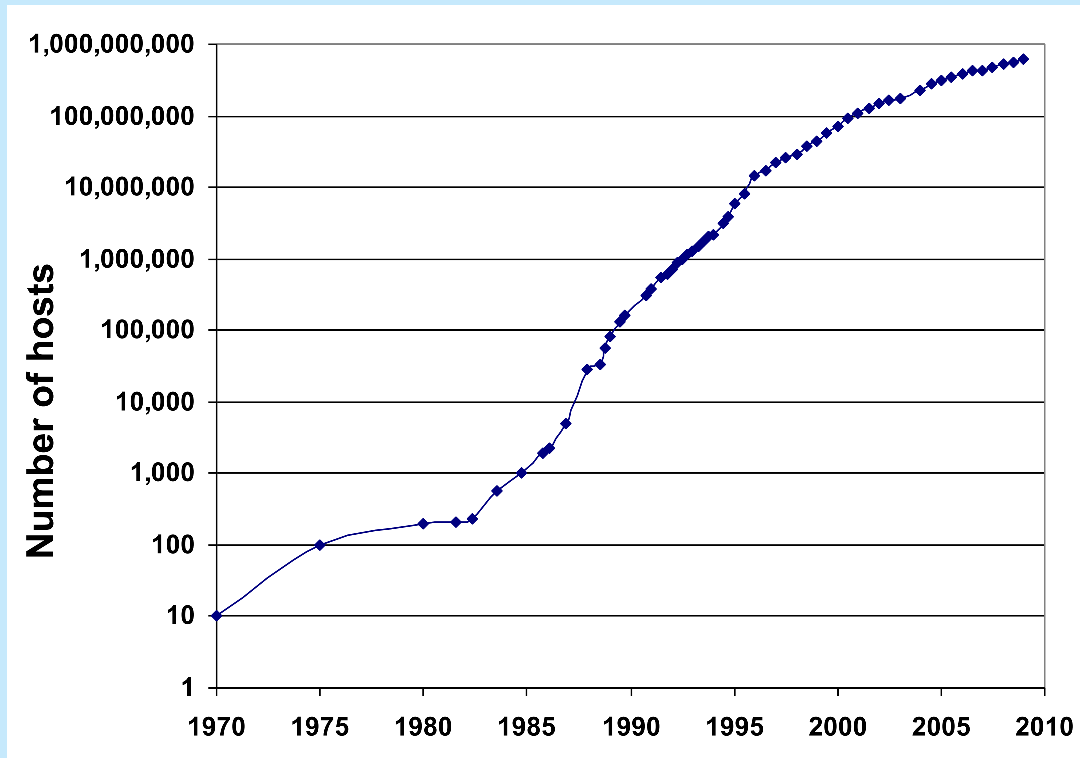
Same for the Internet





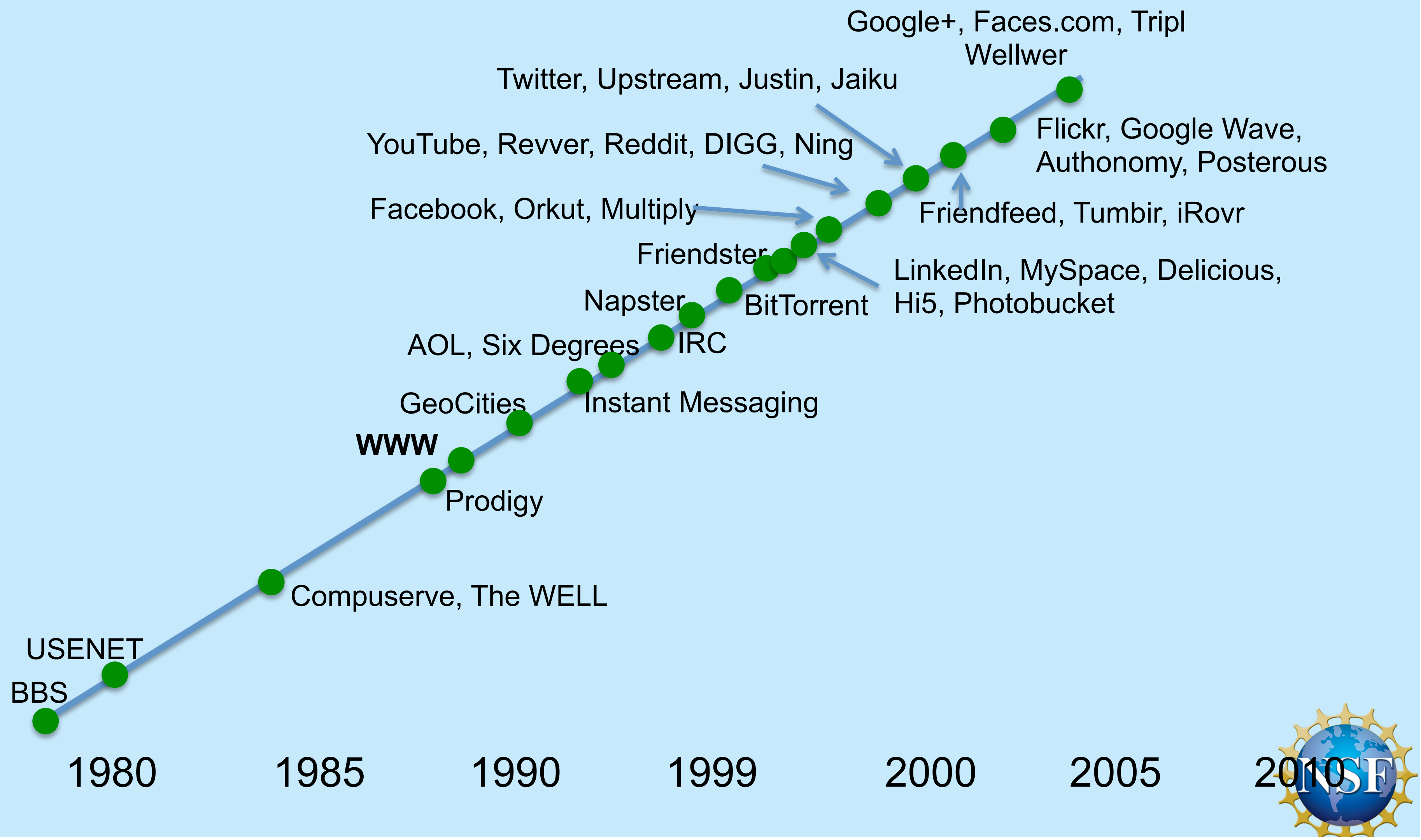
- Ditto the Internet



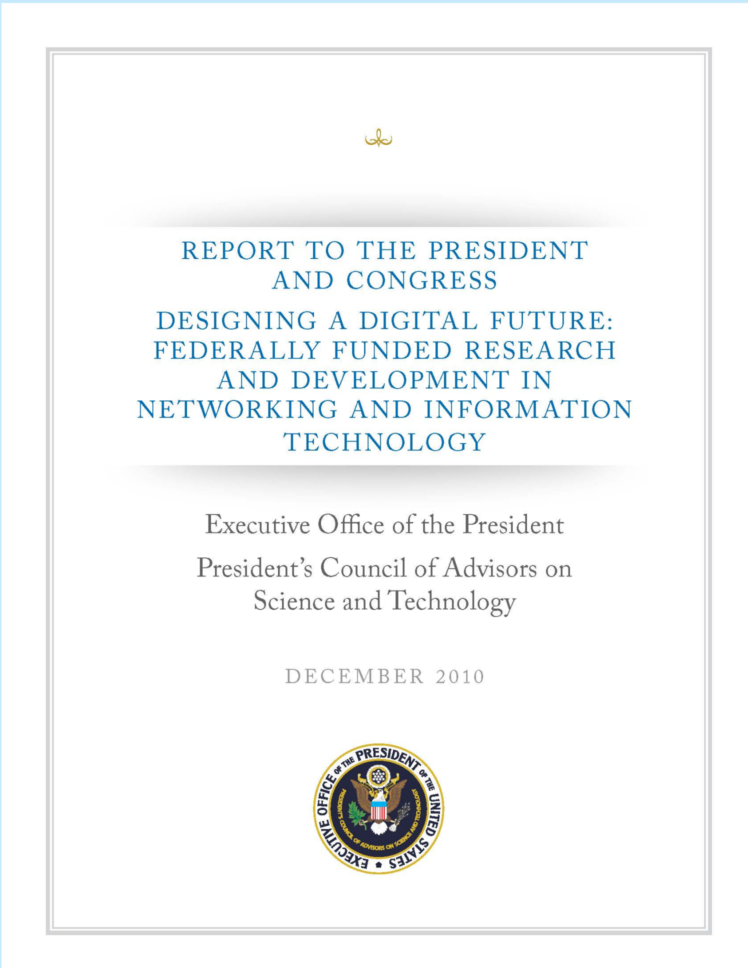


In just the past 20 years (1992-2012), the number of Internet hosts and the number of transistors on a die each have increased 2000x!

Social Networks



A National Imperative


REPORT TO THE PRESIDENT
AND CONGRESS
DESIGNING A DIGITAL FUTURE:
FEDERALLY FUNDED RESEARCH
AND DEVELOPMENT IN
NETWORKING AND INFORMATION
TECHNOLOGY

Executive Office of the President

President's Council of Advisors on
Science and Technology

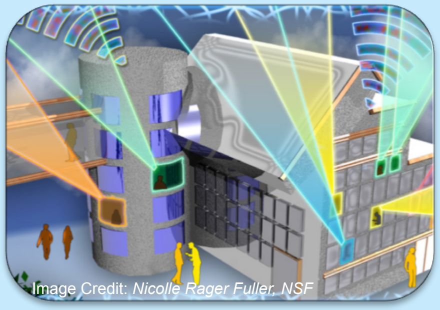
DECEMBER 2010

http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-nitrd-report-2010.pdf

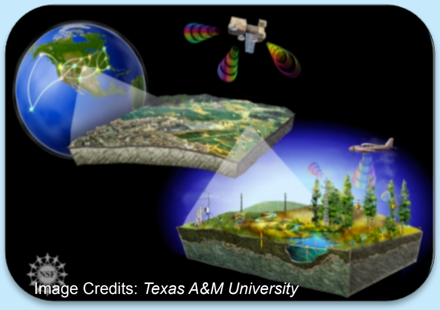
"Recent technological and societal trends place the further advancement and application of networking and information technology squarely at the center of our Nation's ability to achieve essentially all of our priorities and to address essentially all of our challenges."

Source: PCAST (2010). Designing a Digital Future: Federally Funded Research and Development in Networking and Information Technology. – A periodic congressionally-mandated review of the Federal Networking and Information Technology Research and Development (NITRD) Program.

CISE and National Priorities



Broadband & Universal Connectivity



Environment & Sustainability

Emergency Response & Disaster Resiliency

Health & Wellbeing

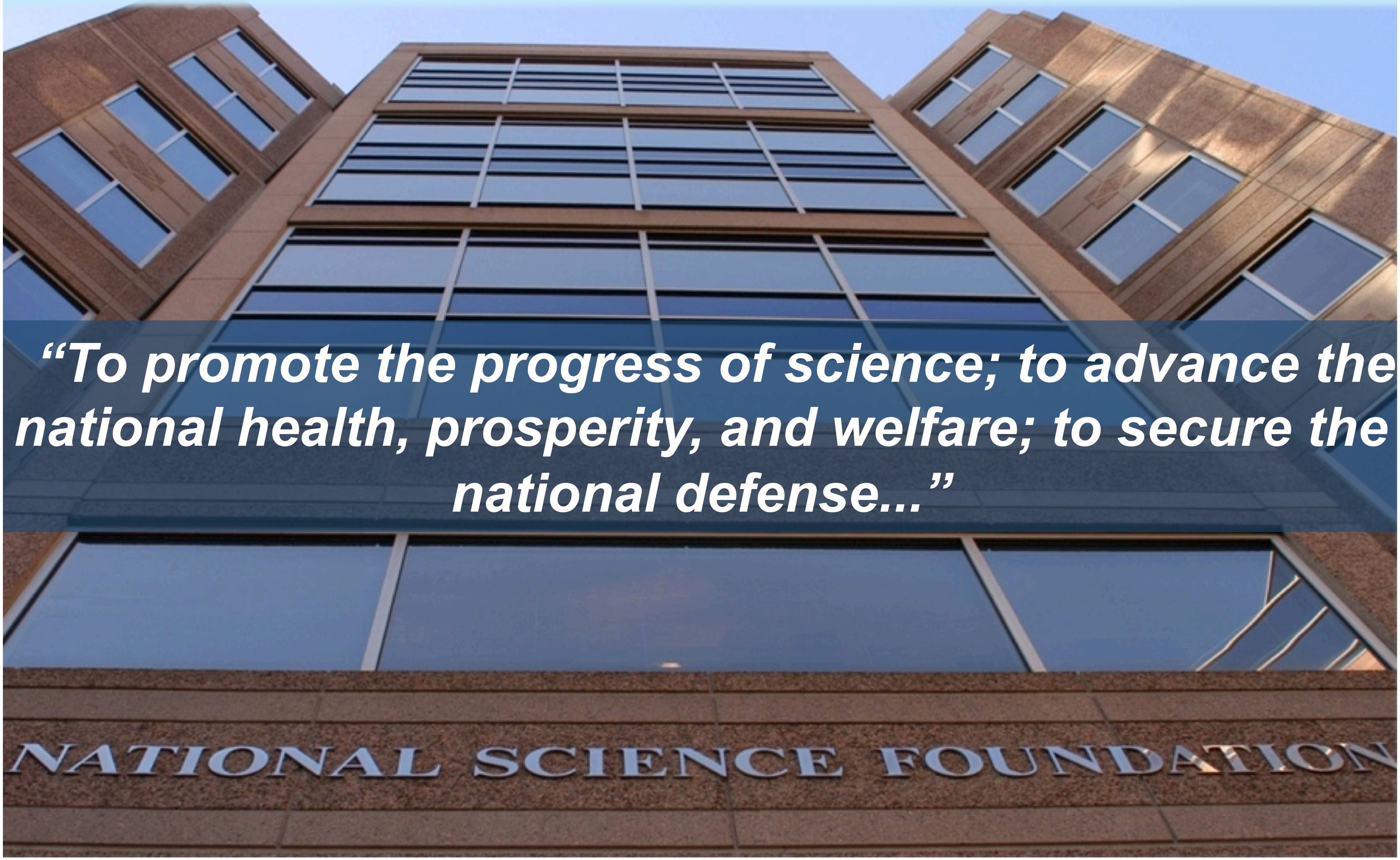
Manufacturing, Robotics, & Smart Systems

Secure Cyberspace

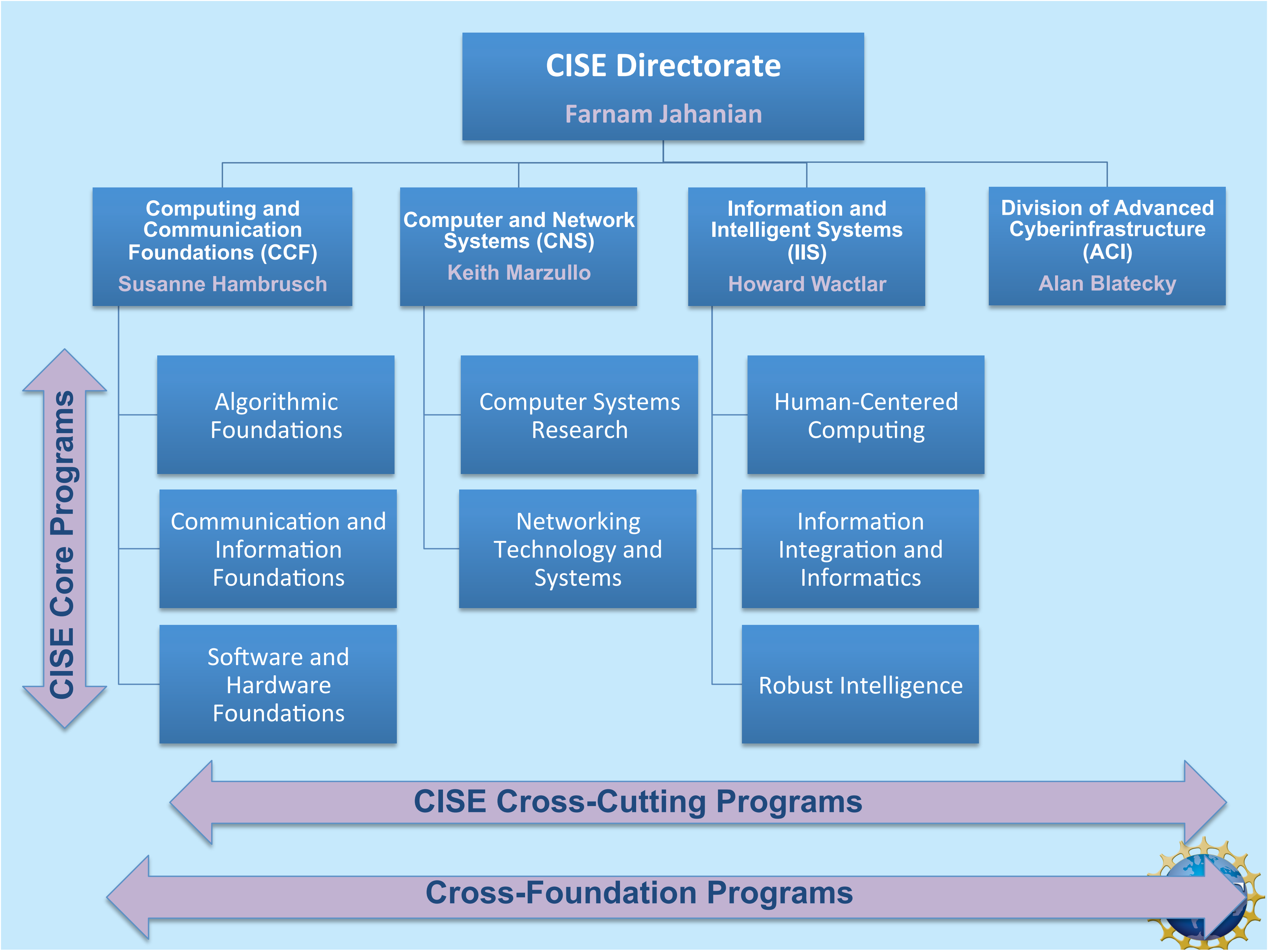
Transportation & Energy

Education and Workforce Development

National Science Foundation's Mission



"To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..."

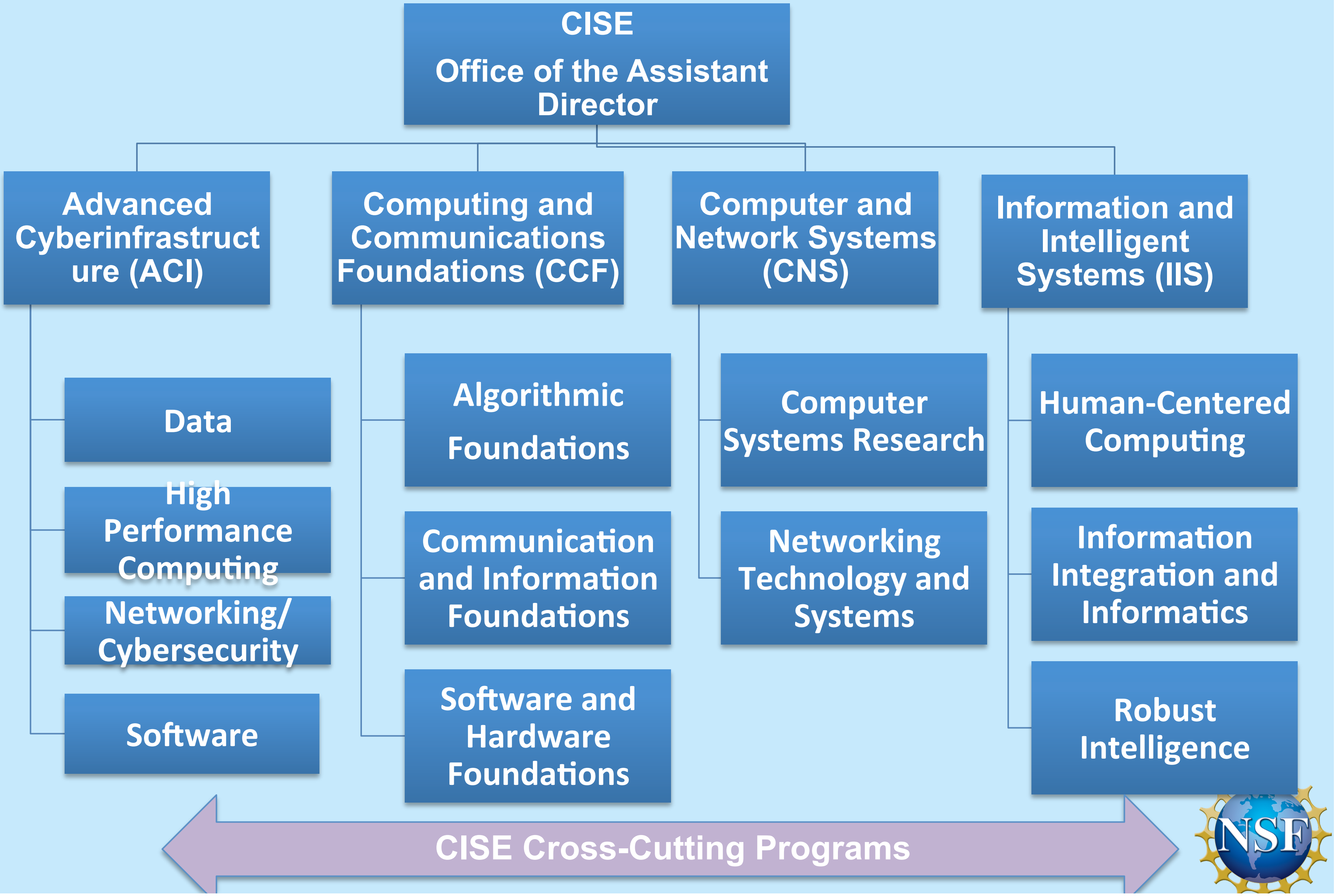

CISE Directorate
Farnam Jahanian
Computing and Communication Foundations (CCF)
Susanne Hambrusch
Computer and Network Systems (CNS)
Keith Marzullo
Information and Intelligent Systems (IIS)
Howard Wactlar
Division of Advanced Cyberinfrastructure (ACI)
Alan Blatecky
CISE Core Programs
Algorithmic Foundations
Communication and Information Foundations
Software and Hardware Foundations
Computer Systems Research
Networking Technology and Systems
Human-Centered Computing
Information Integration and Informatics
Robust Intelligence
CISE Cross-Cutting Programs
Cross-Foundation Programs

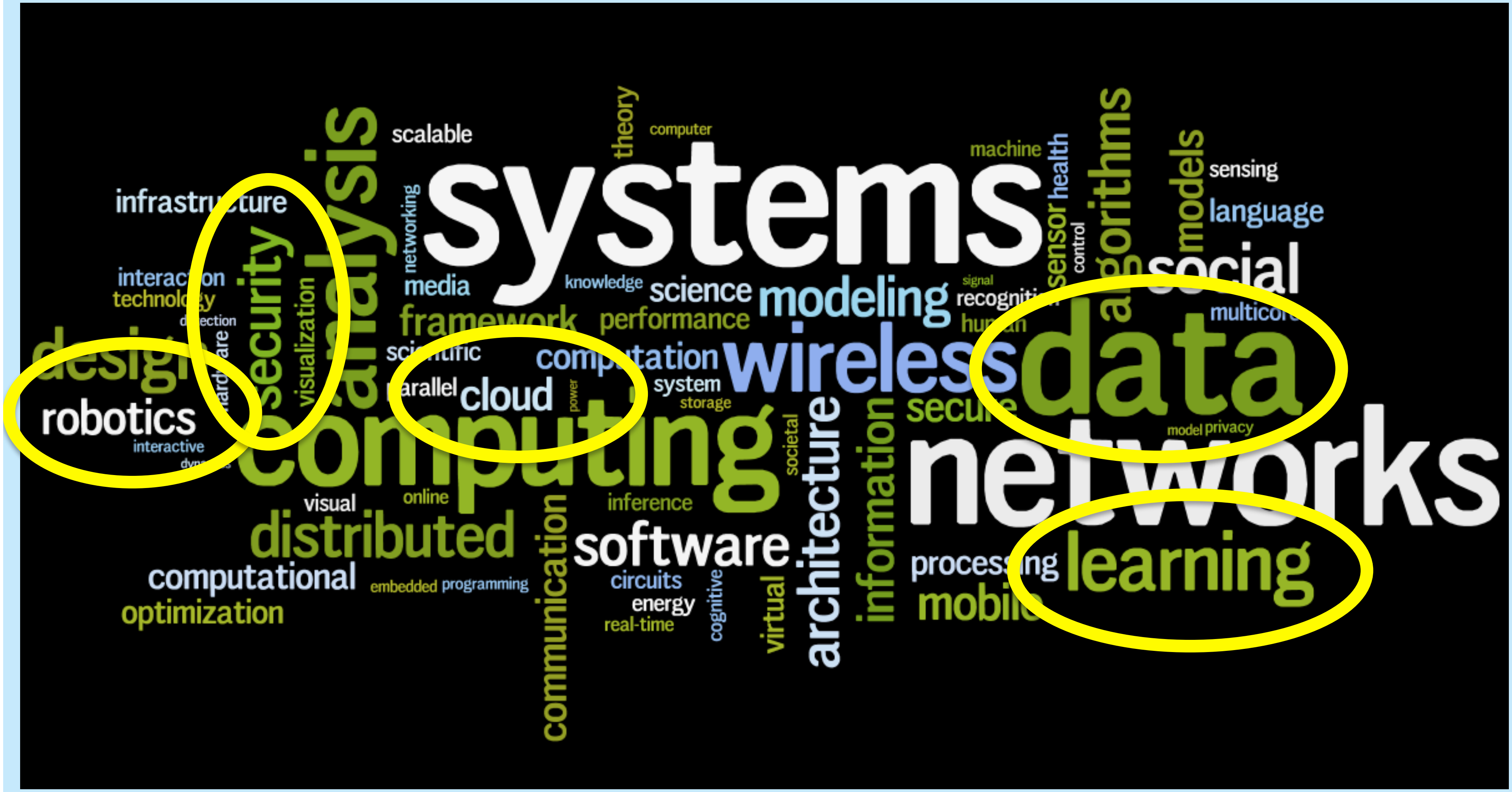
CISE Organization

Office of the Assistant Director for CISE

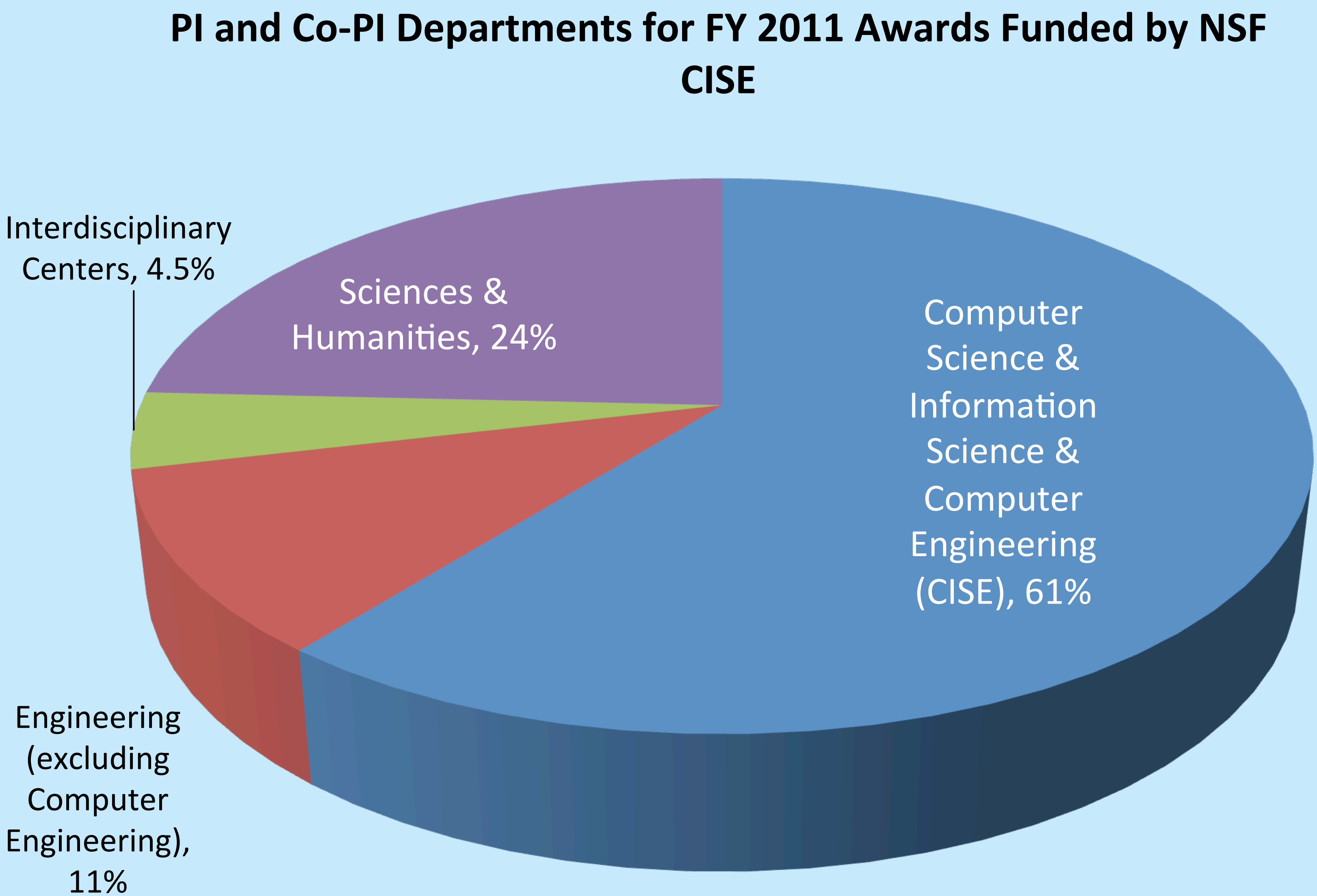
- **Advanced Cyberinfrastructure**
  Division Director
  Mr. Alan Blatecky
- **Computing and Communications Foundations**
  Division Director
  Dr. Susanne Hambrusch
- **Computer and Network Systems**
  Division Director
  Dr. Keith Marzullo
- **Information and Intelligent Systems**
  Division Director
  Dr. Howard Wactlar

CISE Core Research Programs

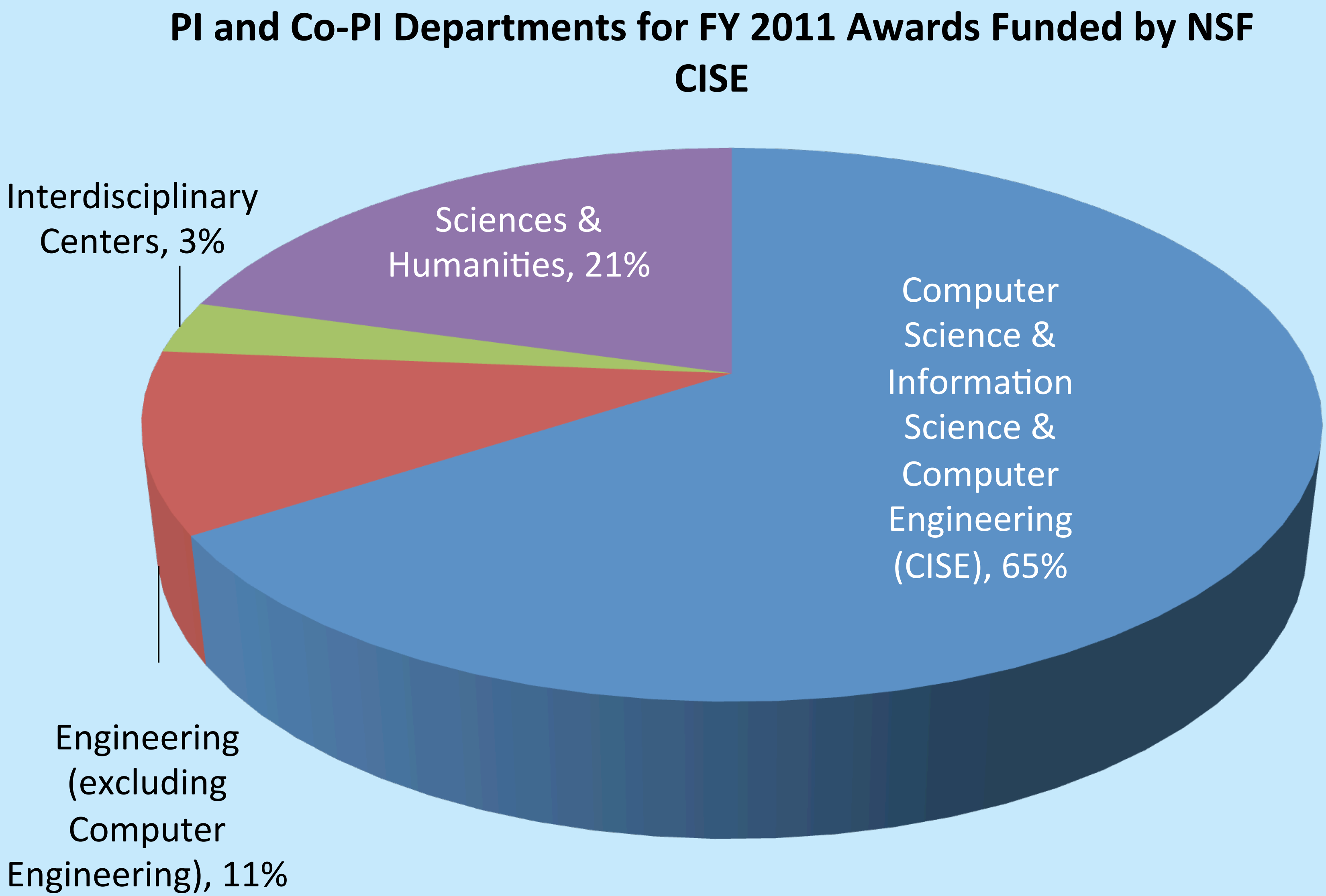



systems
networks
computing
data
wireless
learning
analysis
security
design
robotics
cloud
software
distributed
architecture
information
communication
algorithms
social
modeling
models
scalable
infrastructure
interaction
technology
visualization
networking
media
framework
performance
science
knowledge
theory
computer
machine
sensor
health
control
sensing
language
signal
recognition
multicore
computation
scientific
parallel
system
storage
secure
model
privacy
interactive
visual
online
inference
societal
computational
optimization
embedded
programming
circuits
energy
real-time
cognitive
virtual
processing
mobile

Who is the CISE community?



Who is the CISE community?



Snapshot of CISE FY 2012 Activities

	CISE
Research Budget	$865M
Number of Proposals	7695
Number of Awards	1,741
Success Rate	~22%
Average Annualized Award Size	$200K
Number of Panels Held	316
Number of People Supported	18,460

	CISE
Senior Researchers	8417
Other Professionals	943
Postdoctoral Associates	371
Graduate Students	6131
Undergraduate Students	2,513

Budget Process Brief Overview

Community Input

- Societies and Academies
- CCC and CRA visioning activities
- CSTB Studies
- CISE Advisory Committee and Industry
- Workshops and direct engagement of PIs

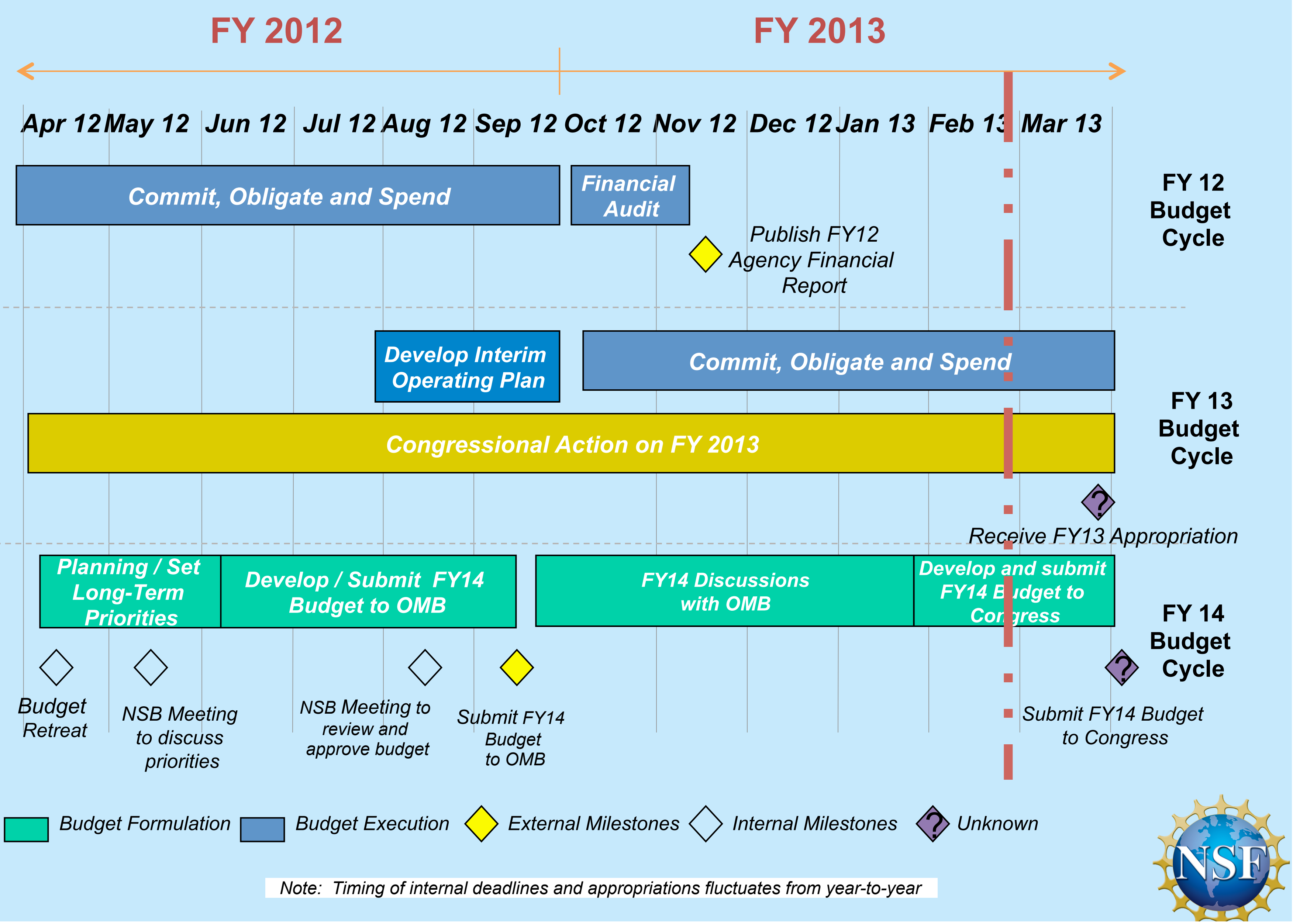
Administration Priorities

- Office of Science and Technology Policy (OSTP)
- Office of Management and Budget (OMB)

Internal Deliberation and Negotiation

- within directorate
- cross-foundation
- cross-agency

Budget Activity Timeline



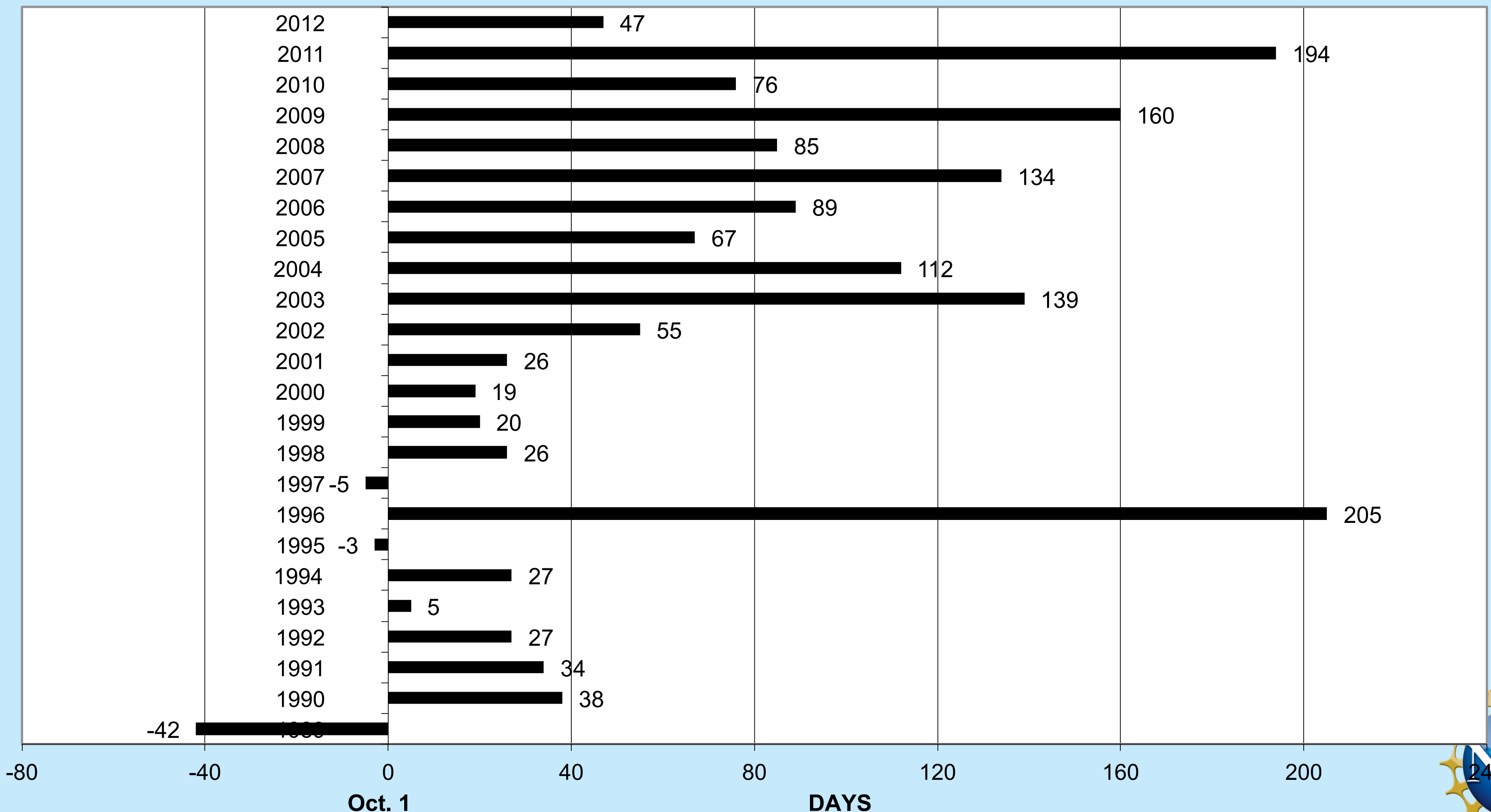
Note: Timing of internal deadlines and appropriations fluctuates from year-to-year

Appropriations Drift

NSF Appropriations Dates* versus Start of Federal Fiscal Year (October 1)

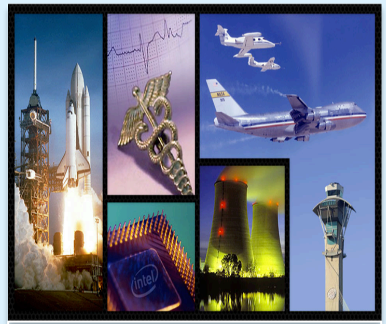
*Date that Congress passes appropriation bill

FY 2013: 170 days and counting

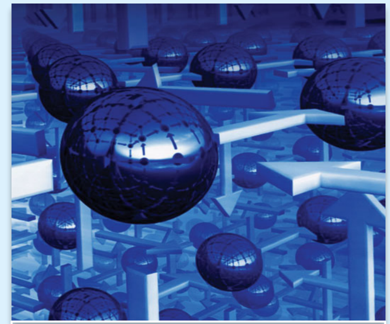


Emerging Frontiers

Data Explosion



Smart Systems: Sensing, Analysis and Decision



Expanding the Limits of Computation

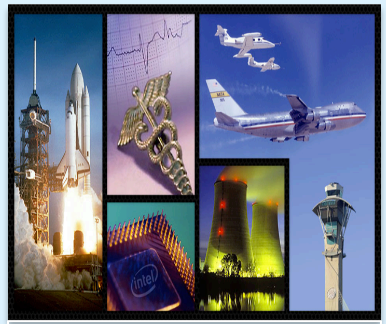
Secure Cyberspace

Universal Connectivity

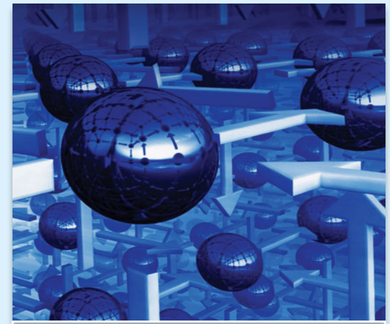
Augmenting Human Capabilities

Emerging Frontiers

Data Explosion



Smart Systems: Sensing, Analysis and Decision



Expanding the Limits of Computation

Secure Cyberspace

Universal Connectivity

Augmenting Human Capabilities


FROM DATA TO
KNOWLEDGE TO ACTION
Data represent a transformative new currency for science, engineering, education and commerce.
Image Credit: CCC and SIGACT CATCS

Seizing the Big Data Revolution

- **Data Tsunami: Explosive Growth in Size, Complexity, and Data Rates**
  – Enabled by experimental methods, observational studies, scientific instruments, simulations, email, videos, images, click streams, Internet transactions … and sensors everywhere!

- **The Age of Data: From Data to Knowledge to Action**
  – Widespread use of data to create actionable information leads to timely and more informed decisions and actions.

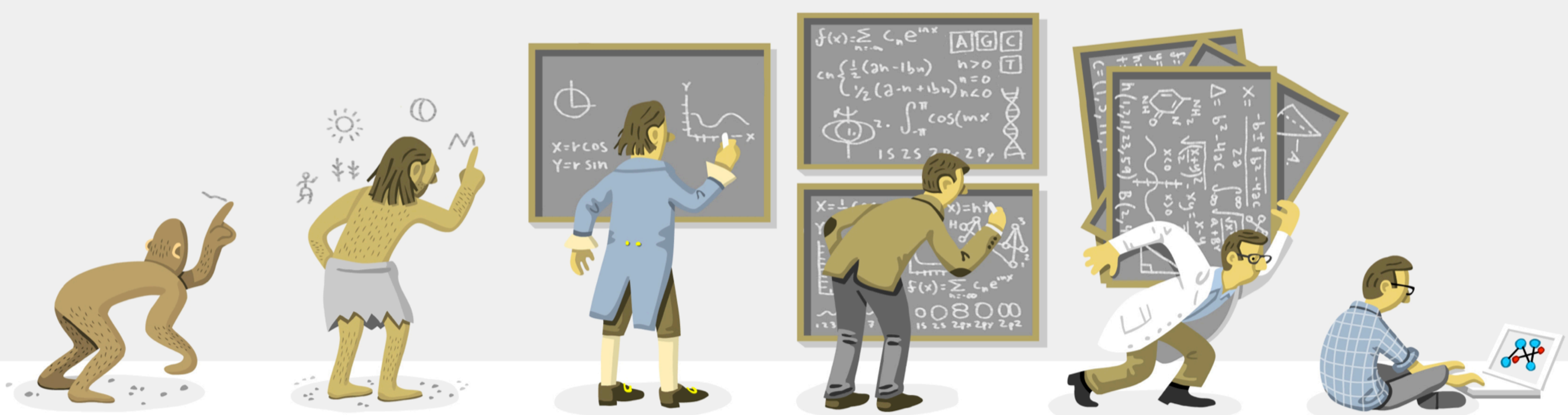
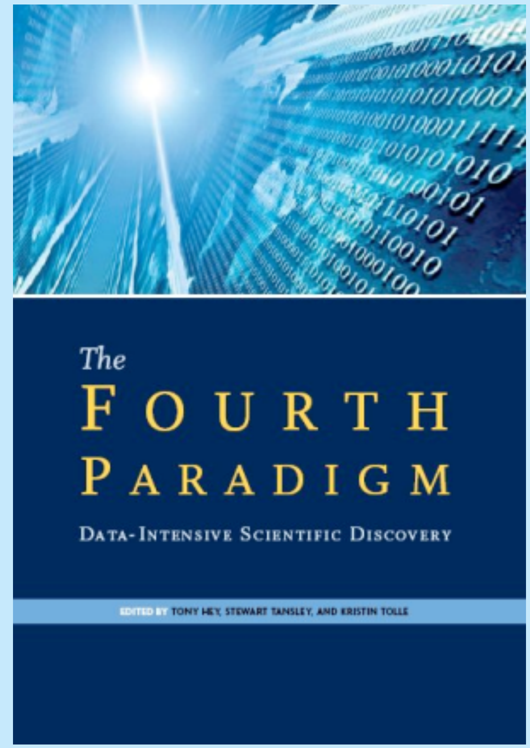


Image Credit: *Chi Birmingham*

Paradigm Shift: from Hypothesis-driven to Data-driven Discovery



http://www.sciencemag.org/site/special/data/

http://www.economist.com/node/15579717

http://research.microsoft.com/en-us/collaboration/fourthparadigm/

Data are motivating a profound transformation in the culture and conduct of scientific research.

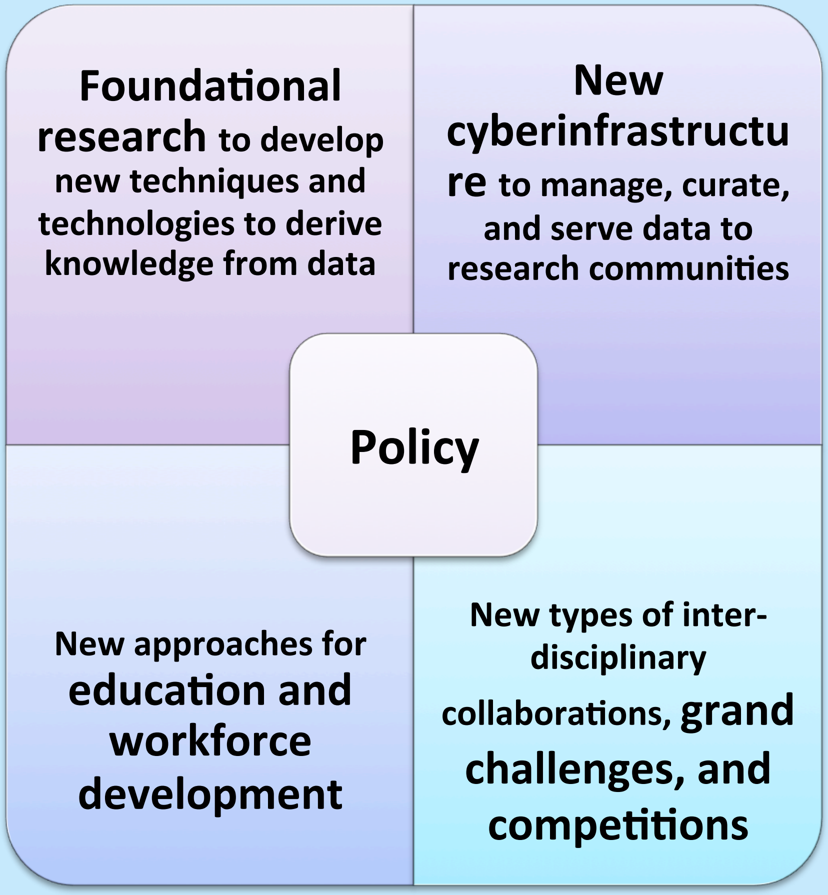
Education, Learning, Workforce Development, Computational and Data-enabled Science

"By 2018 the United States alone faces a shortage of 140,000 to 190,000 people with analytical expertise and 1.5 million managers and analysts with the skills to understand and make decisions based on the analysis of big data."[1]

[1] McKinsey&Company (May 2011), "Big data: The next frontier for innovation, competition, and productivity." Available at: http://www.mckinsey.com/Insights/MGI/Research/Technology_and_Innovation/Big_data_The_next_frontier_for_innovation

Federal Big Data R&D Initiative
(WH Launch on March 29,2012)

- **Cross-agency "Big Data" Senior Steering Group –** chartered in spring 2011 by the White House OSTP:
  - Co-chaired by NSF and NIH
  - Significant research community input
- **Major Announcements**: NSF, NIH, USGS, DoD, DARPA, DOE
- **NEW PROGRAM**: Core Techniques and Technologies for Advancing Big Data Science & Engineering (BIG DATA)
  - All NSF Directorates and 8 NIH Institutes
  - Research thrusts: Collection, Storage, and Management; Data Analytics; Research in Data Sharing and Collaboration



More information available at:
http://nsf.gov/news/news_summ.jsp?org=CISE&cntn_id=123607&preview=false

U.S. Federal "Big Data" R&D Initiative

- Big Data Senior Steering Group – chartered in spring 2011 under the Networking and Information Technology R&D (NITRD) Program
  - Members from DARPA, DOD OSD, DHS, DOE-Science, HHS, NARA, NASA, NIST, NOAA, NSA, OFR, and USGS
  - Co-chaired by NSF and NIH
- Initiative launched by White House OSTP on March 29, 2012

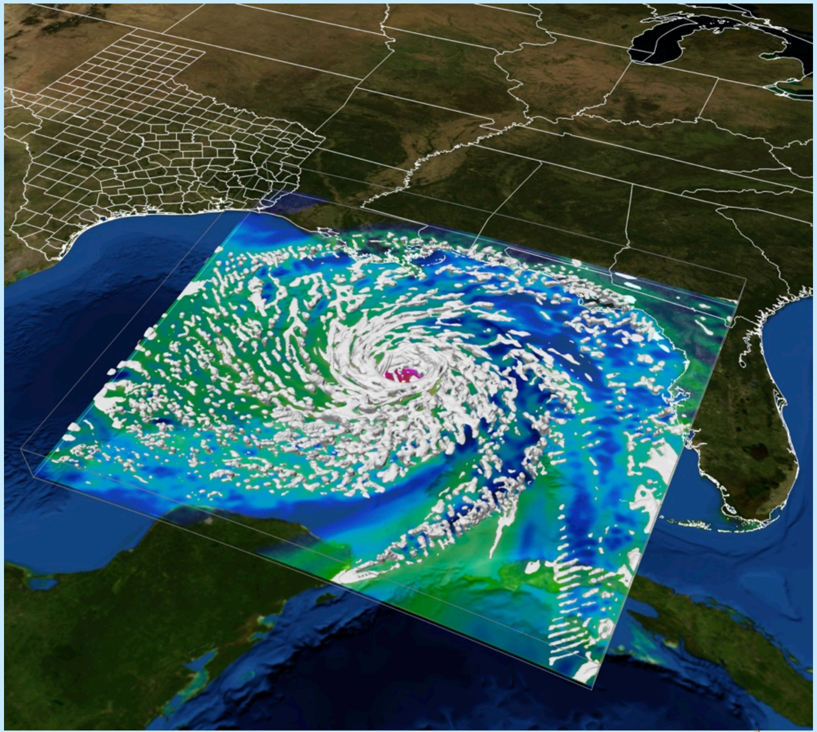


Image Credit: *Fuqing Zhang and Yonghui Weng, Pennsylvania State University; Frank Marks, NOAA; Gregory P. Johnson, Romy Schneider, John Cazes, Karl Schulz, Bill Barth, The University of Texas at Austin*

Framework for Investments

Foundational research to develop new techniques and technologies to derive knowledge from data

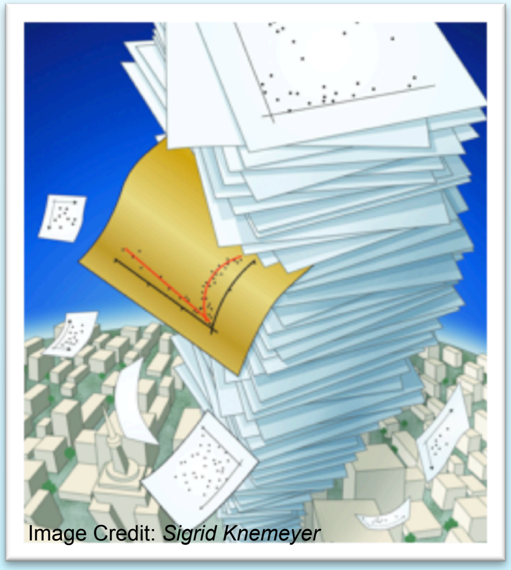
New cyberinfrastructure to manage, curate, and serve data to research communities

Policy

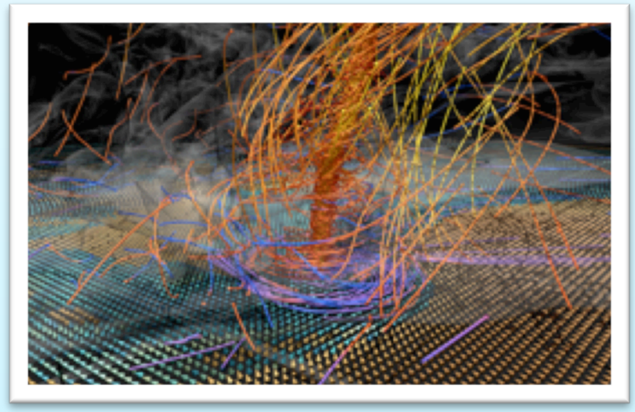
New approaches for education and workforce development

New types of inter-disciplinary collaboration, community building

Extracting Knowledge from Data

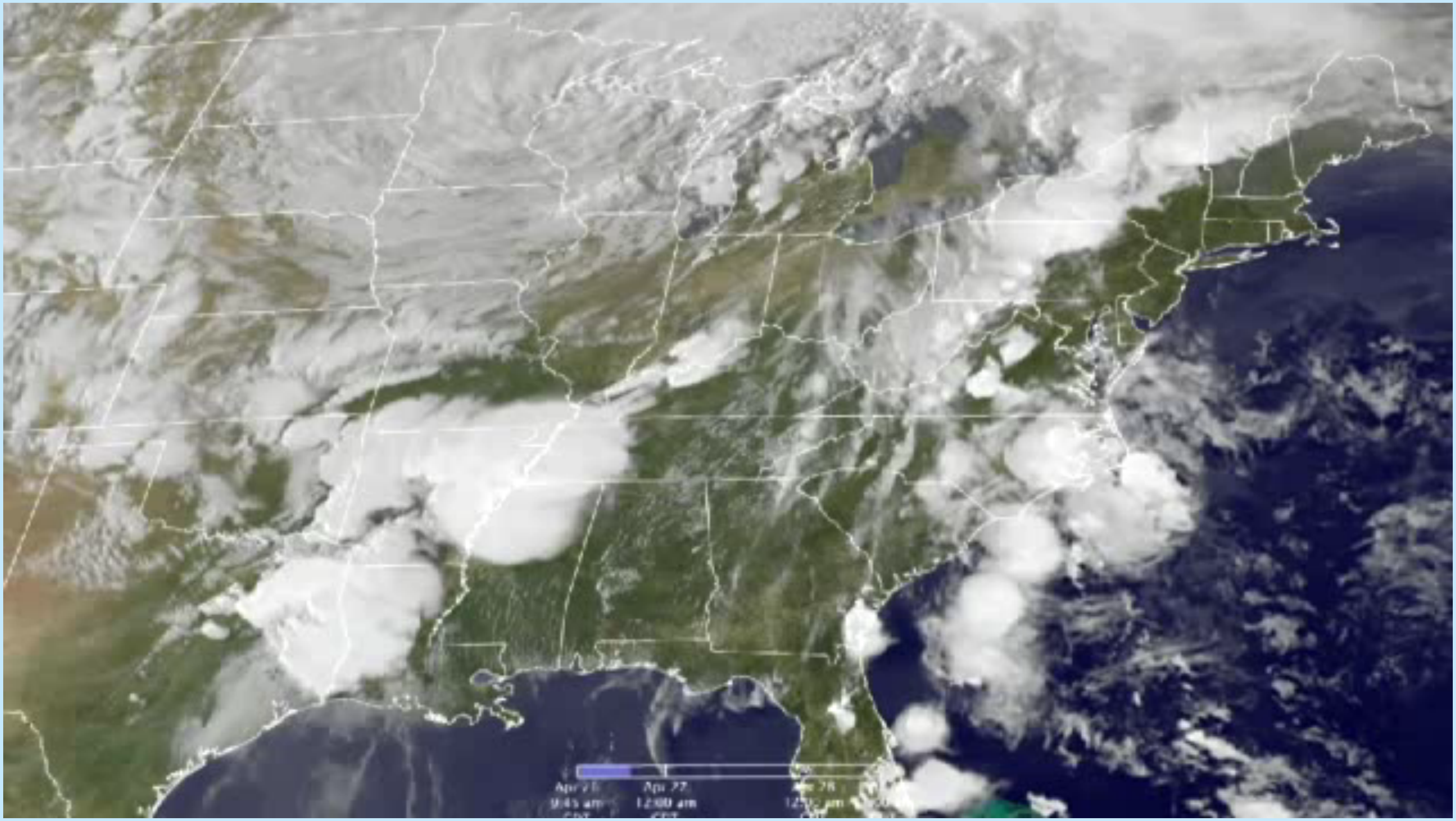


New Tool for Extracting Knowledge from Large Data Sets: A new statistical tool, part of a suite called MINE, can tease out multiple patterns hidden in health information from around the globe, statistics amassed from major league baseball, data on bacterial biodiversity, and much more. (Michael Mitzenmacher, Harvard with researchers from the Broad Institute)



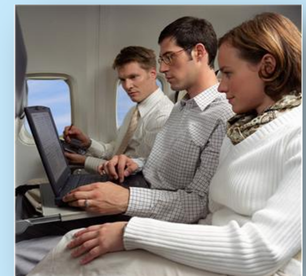
Forecasting Tornadoes: Parallel computing, data mining, and meteorology are being used to determine tornado formation and more reliable tornado forecasting. (Amy McGovern and Kevin Droegemeier, University of Oklahoma)

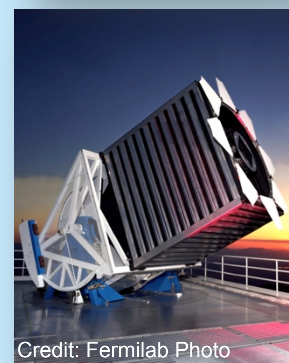
Image Credit: Bob Wilhelmson, NCSA and the University of Illinois at Urbana-Champaign; Lou Wicker, National Oceanic and Atmospheric Administration's National Severe Storms Laboratory; Matt Gilmore and Lee Cronce, University of Illinois atmospheric science department. Visualization by Donna Cox, Robert Patterson, Stuart Levy, Matt Hall and Alex Betts, NCSA



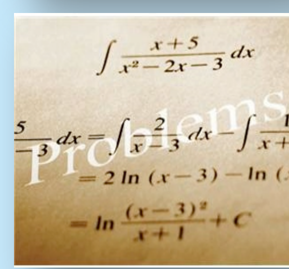
Complex Policy Setting

- Researchers want data.
- Public policy requires access to data.
- Public policy also requires protection of privacy, intellectual property, and sensitive information.
- Policy and implementation plan for data sharing and open access are needed.





Credit: Fermilab Photo



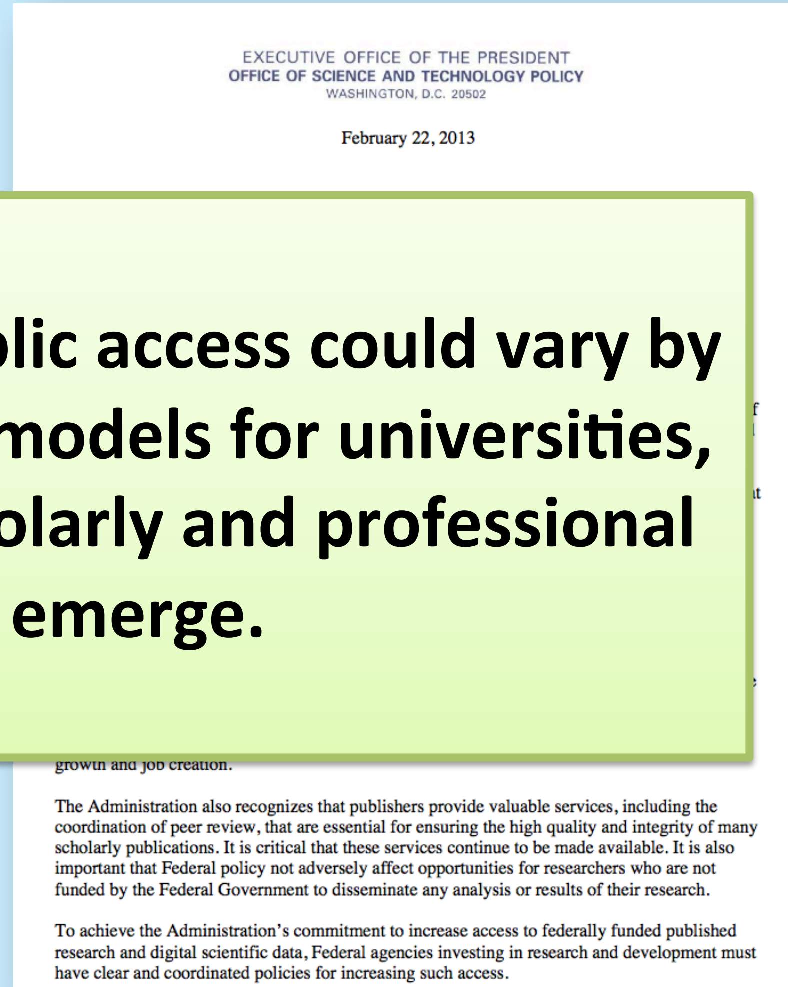
Public Access

- White House Memo on Feb. 22 directs United States federal agencies to develop a plan to support "increased public access" of results from federally

-

Implementation plans for public access could vary by discipline, and new business models for universities, libraries, publishers, and scholarly and professional societies could emerge.

- *Digitally formatted scientific data resulting from unclassified research … "should be stored and publicly accessible to search, retrieve, and analyze."*



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

February 22, 2013

growth and job creation.

The Administration also recognizes that publishers provide valuable services, including the coordination of peer review, that are essential for ensuring the high quality and integrity of many scholarly publications. It is critical that these services continue to be made available. It is also important that Federal policy not adversely affect opportunities for researchers who are not funded by the Federal Government to disseminate any analysis or results of their research.

To achieve the Administration's commitment to increase access to federally funded published research and digital scientific data, Federal agencies investing in research and development must have clear and coordinated policies for increasing such access.

Principles for Public Access

- *Value to the Society.* Investing in fundamental STEM research and education is an essential pathway to the future prosperity.

Implementation plans for public access could vary by discipline, and new business models for universities, libraries, publishers, and scholarly and professional societies could emerge.

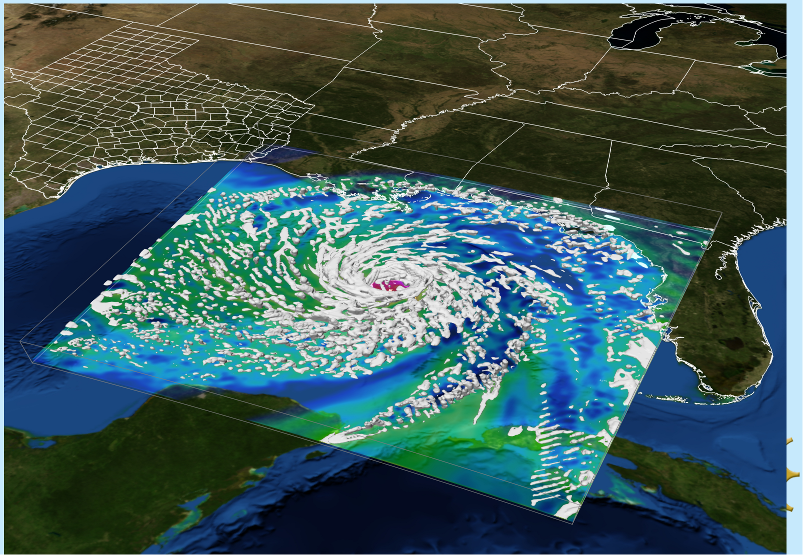
- *Community roles.* Future policy must acknowledge diverse communities of practice and varied roles and responsibilities, and the role of technology in information and knowledge sharing and dissemination.

A Complex Policy Setting

- Researchers want data.
- Public policy requires access to data and publications
- Public policy also requires protection of privacy and intellectual property and other sensitive information.
- Business model challenges for publishers and societies

More to come: Policy on data management and open access

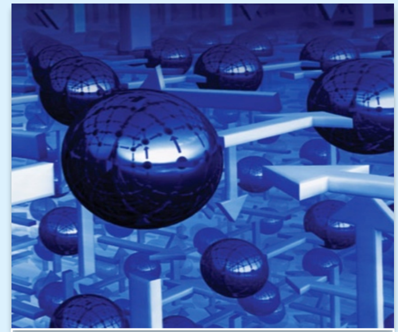
Opportunity for the CISE community to lead the nation



Emerging Frontiers

Data Explosion

Smart Systems: Sensing, Analysis and Decision



Expanding the Limits of Computation

Secure Cyberspace

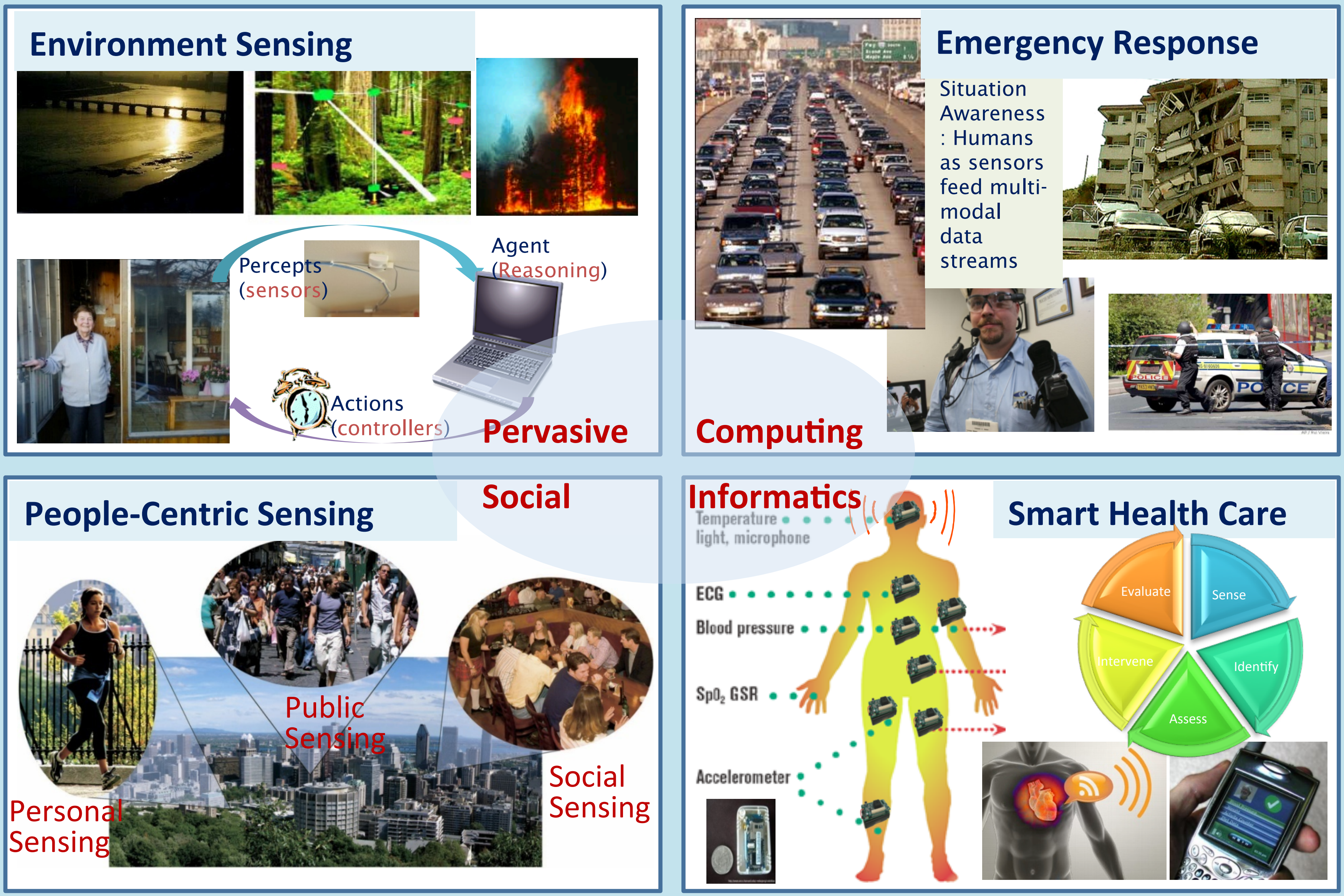
Universal Connectivity

Augmenting Human Capabilities

Ubiquitous deployment of sensors

The melding of the cyber and physical worlds enables smart systems all around us.

Smart Systems: Sensing, Reasoning, and Decision



Source: Sajal Das, Keith Marzullo

Credit: Image courtesy of University of Florida

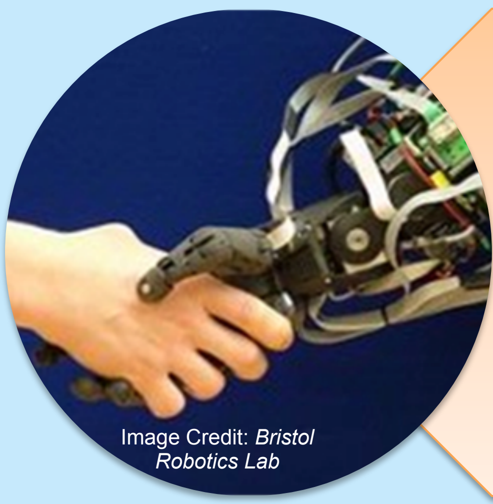
Research to Enable Smart Systems

Application sectors

200+ total awards since 2009:
- $140M+ total investment
- 350+ PIs and Co-PIs
- 35 states

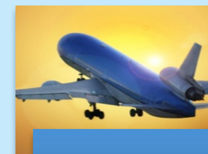
FY 12 commitment:
- 45 new awards (29 projects)
- $30M+ investment

Coming this Year:
- Frontiers in CPS



Over 700 proposals submitted & $1B in funding requested

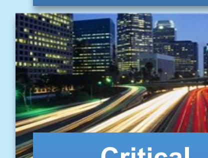
NSF FY 12 commitment:
- ~$30M (~$50M across agencies)
- 31 projects
- 108 PIs and Co-PIs
- 22 states



Transportation

Energy and Industrial Automation

Health and Medical Care



Critical Infrastructure

Research to Enable Smart Systems


Image Credit: *MicroStrain, Inc.*

Cyber-Physical Systems (CPS)

- ***Deeply integrate computation, communication, and control into physical systems***
- Aspects of CPS include pervasive computation, sensing and control; networking at multi- and extreme scales; dynamically reorganizing/reconfiguring systems; and high degrees of automation
- Dependable operation with high assurance of reliability, safety, security, and usability

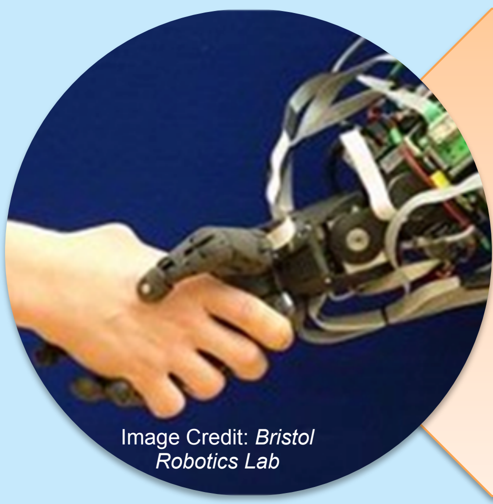
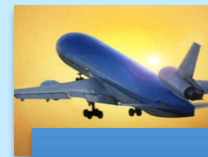


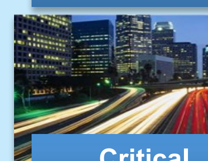
Image Credit: *Bristol Robotics Lab*

National Robotics Initiative (NRI)

- ***Develop the next generation of collaborative robots, or co-robots, that work beside and cooperatively with people***
- A nationally concerted cross-agency effort among NSF, NASA, USDA, and NIH
- Initiative includes aim to understand the long-term social, behavioral, and economic implications
- Potential to enhance personal safety, health, and productivity

Application sectors





NSF

The National Robotics Initiative (NRI)

A **nationally coordinated** program across multiple government agencies to develop the **next generation of robotics**, to advance the **capability and usability** of such systems and artifacts, and to encourage existing and new communities to focus on **innovative application areas**.

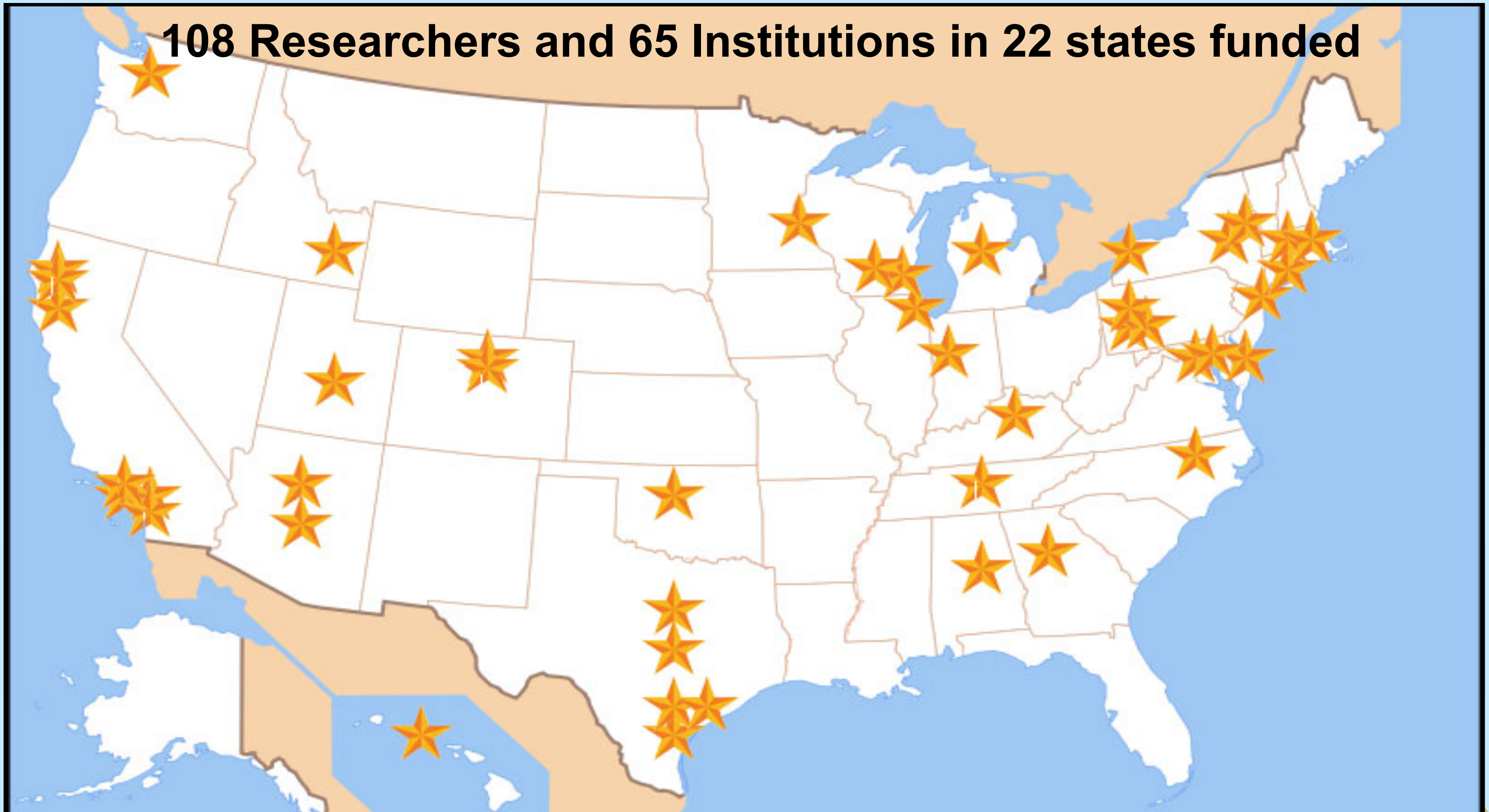
NSF

NASA

NATIONAL INSTITUTES OF HEALTH

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

"If you build it, they will come"



Broad Applications for Smart Systems

Assistive Medical Technologies: Programmable second skin senses and re-educates injured nervous systems. (Eugene Goldfield, Harvard Medical School)

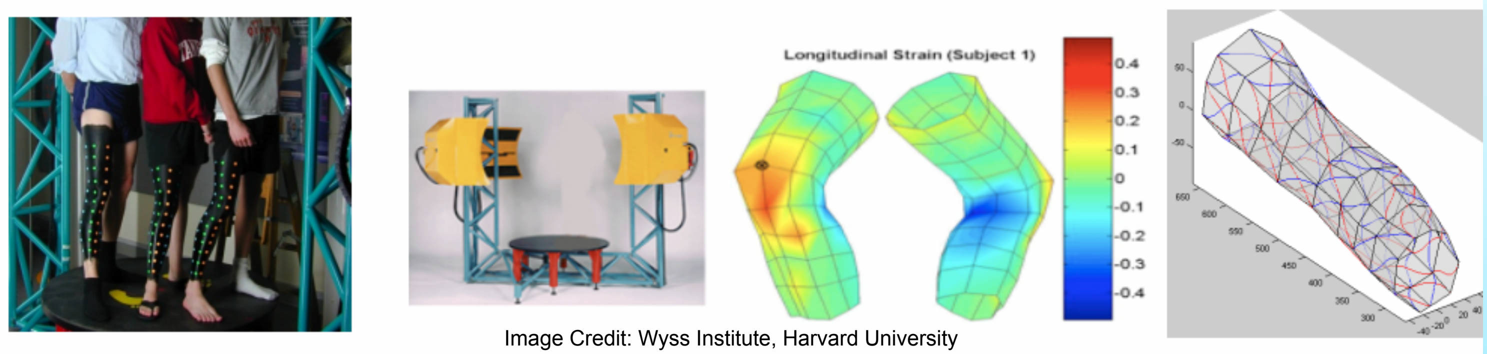


Image Credit: Wyss Institute, Harvard University

Towel-folding Robots: Development of novel computer vision and algorithms enable robots to manipulate flexible objects that change shape. (Pieter Abbeel, UC Berkeley)

Credit: Provided by NSF

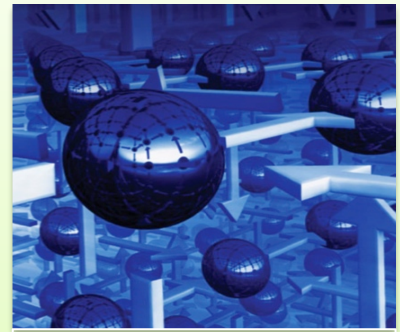
Autonomous Vehicles: Development of precision and real-time sensors, smart algorithms, and verification tools enabling self-driving cars. (Ragunathan “Raj” Rajkumar, CMU, et al.)

http://www.nsf.gov/news/special_reports/science_nation/carswithoutdrivers.jsp http://www.nbclearn.com/portal/site/learn/science-of-the-summer-olympics

Emerging Frontiers

Data Explosion

Smart Systems: Sensing, Analysis and Decision



Expanding the Limits of Computation

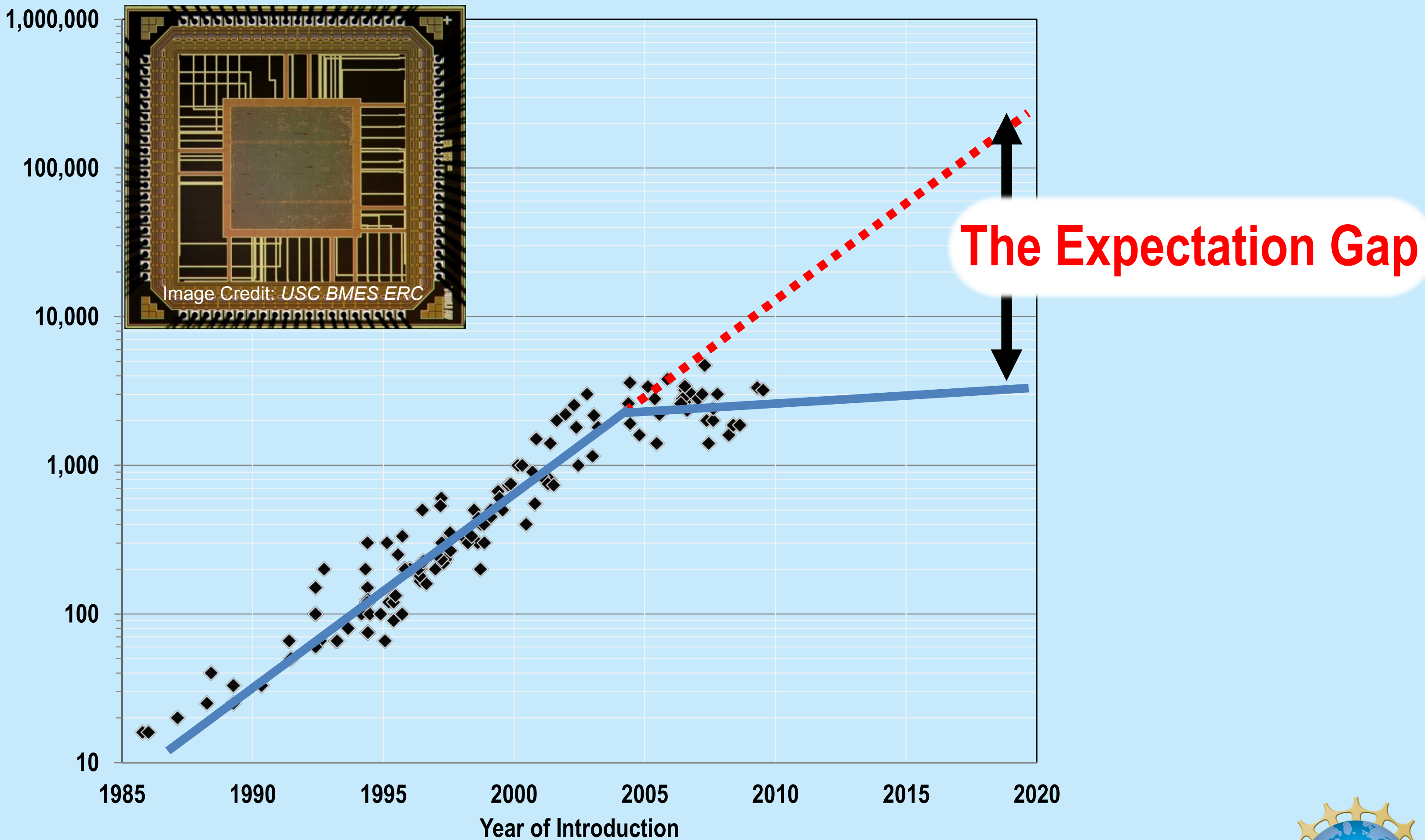
Secure Cyberspace

Universal Connectivity

Augmenting Human Capabilities

Processor Performance Plateaued Around 2004

Microprocessor Performance "Expectation Gap" over Time (1985-2020 projected)



Credit: Graph reprinted with permission from *The Future of Computing Performance: Game Over or Next Level?* National Academy of Sciences (2011).

Impact of Single-Processor Performance

Accentuated by emergence of **massive data sets**, scientists have an increasing appetite and need for speed and performance.

Important new science questions in **physics, materials, biology, health and medicine, and climate change** require increased processing power.

Support of national defense and intelligence community will need increasingly more processing power.

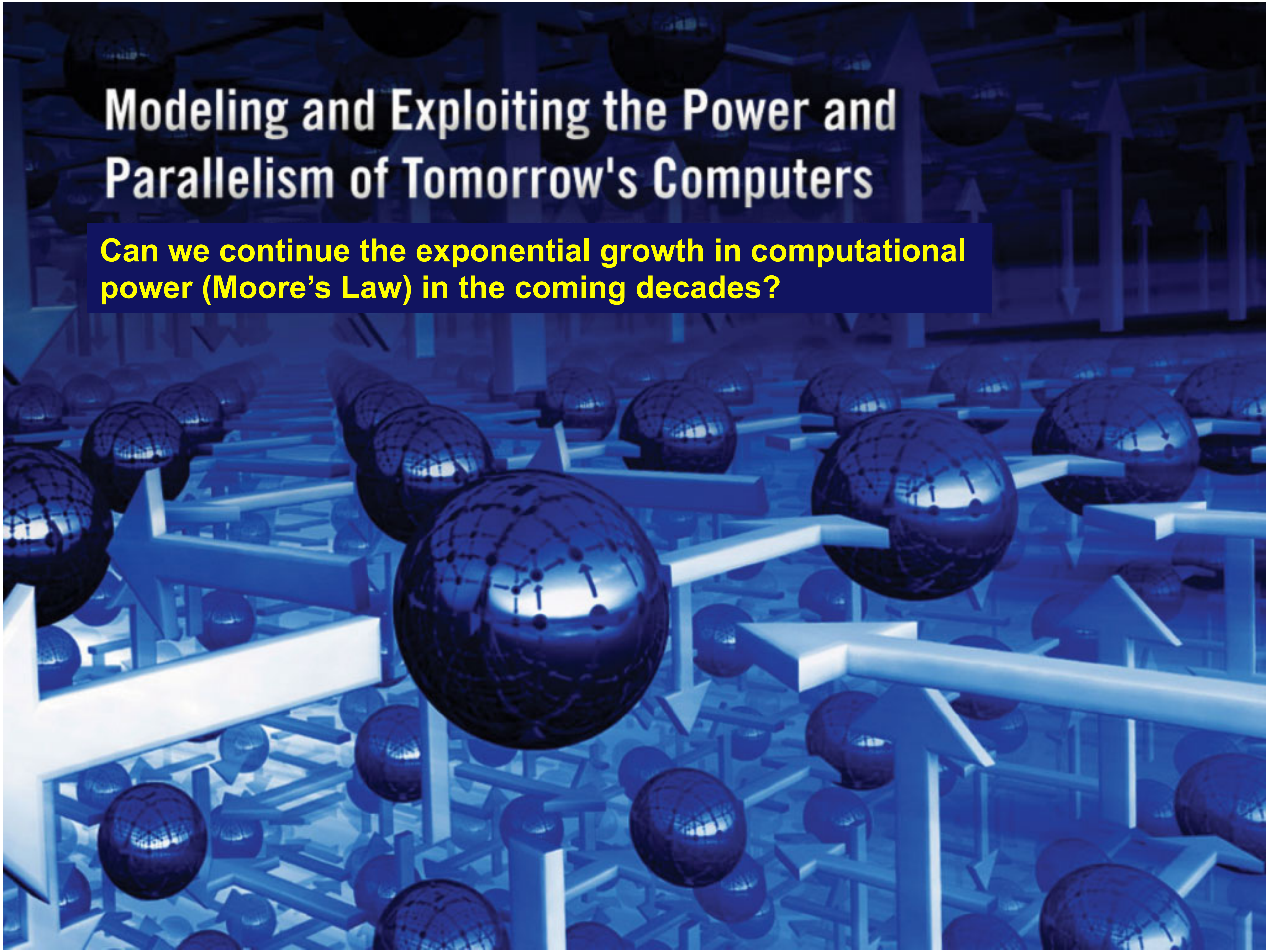
Applications include training simulations, autonomous robotic vehicles, airport security, surveillance, video analytics, infrastructure defense against cyber attacks, and data analysis for intelligence.

Both **consumer and enterprise needs** are increasing.

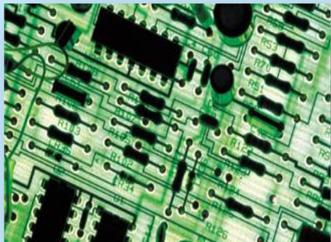
Applications include search and data mining, real-time decision-making, web services, digital content creation, speech recognition, and simulation and modeling for product design.

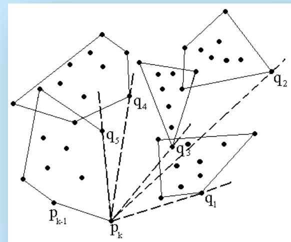
Modeling and Exploiting the Power and Parallelism of Tomorrow's Computers

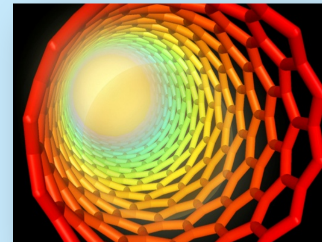
Can we continue the exponential growth in computational power (Moore’s Law) in the coming decades?



Research to Expand the Limits of Computation







Happening now

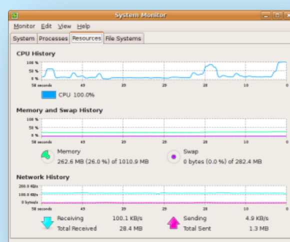
- Architectural innovations with multi-core and many-core
- Domain-specific integrated circuits
- Energy-efficient computing and new processor architectures

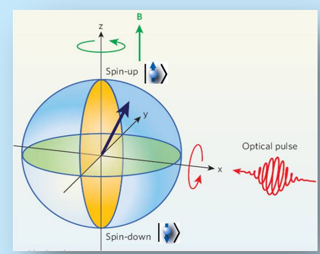
Mid-term solutions

- Need to fully exploit broadly available concurrency and parallelism
- Algorithmic innovations exploiting parallelism
- Software systems leading to improved performance

Long-term solutions

- New materials (e.g., carbon nano-tubes, graphene based devices)
- Non-charge transfer devices; (e.g., electron spin)
- Bio, nano, and quantum devices

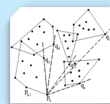




Exploiting Parallelism and Scalability (XPS)

Support groundbreaking research that will lead to a new era of parallel computing.

- Goal is to establish *new* collaborations combining expertise cutting across abstraction, software, hardware layers.
- Each proposal must have two, or more, PIs providing different and distinct expertise.



Foundational Principles

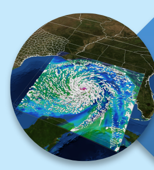
- New models guiding parallel algorithm design on diverse platforms
- Optimization for resources (energy, bandwidth, memory hierarchy)

Cross-layer Approaches

- Re-thinking/re-designing the hardware and software stack
- Coordination across all layers

Scalable Distributed Architectures

- Highly scalable and parallel architectures for people and things connected everywhere
- Runtime platforms and virtualization tools



Domain-specific Design

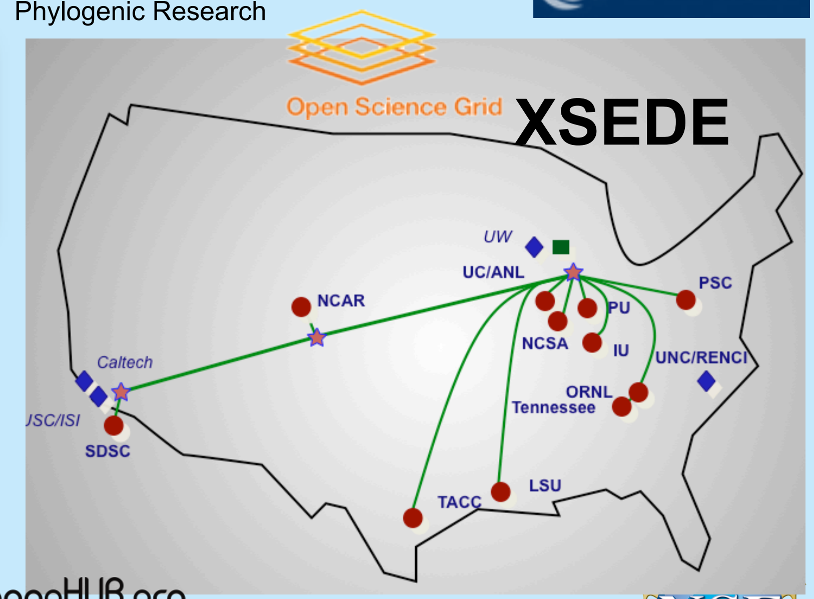
- Exploiting domain knowledge to improve programmability and performance

Advanced Computational Infrastructure

- Anticipate and invest in diverse and innovative national scale shared resources, outreach and education complementing campus and other national investments
- Leverage and invest in collaborative flexible “fabrics” dynamically connecting scientific communities with computational resources and services at all scales (campus, regional, national, international)

CIPRES –
Cyberinfrastructure for
Phylogenic Research

iPlant Collaborative

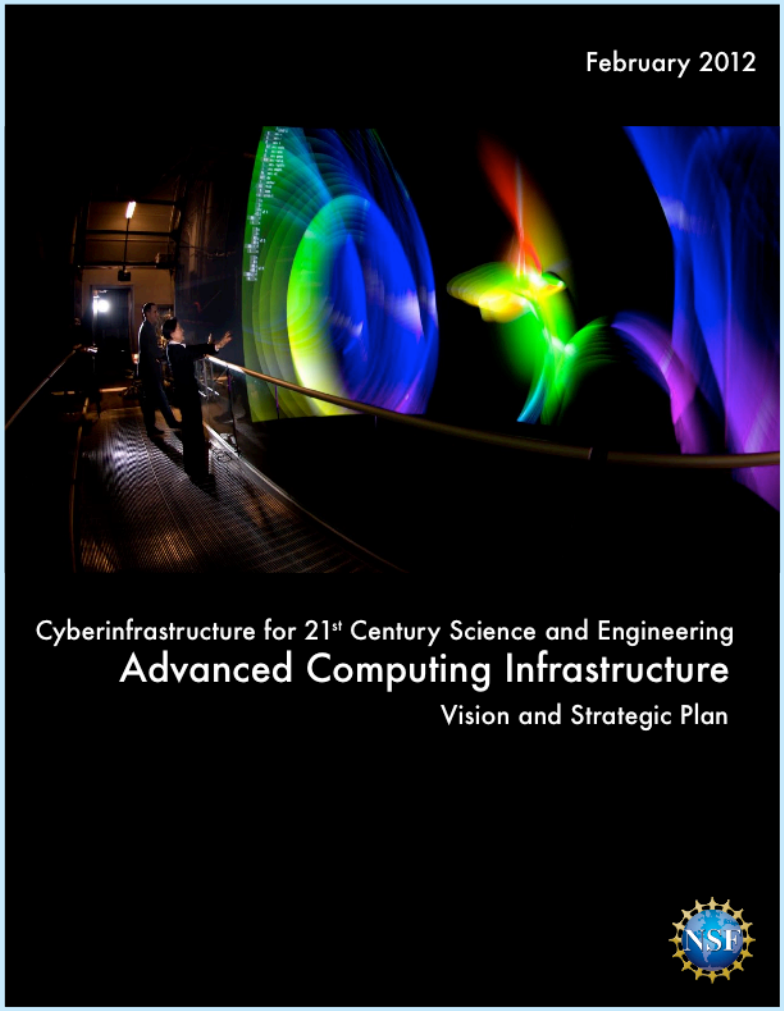


nanoHUB.org

NSF

Building Rome in a Day

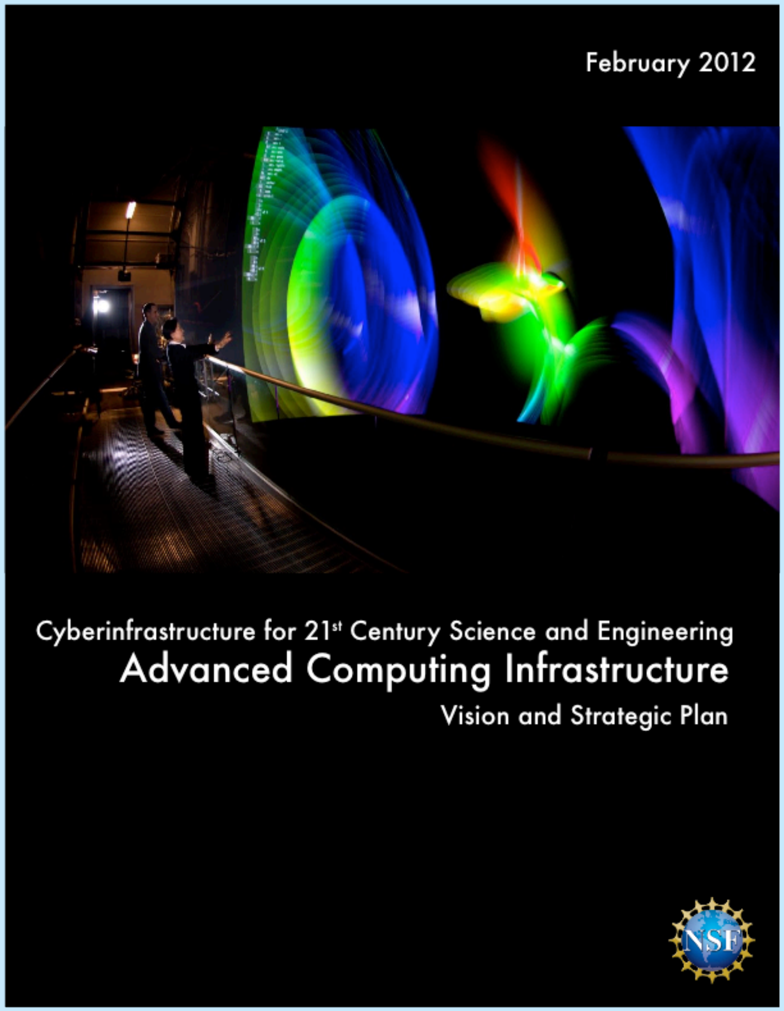
Advanced Computing Infrastructure



www.nsf.gov/pubs/2012/nsf12051/nsf12051.pdf

- ACI prioritizes NSF investments in data analytics and management and in fundamental research in computer science and engineering above funding for the development and procurement of large-scale high performance computing systems.
- Including :
  1. Foundational research to fully exploit parallelism and concurrency
  2. Research and development in the use of high-end computing resources in partnerships with scientific domains
  3. Building, testing, and deploying sustainable and innovative resources into a collaborative ecosystem
  4. Development of comprehensive education and workforce programs
  5. Development and evaluation of transformational and grand challenge community programs that support contemporary complex problem solving

Advanced Computing Infrastructure



www.nsf.gov/pubs/2012/nsf12051/nsf12051.pdf

- **NSF strategic plan for "Advanced Computing Infrastructure" announced in February 2012.**

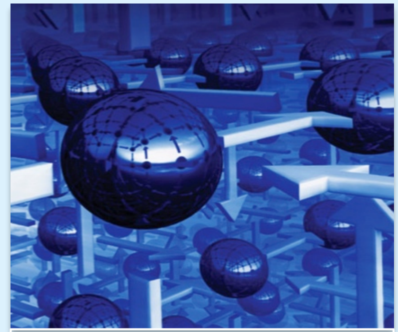
- **"Agencies should give priority to investment in data analytics and management and in fundamental research in computer science and engineering above funding for the development and procurement of large-scale high performance computing systems."**

-OMB and OSTP Memo on the Federal Research and Development (R&D) Priorities, June 6, 2012.

Emerging Frontiers

Data Explosion

Smart Systems: Sensing, Analysis and Decision



Expanding the Limits of Computation

Secure Cyberspace

Universal Connectivity

Augmenting Human Capabilities

Cyber Security Challenge

- **Attacks and defenses co-evolve**: a system that was secure yesterday might no longer be secure tomorrow.
- The technology base of our systems is frequently updated to improve functionality, availability, and/or performance. **New systems introduce new vulnerabilities** that need new defenses.
- The **environments** in which our computing systems are deployed and the functionality they provide are **dynamic**, e.g. cloud computing, mobile platforms.
- As **automation pervades new platforms**, vulnerabilities will be found in critical infrastructure, automotive systems, medical devices.
- The **sophistication** of attackers is increasing as well as their sheer **number** and the **specificity** of their targets.
- Cyber security is a **multi-dimensional** problem requiring expertise from CS, mathematics, economics, behavioral and social sciences.

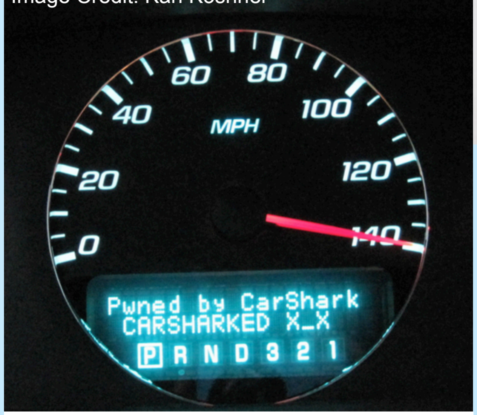
Image Credit: *ThinkStock*

Cyber-physical Security

Image Credit: Matt Blaze

Law Enforcement Communications

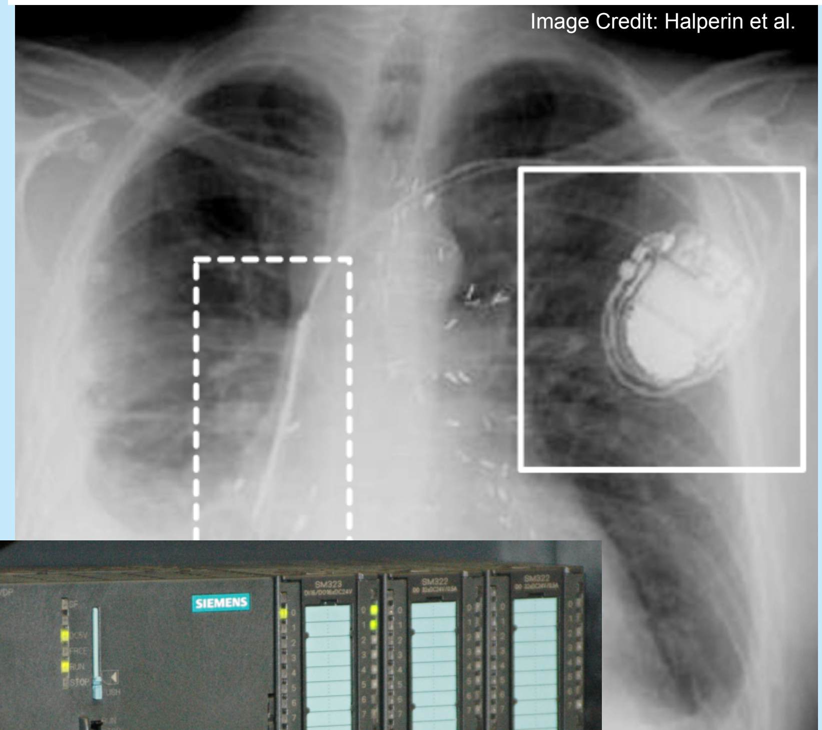
Image Credit: Karl Koshner



Automobiles

Embedded Medical Devices

Image Credit: Halperin et al.



Control Systems

THE BEST OF BOTH WORLDS:

Achieving Privacy & Utility

Reaping the benefits of a data-rich world
without sacrificing our privacy

Secure and Trustworthy Cyberspace (SaTC)

Securing our Nation's cyberspace

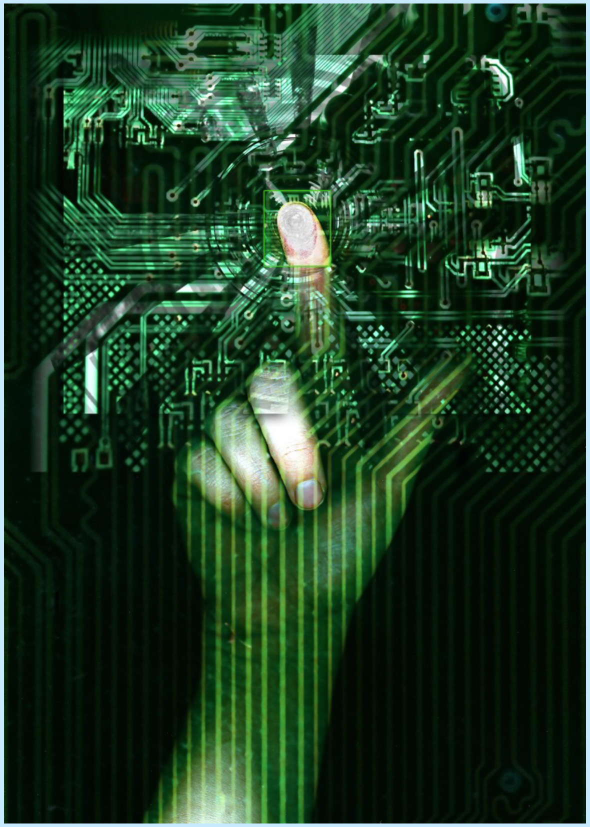


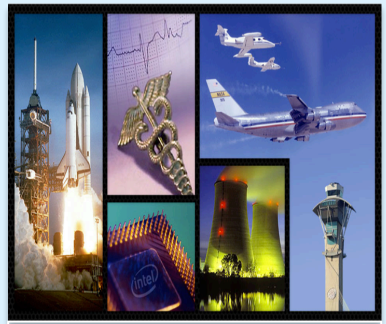
Image Credit: *ThinkStock*

- Aims to support fundamental scientific advances and technologies to protect cyber-systems from malicious behavior, while preserving privacy and promoting usability.
- Program addresses three perspectives:
  - Trustworthy Computing Systems
  - Social, Behavioral and Economic Sciences
  - Transition to Practice
- *Frontiers* support center-scale activities

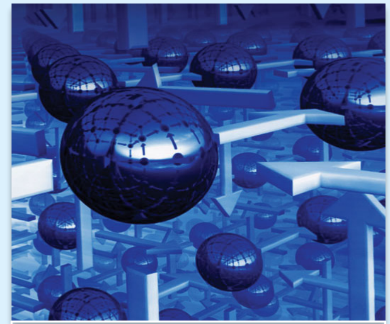
Cross-Directorate Effort: CISE, ENG, EHR, MPS, OCI, and SBE

Emerging Frontiers

Data Explosion



Smart Systems: Sensing, Analysis and Decision



Expanding the Limits of Computation

Secure Cyberspace

Universal Connectivity

Augmenting Human Capabilities

Explosive Growth in Volume & Traffic Diversity

VoIP

663M registered Skype users in September 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; 35 hours of new videos are uploaded every minute in 2011; 2 billion views per day.

Twitter

Expected to reach 500M registered users in 2012.

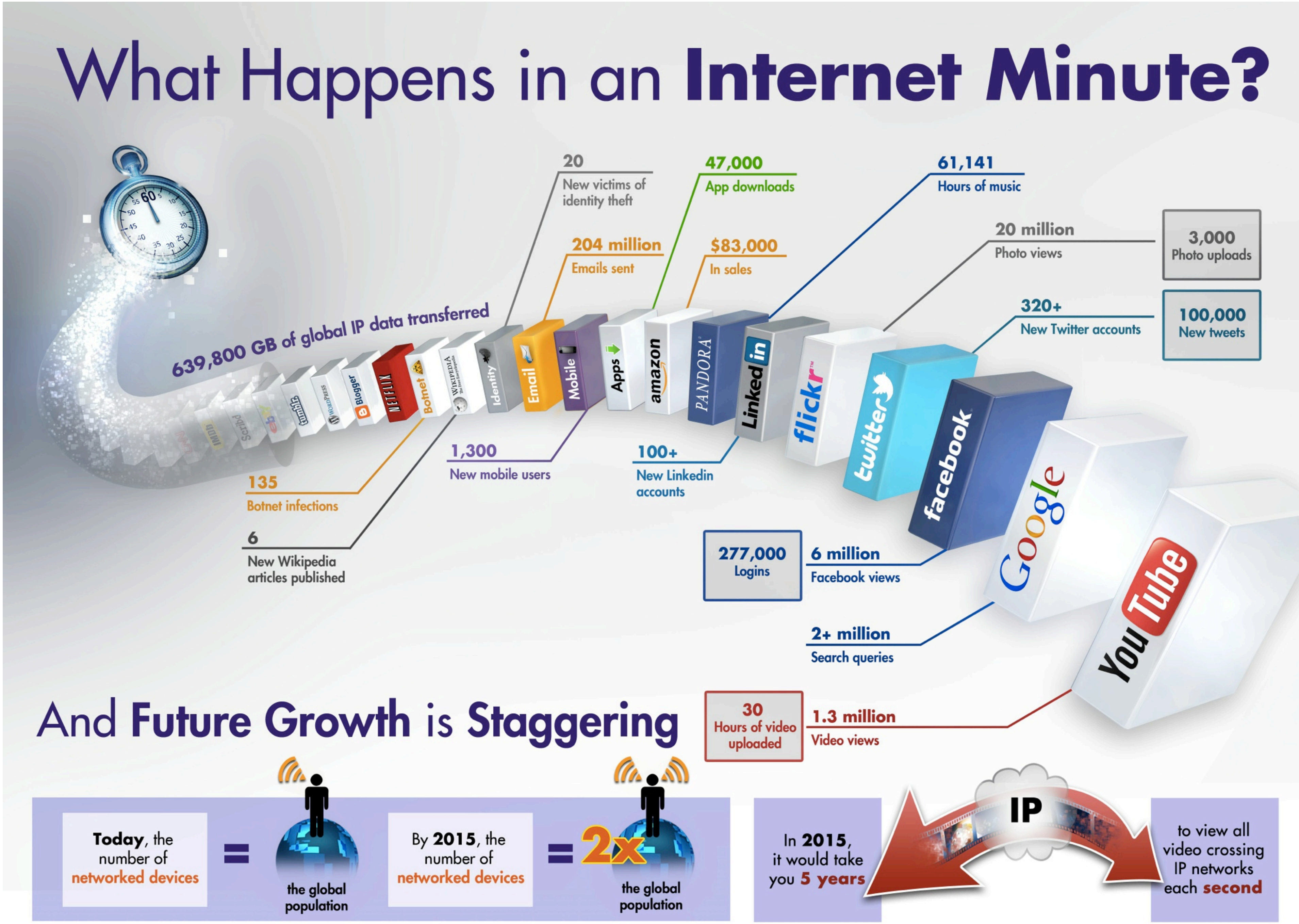
Broadband

20% of global internet users have residential broadband; 68% in U.S. subscribe to broadband.

1988

Remarkable Pace of Innovation

Today



Credit: Intel Corporation

Cellular Networks, Mobile Devices and Pervasive Computing

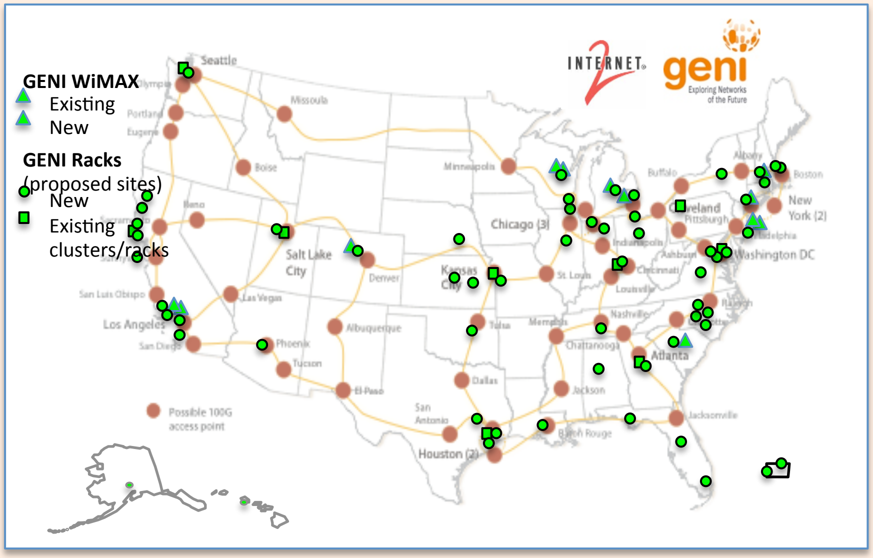
- 5.3 billion mobile phone subscribers; 85% of new handsets will be able to access the mobile web; 1 in 5 has access to fast service, 3G or better; IM, MMS, SMS expected to exceed 10 trillion message by 2013.
  - Only digital system accessible to the majority of the planet.
- Growing ecosystem of tools and applications:
  - Banking, commerce, healthcare, social networking:
    600K distinct active apps just in App Store.
  - Mobile browsers can now display much of the content available to their desktop counterparts.
- Mobile payment systems are now common in the developing world.
- Sensitive and private data stored & entered on devices.

Image Credit: Nicolle Rager Fuller, NSF

Research Themes:

Infrastructure scalability	Spectrum management	Security and privacy	Energy consumption	Leveraging and advancing new networking technologies

Mid-scale Research Infrastructure



Advancing networking, distributed systems, cloud computing and cybersecurity research through experimentation at scale

Global Environment for Networking Innovations (GENI)

- A virtual laboratory for exploring future internets at-scale, now taking shape in prototype form across the U.S.
- Key GENI concepts:
  - Slices & deep programmability
  - Federation and enabling "at scale" experiments

US Ignite

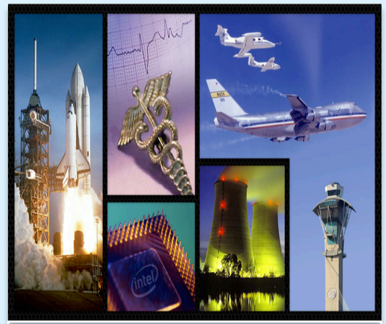
- Launched June 14, 2012 at the WH
- NSF leadership
  - Leveraging GENI investments
  - Stitching together testbeds and network resources across the country
  - Jumpstarting gigabit public sector application development
- Public Private Partnership
  - Bringing industry and foundations into he mix

NSF Cloud

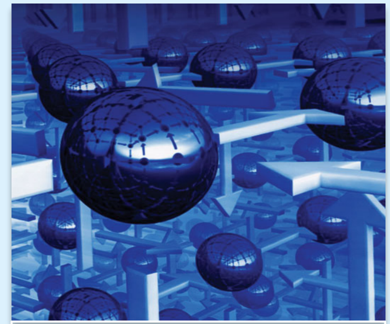
- Virtualization beyond the network to resources located in the "cloud"
- Develop competing prototypes
- Allow for experimentation not possible elsewhere

Emerging Frontiers

Data Explosion



Smart Systems: Sensing, Analysis and Decision



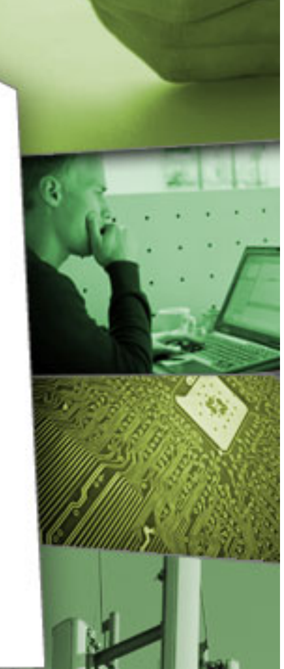
Expanding the Limits of Computation

Secure Cyberspace

Universal Connectivity

Augmenting Human Capabilities

Networked Society



Computing technologies and human societies co-evolve, transforming each other in the process

Networked Society

Computing technologies and human societies co-evolve, transforming each other in the process

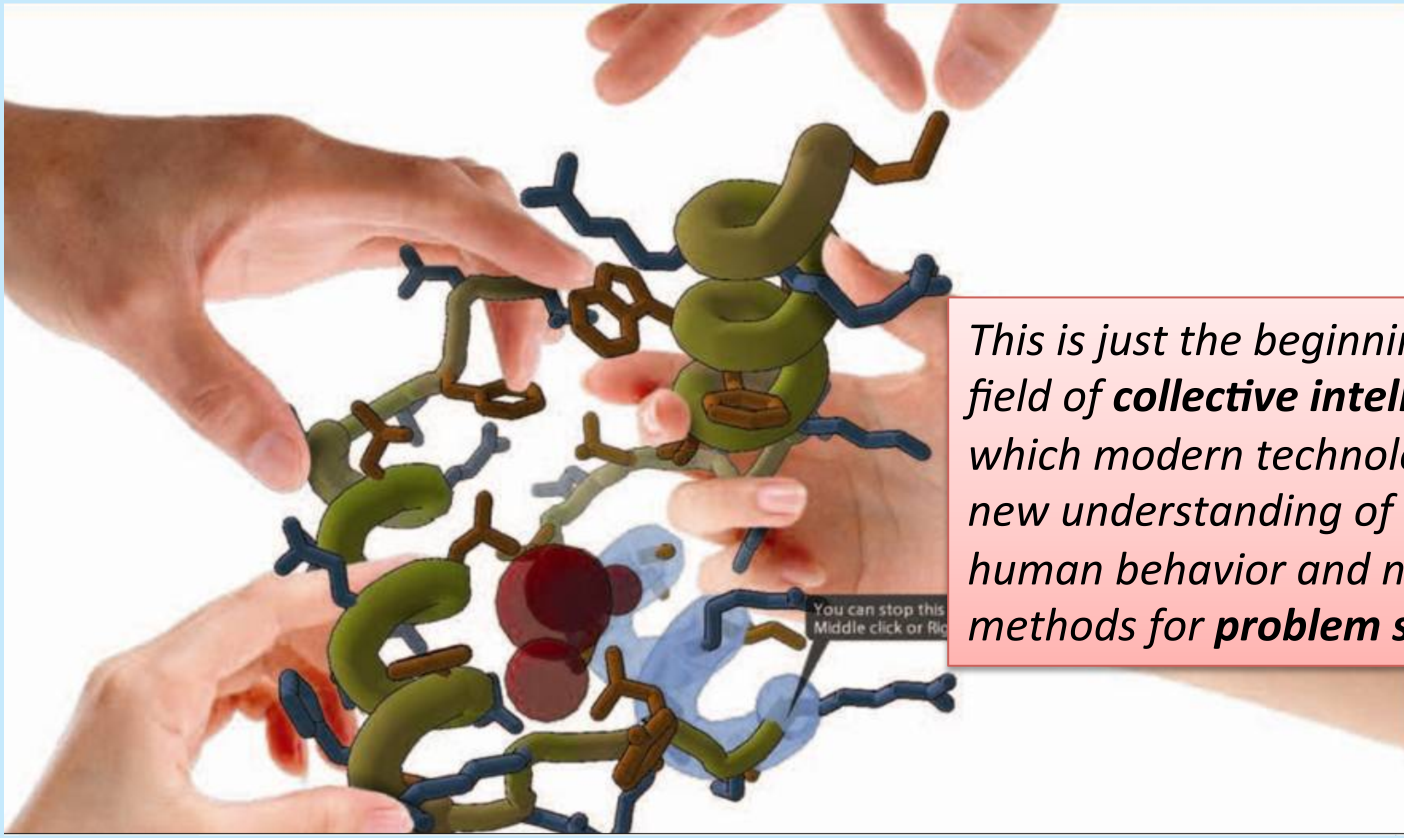
- We are increasingly becoming a networked society.
- Access to technology and information is enhancing our cognitive and physical capabilities.
- This trend will be accelerated by advances in:
  - social informatics
  - assistive technologies
  - augmented reality
  - robotics
  - crowd sourcing
  - learning technologies

  understanding
  - vision and perception
  - artificial intelligence
  - machine learning
  - information retrieval

- natural language

Social Networks Solving Complex Problems

Networks of human minds are taking citizen science to a new level



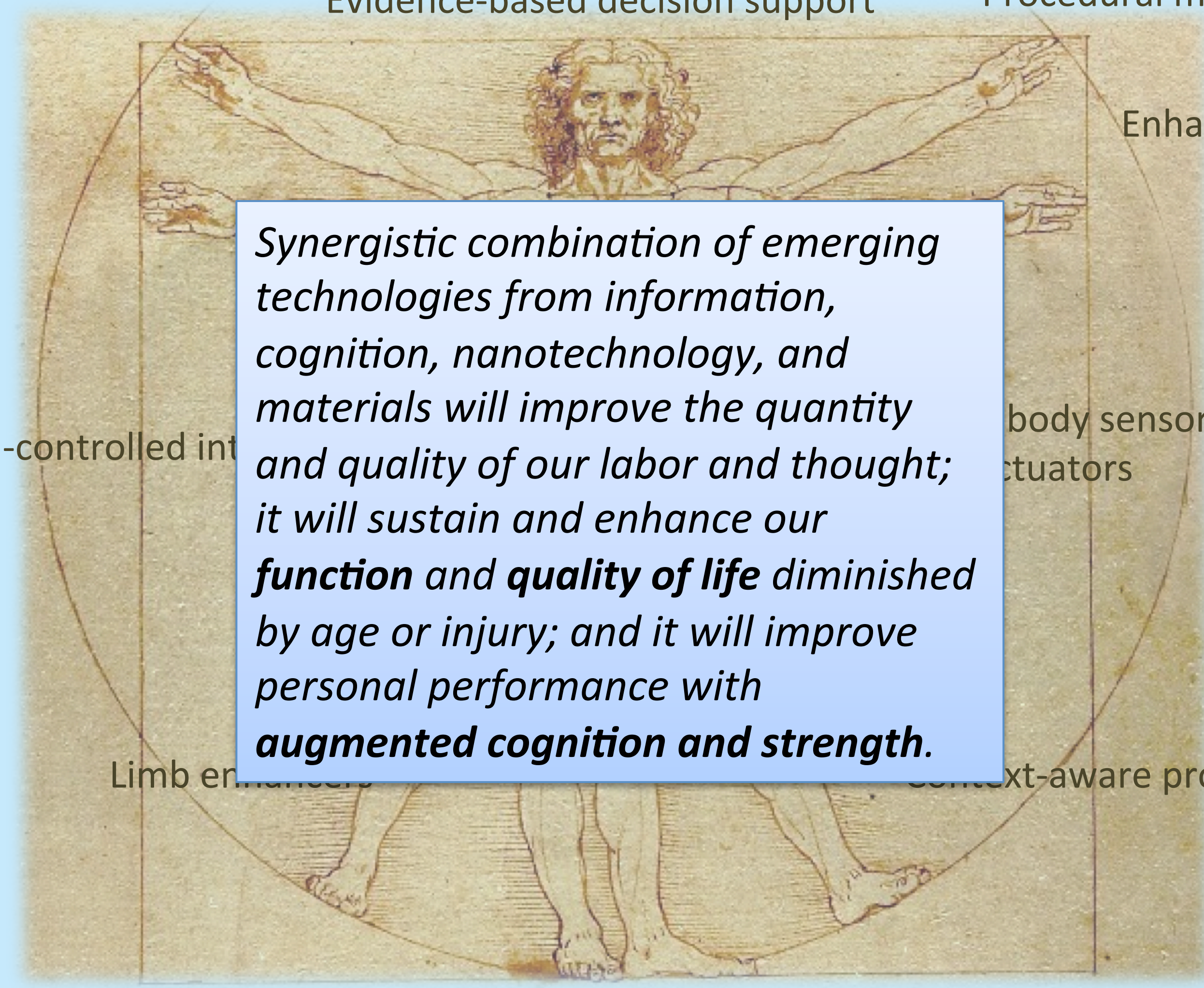
*This is just the beginning of a new field of **collective intelligence** in which modern technology yields new understanding of collective human behavior and new methods for **problem solving**.*

Foldit image: Univ. Washington Center For Game Science; artwork by W. Fernandes, Nature, Aug 2010

In 2011, players of Foldit helped to decipher the crystal structure of the Mason-Pfizer monkey virus (M-PMV) retroviral protease, an AIDS-causing monkey virus. Players produced an **accurate 3D model** of the enzyme **in just ten days**. The problem of how to configure the structure of the enzyme had **stumped scientists for 15 years**.

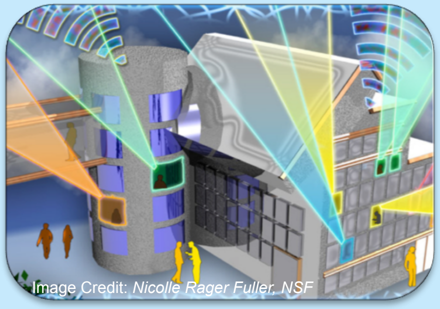
Augmenting Human Capabilities

Converging technologies for enhancing performance and quality of life



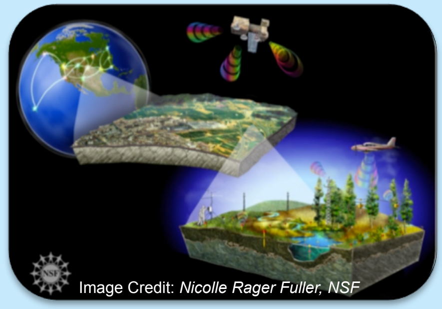
*Synergistic combination of emerging technologies from information, cognition, nanotechnology, and materials will improve the quantity and quality of our labor and thought; it will sustain and enhance our **function** and **quality of life** diminished by age or injury; and it will improve personal performance with **augmented cognition and strength**.*

CISE and National Priorities



Broadband & Universal Connectivity

Emergency Response & Disaster Resiliency



Environment & Sustainability

Health & Wellbeing

Manufacturing, Robotics, & Smart Systems

Secure Cyberspace

Transportation & Energy

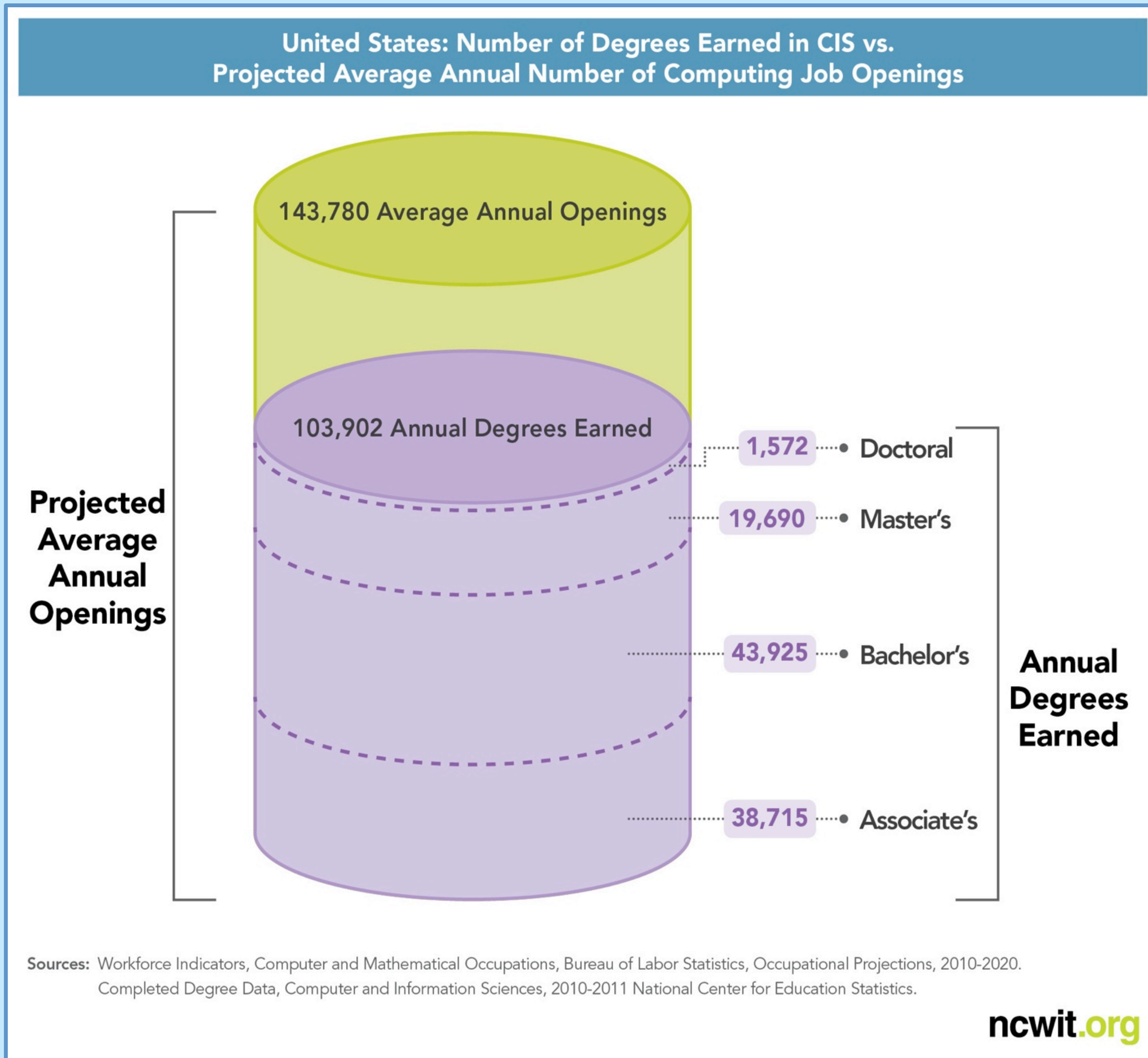
Education and Workforce Development

The computing community faces three significant and interrelated challenges in workforce development

Underproduction of degrees

Under-representation

Lack of a presence in K-12



CS10K

Transforming high school computing

Get engaging, rigorous curricula into computing courses in 10,000 high schools, taught by 10,000 well-prepared teachers by 2016*.*

- New preAP course, *Exploring Computer Science (ECS)*
- New (proposed) AP Course, *CS Principles*
- Develops scalable models, curricula and materials for professional development for teachers
- Fosters the growth of national community and partnerships needed to scale to 10,000 teachers & schools

Cyberlearning

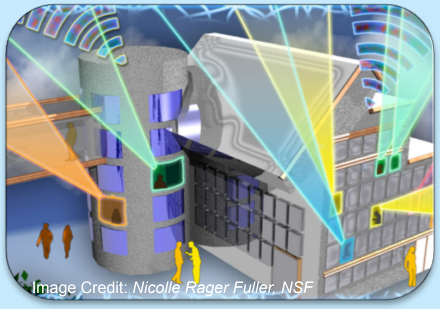
Improving learning by integrating emerging technologies with knowledge from research about how people learn

Computer science is both the **enabling discipline** for the development of technologies that enhance learning and a discipline with an **immediate and critical need** for cyberlearning technologies as it aims to scale K-16 educational transformations at the national scale

Goals:

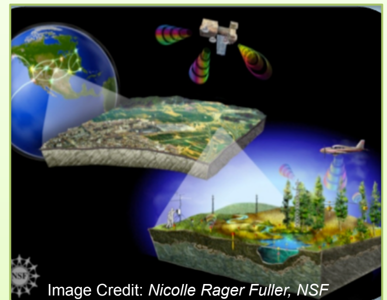
- Understand how people learn in technology rich environments
- Design and study ways in which innovative technologies and tools can promote learning and support assessment
- Prototype new technologies and integrate them into learning environments

CISE and National Priorities



Broadband & Universal Connectivity

Emergency Response & Disaster Resiliency



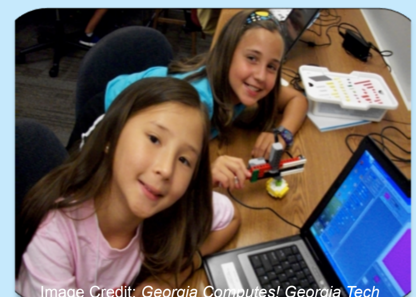
Environment & Sustainability

Health & Wellbeing

Manufacturing, Robotics, & Smart Systems

Secure Cyberspace

Transportation & Energy



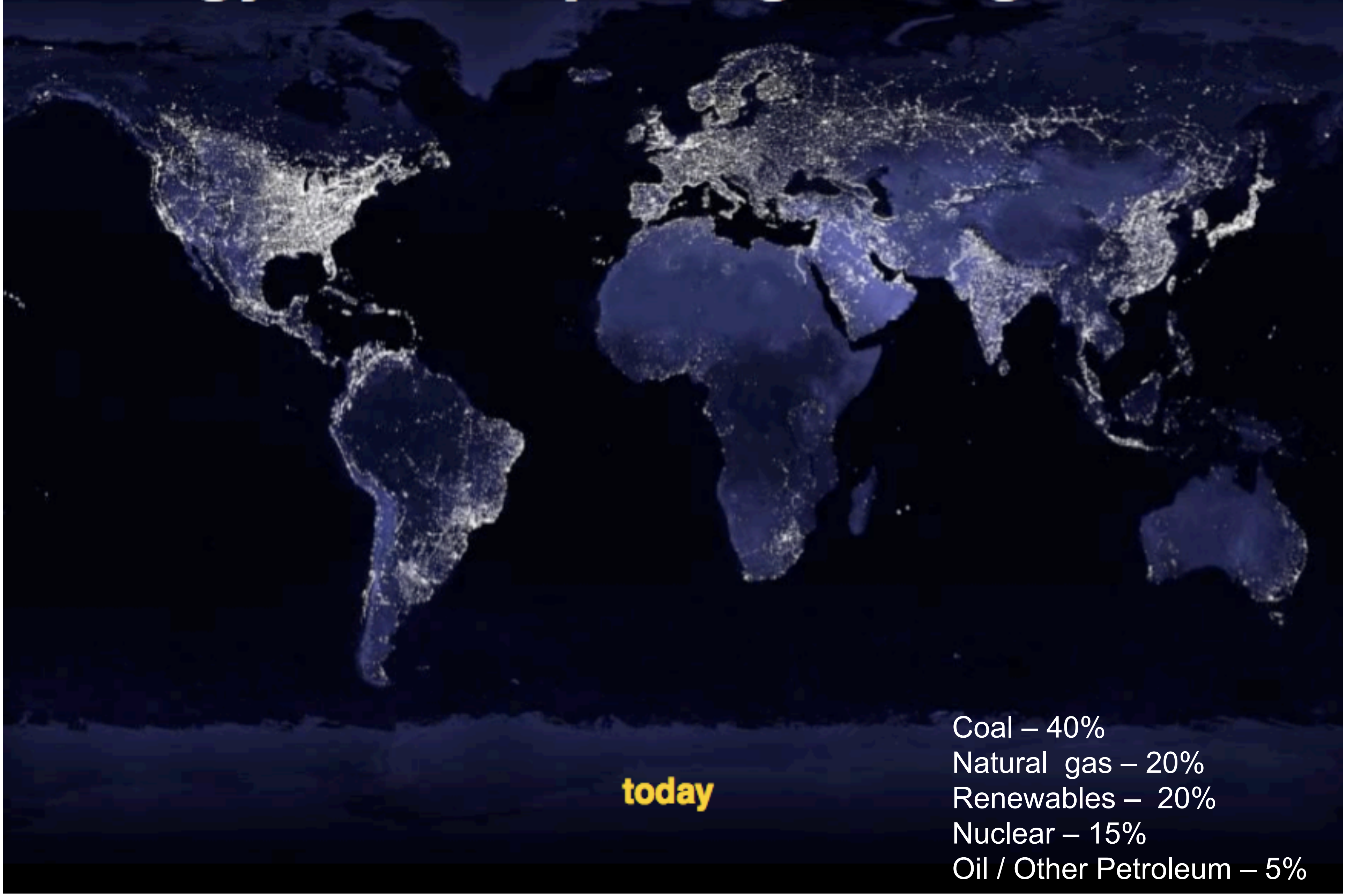
Education and Workforce Development

Towards a Sustainable Human Future

Of all the challenges we face as a nation and as a planet, none is as pressing as the three-pronged challenge of ***climate change, sustainable development*** *and the need to foster* ***new and cleaner sources of energy.***

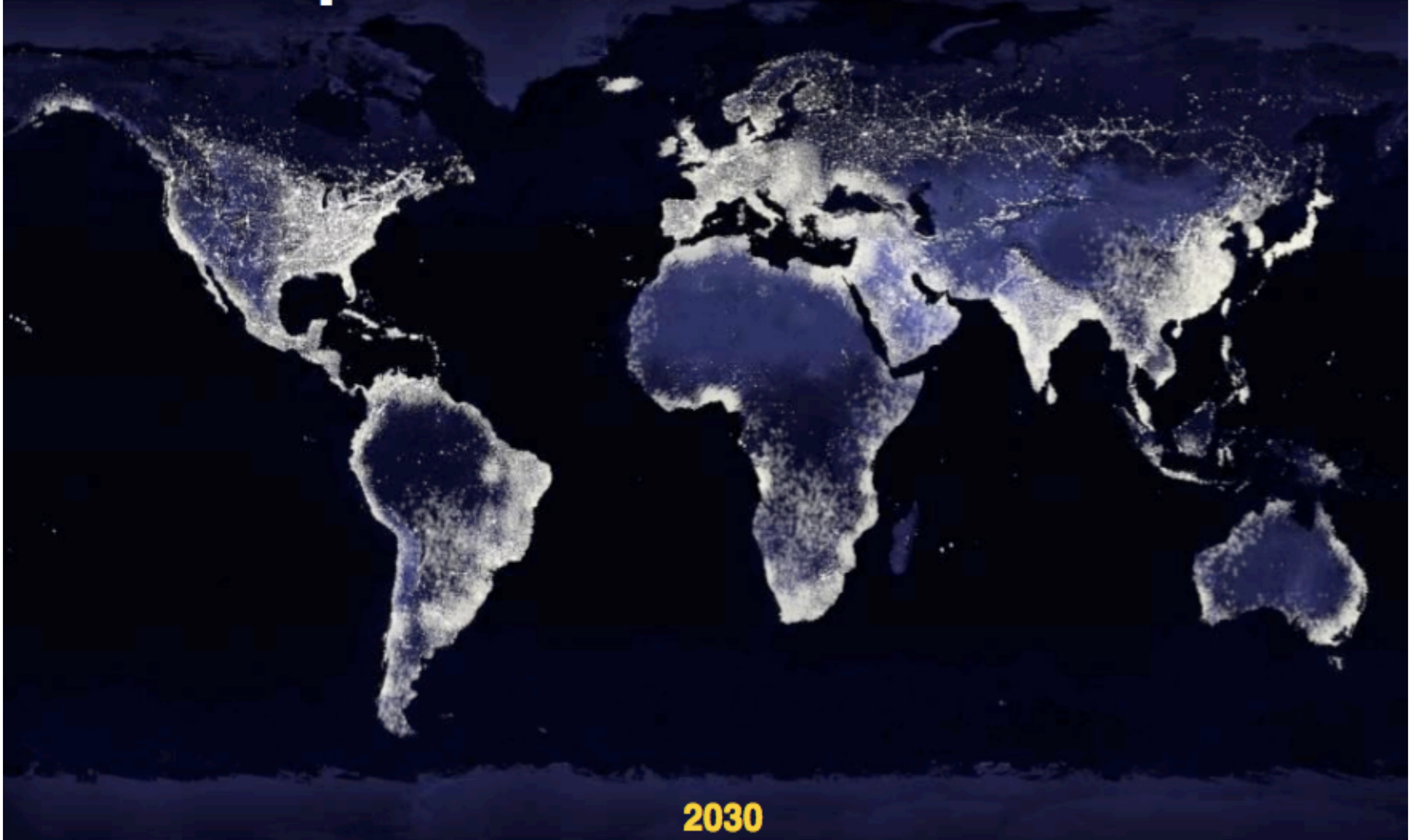
(Office of Science and Technology Policy, Executive Office of the President)

Energy consumption growing



Coal – 40%
Natural gas – 20%
Renewables – 20%
Nuclear – 15%
Oil / Other Petroleum – 5%

… to unprecedented demands



Looking ahead to 2030 … you can see sustained growth in global demand for electricity is inevitable. Demand is forecasted to more than double by 2030 (Energy Information Administration).

Cyber-Enabled Sustainability Science and Engineering (CyberSEES)

New program announced October 2012

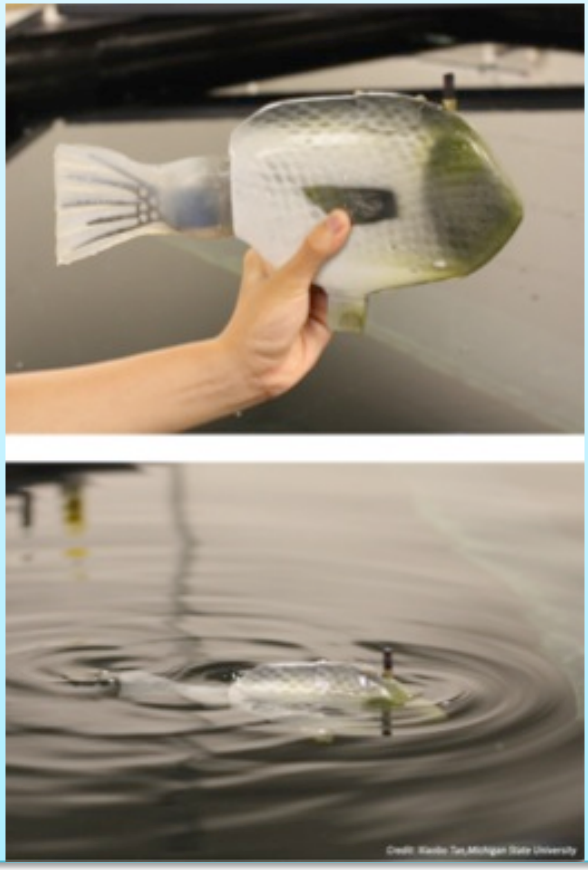
Co-funding with **Semiconductor Research Corporation (SRC) Energy Research Initiative** in areas of smart infrastructure

CISE-led program aims to advance interdisciplinary research in which

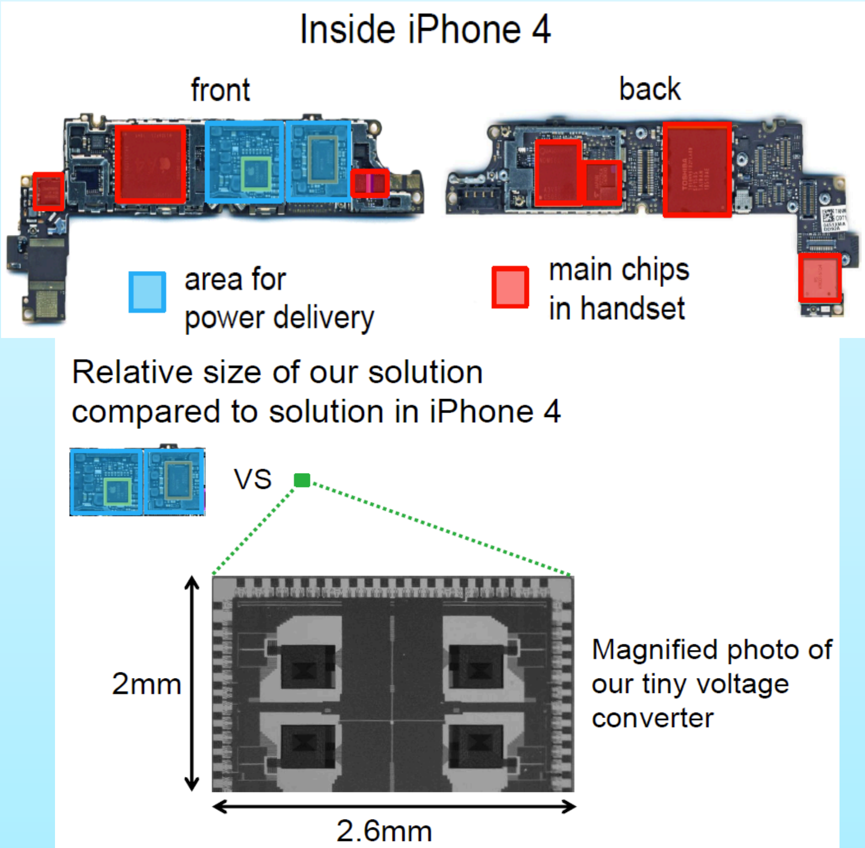
- **the science and engineering of sustainability are enabled by new advances in computing, and**
- **where computational innovation is grounded in the context of sustainability problems**

Cyber-enabled Sustainability & “Green” Computing

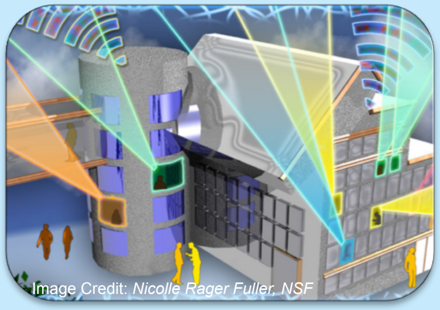
Monitoring Aquatic Environments: Sensors in autonomous robotic fish monitor real-time movement and quality of water in lakes at the Kellogg Biological Station. (Xiabo Tan, Michigan State University)



New Approach to Power Distribution in Mobile Devices: Reduces battery usage by up to 20% and may revolutionize handset design. (David Brooks, Harvard)

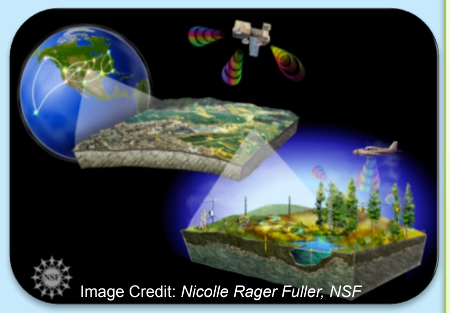


CISE and National Priorities



Broadband & Universal Connectivity

Emergency Response & Disaster Resiliency



Environment & Sustainability

Health & Wellbeing

Manufacturing, Robotics, & Smart Systems

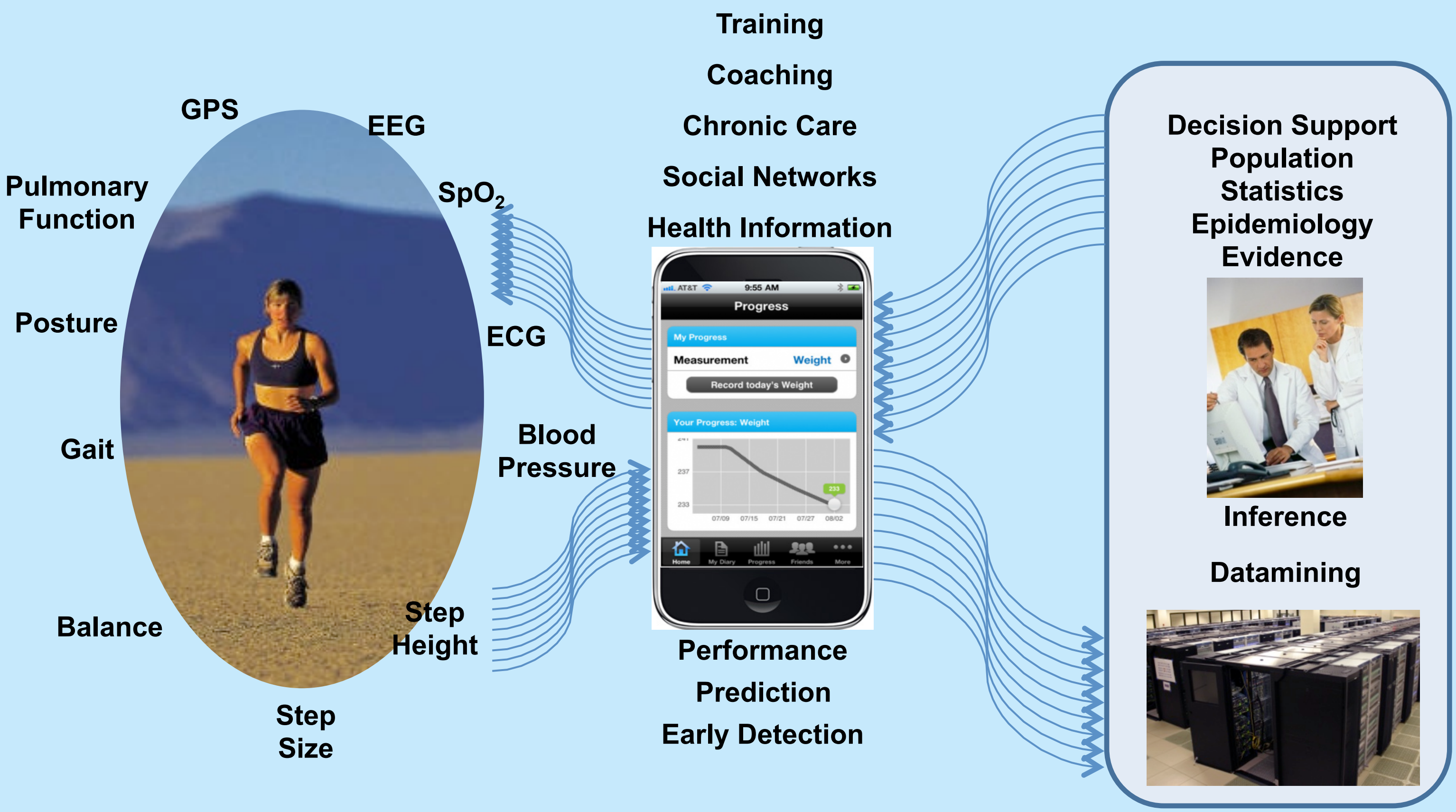
Secure Cyberspace

Transportation & Energy

Education and Workforce Development

Smart and Connected Health

Transforming healthcare from reactive and hospital-centered to preventive, proactive, evidence-based, person-centered and focused on wellbeing rather than disease



Cross-Directorate Program: CISE, ENG, and SBE, also NIH

Expeditions-in-Computing

Exploring scientific frontiers that promise transformative innovations in computing

Credit: Jason Dorfman, CSAIL/MIT

- $10M total per project
  - $2M/year per award for 5 years
- 14 awards to date

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***
- ***Socially Assistive Robots, Yale, USC, MIT, Stanford, Willow Garage, 2011***

Robotics

- ***RoboBees: A Convergence of Body, Brain and Colony – Harvard, Northeastern, 2009***
- ***An Expedition in Computing for Compiling Printable Programmable Machines, MIT, U Penn, Harvard, 2011***

Image Credit: Harvard University

Limits of Computation

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

Formal Modeling and Verification

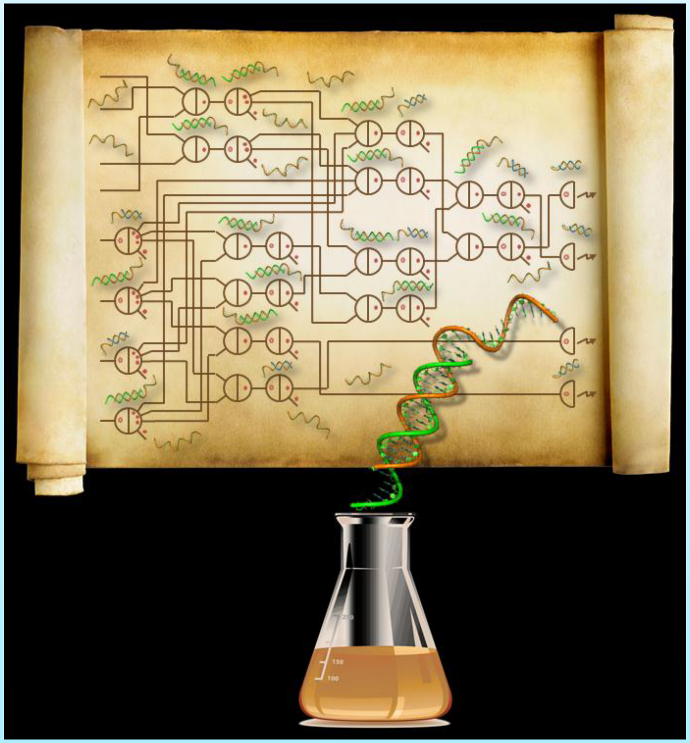
- ***Next-Generation Model Checking and Abstract Interpretation with a Focus on Embedded Control and Systems Biology, Carnegie Mellon, Stony Brook, NYU, UMD, Pitt, Lehman College, JPL, 2009***
- ***Expeditions in Computer Augmented Program Engineering, U Penn, UC Berkeley, UMD, Rice, Cornell, U of Michigan, U of Illinois-UC, UCLA, MIT, 2011***

Big Data

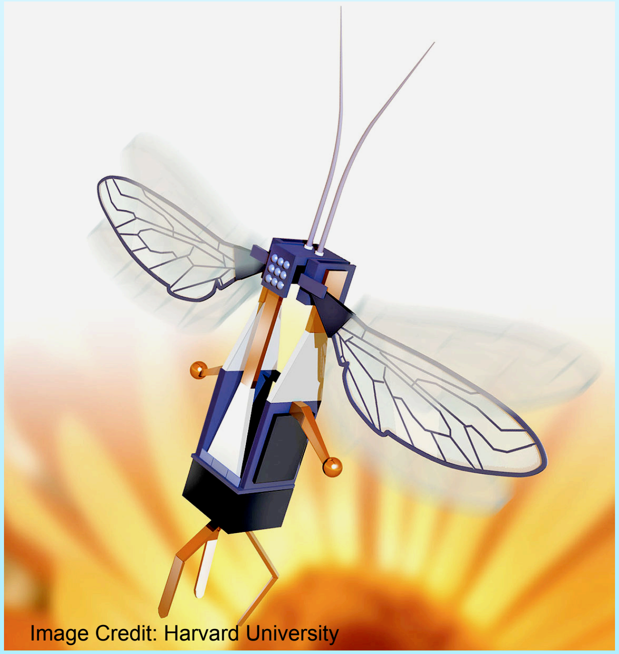
- ***Algorithms, Machines, and People, UC Berkeley, UC San Francisco, 2011***
- ***Understanding Climate Change: A Data Driven Approach*** **– Minnesota, Northwestern, NC State, NC A&T State, 2010**

Expeditions-in-Computing

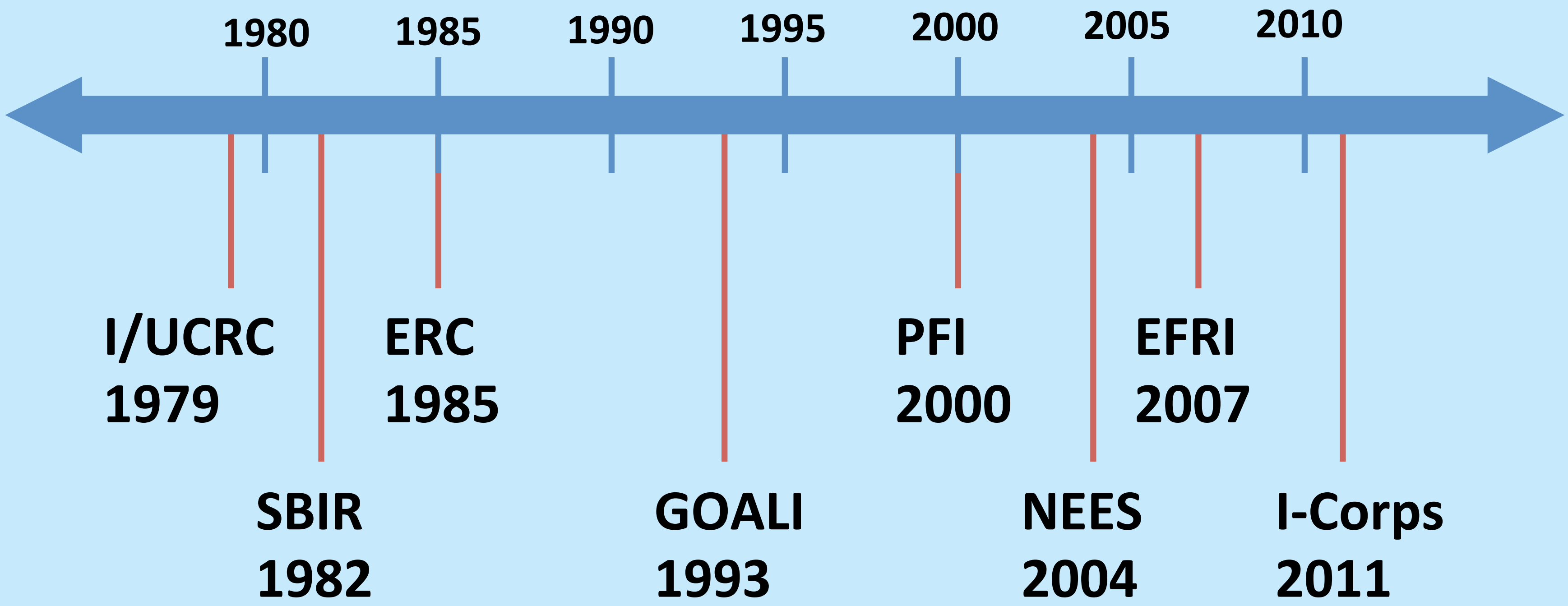
Programming with DNA: Employing logic circuits using DNA and RNA has the potential to change the way we analyze, understand, and manipulate molecular systems. (Erik Winfree, Caltech, et al.)



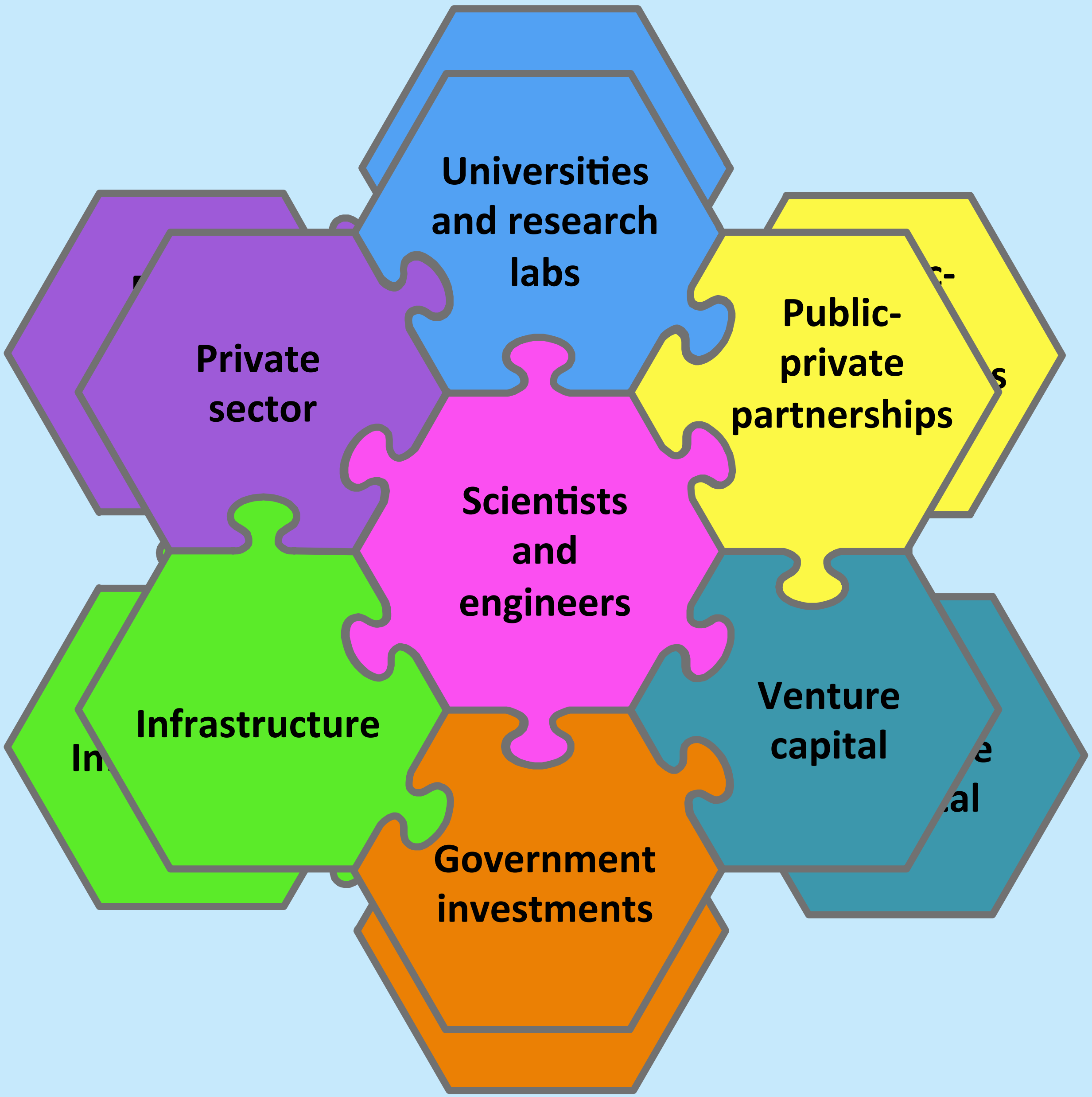
RoboBees: Microrobots with real-time sensing and communication capabilities with the potential to impact assisted agriculture, search and rescue, and environmental monitoring. (Robert Wood, Harvard, et al.)



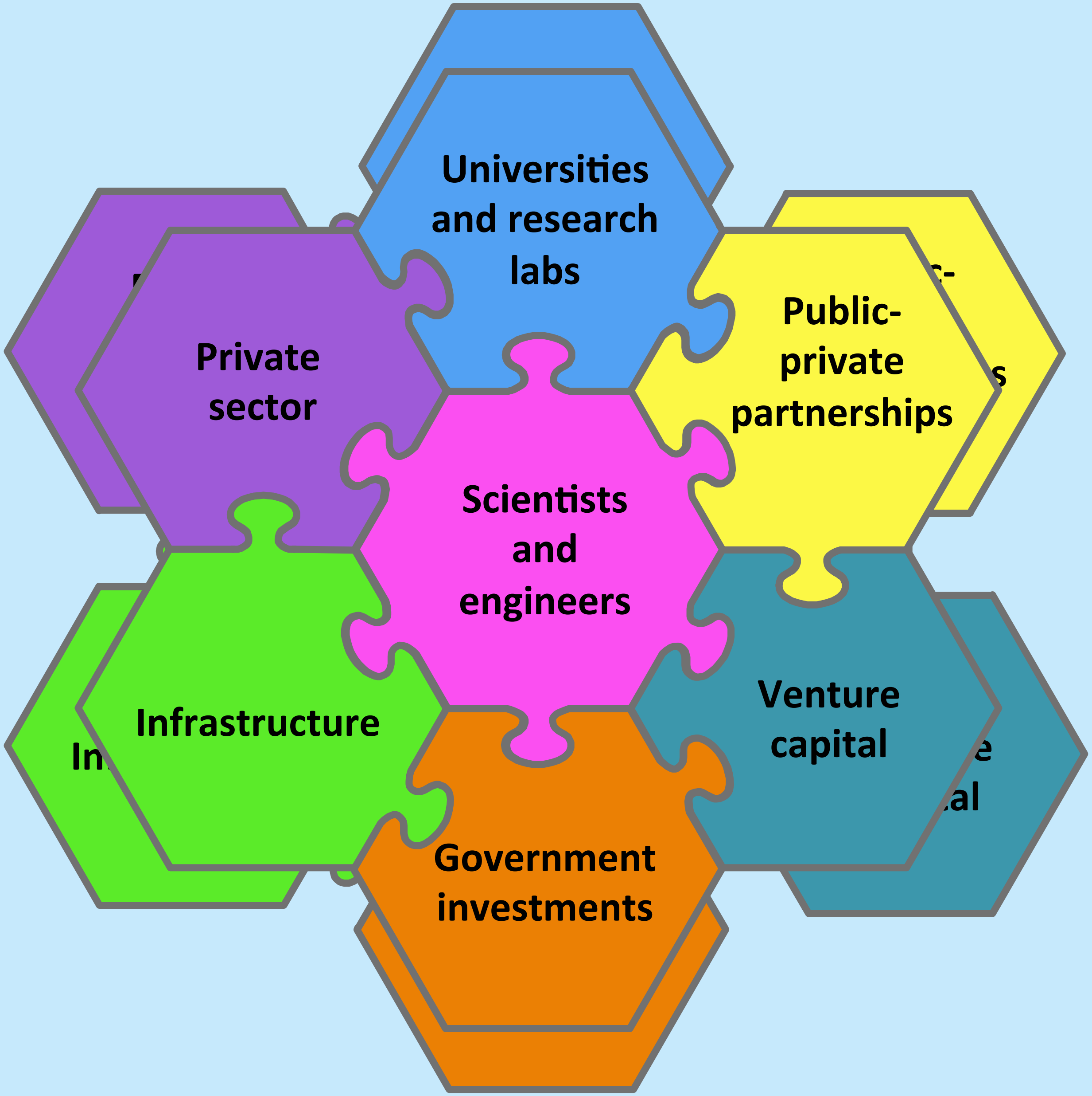
Programmatic Innovation in Translational Research



Discovery and Innovation Ecosystem



Discovery and Innovation Ecosystem



Innovation Corps (I-Corps)

Accelerating innovations from the laboratory to the market

- Aims to develop and nurture a national innovation ecosystem that builds upon fundamental research to guide the output of scientific discoveries to the development of technologies, products and processes that benefit society.
- Seeks to identify NSF-funded researchers to receive additional support - in the form of mentoring and funding.
- Two new subcomponents in FY 2013:
  - **Sites**: fund academic institutions with existing innovation units to enable them to nurture and support multiple, local teams to transition ideas, devices, processes or other intellectual activities into the marketplace.
  - **Nodes**: establish regional nodes to provide training to I-Corps teams; develop tools and resources that impact and expand benefits; identify and pursue longer-term research and development projects.

Award Information:
- 25 awards in FY11
- 100 awards in FY12

NSF-wide Initiative

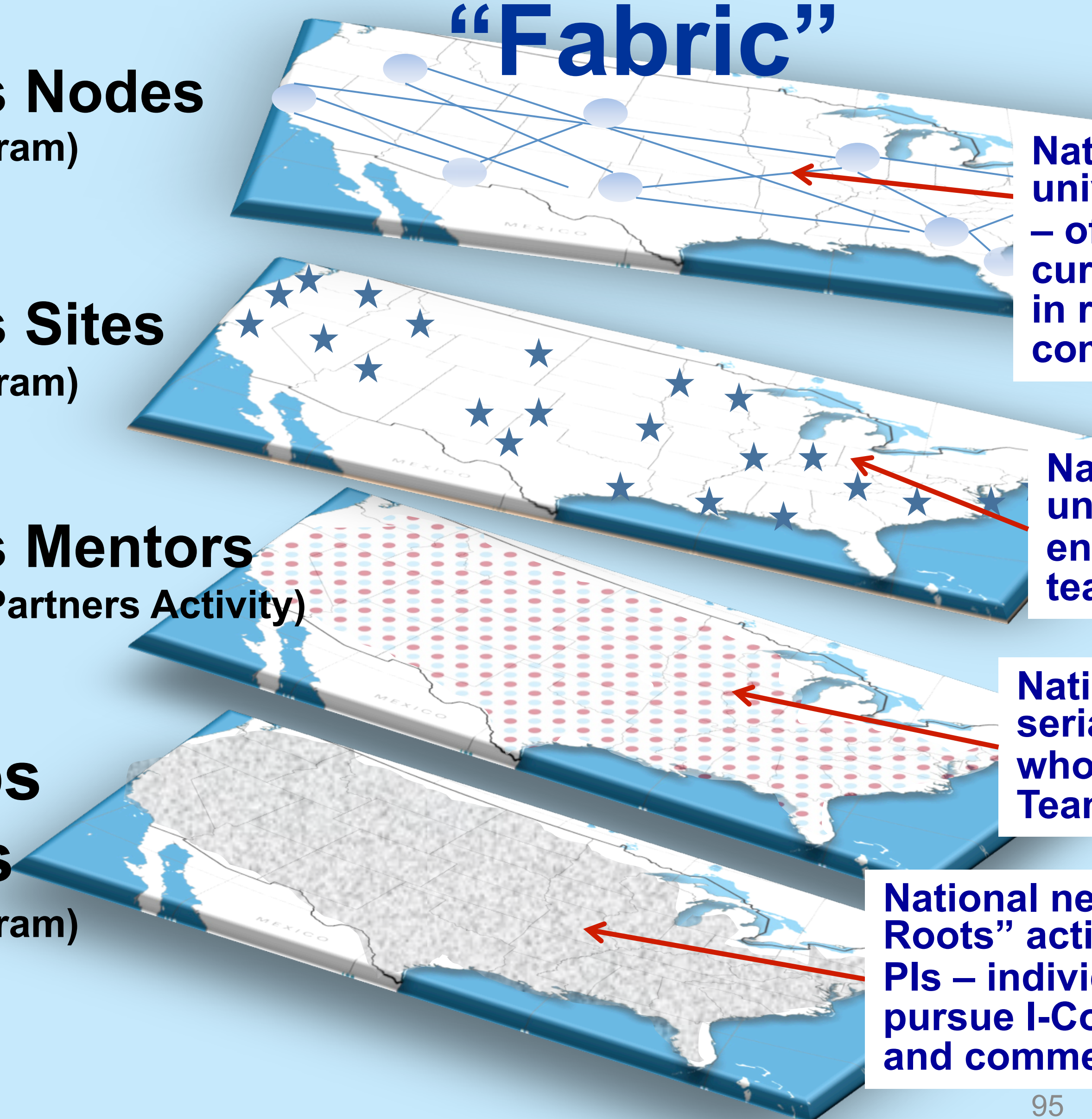
CISE Startups

Google
coverity
Voltage security
vmware
panasas
Coreopsys Opportunistic Computing™
NexID Biometrics
VERAYO
ARBOR NETWORKS
reCAPTCHA
Sana Security
NETSHIFT
RECON ROBOTICS™ WORLD LEADER IN TACTICAL MICRO-ROBOT SYSTEMS
nicira
mushroom NETWORKS
voci™ voci technologies incorporated
algenta
CONVIVA
AVIRTEK Smarter Cyber Resilience
ASSURE Technologies
TerraFly
JASPER design automation
CILK ARTS
wombat™ security technologies
Zipano TECHNOLOGIES YOUR PRIVACY IN YOUR HANDS
Power Fingerprinting, Inc.
DayZero Systems Incorporated
Private Machines
usable security systems
REPOW
DEPENDABLE COMPUTING INCORPORATED

Innovation Corps (I-Corps)

Accelerating innovations from the laboratory to the market

Building the Nation's I-Corps "Fabric"



I-Corps Nodes
(NSF Program)

National Network of university collaborators – offer immersion curriculum and engage in research about commercialization

I-Corps Sites
(NSF Program)

National network of universities that can enable their local teams

I-Corps Mentors
(External Partners Activity)

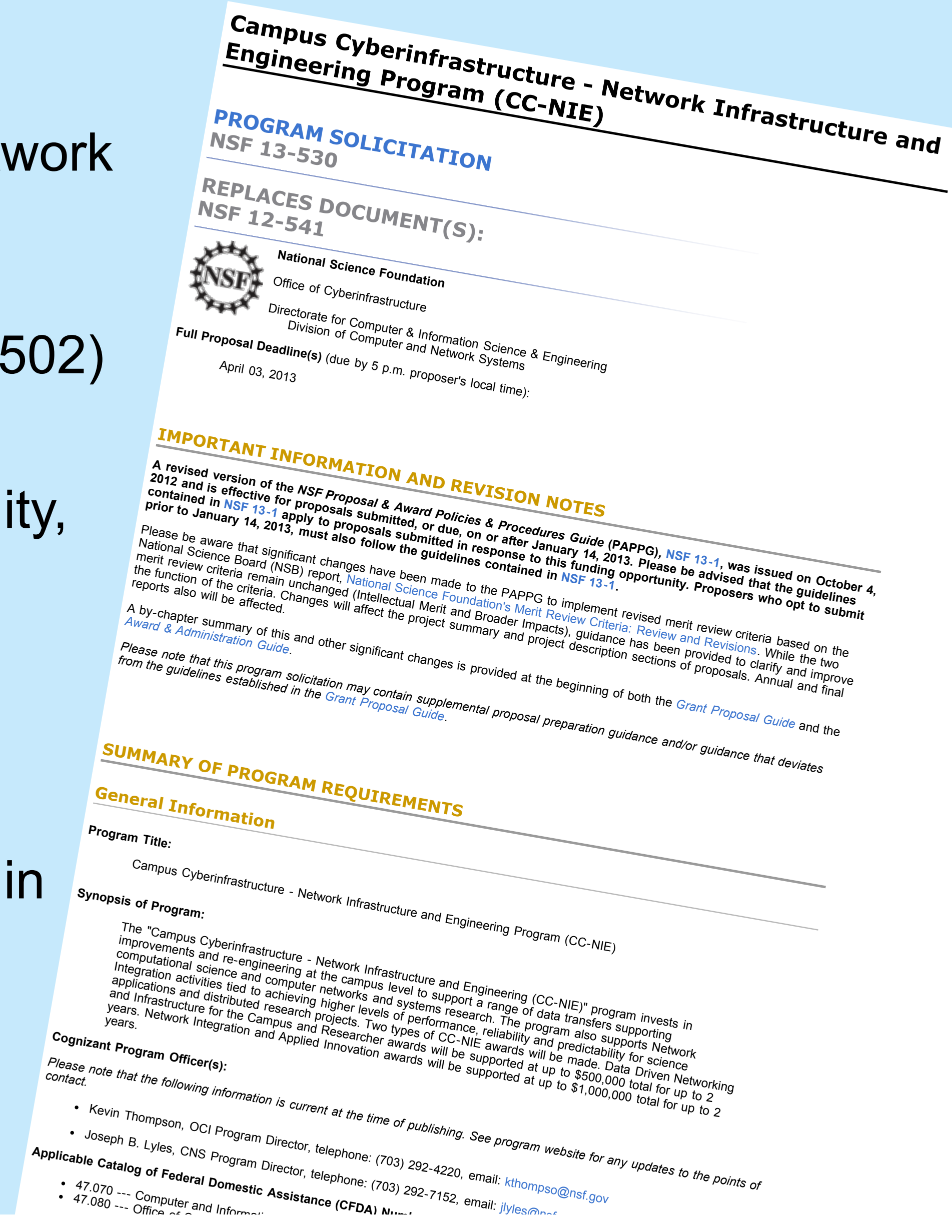
National network of serial -entrepreneurs who Mentor I-Corps Teams

I-Corps Teams
(NSF Program)

National network of" Grass-Roots" activities by NSF PIs – individual teams pursue I-Corps Curriculum and commercialization

Some New CISE Solicitations

- BIGDATA (NSF 12-499)
- Campus Cyberinfrastructure – Network Infrastructure and Engineering Program (NSF 13-530) – 2nd year
- Cyber Physical Systems (NSF 13-502)
- CyberSEES (NSF 13-500)
- Exploiting Parallelism and Scalability, XPS (NSF 13-507)
- Hazards SEES (NSF 12-610)
- NRI (NSF 12-607) – 2nd year
- SaTC (NSF 12-596) – 2nd year
- United States-Israel Collaboration in Computer Science, USICCS (NSF 12-603)
- CCF, CNS, IIS Core programs



Campus Cyberinfrastructure - Network Infrastructure and Engineering Program (CC-NIE)

PROGRAM SOLICITATION
NSF 13-530

REPLACES DOCUMENT(S):
NSF 12-541

National Science Foundation

Office of Cyberinfrastructure

Directorate for Computer & Information Science & Engineering
Division of Computer and Network Systems

Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

April 03, 2013

IMPORTANT INFORMATION AND REVISION NOTES

A revised version of the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), NSF 13-1, was issued on October 4, 2012 and is effective for proposals submitted, or due, on or after January 14, 2013. Please be advised that the guidelines contained in NSF 13-1 apply to proposals submitted in response to this funding opportunity. Proposers who opt to submit prior to January 14, 2013, must also follow the guidelines contained in NSF 13-1.

Please be aware that significant changes have been made to the PAPPG to implement revised merit review criteria based on the National Science Board (NSB) report, National Science Foundation's Merit Review Criteria: Review and Revisions. While the two merit review criteria remain unchanged (Intellectual Merit and Broader Impacts), guidance has been provided to clarify and improve the function of the criteria. Changes will affect the project summary and project description sections of proposals. Annual and final reports also will be affected.

A by-chapter summary of this and other significant changes is provided at the beginning of both the Grant Proposal Guide and the Award & Administration Guide.

Please note that this program solicitation may contain supplemental proposal preparation guidance and/or guidance that deviates from the guidelines established in the Grant Proposal Guide.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Campus Cyberinfrastructure - Network Infrastructure and Engineering Program (CC-NIE)

Synopsis of Program:

The "Campus Cyberinfrastructure - Network Infrastructure and Engineering (CC-NIE)" program invests in improvements and re-engineering at the campus level to support a range of data transfers supporting computational science and computer networks and systems research. The program also supports Network Integration activities tied to achieving higher levels of performance, reliability and predictability for science applications and distributed research projects. Two types of CC-NIE awards will be made. Data Driven Networking and Infrastructure for the Campus and Researcher awards will be supported at up to $500,000 total for up to 2 years. Network Integration and Applied Innovation awards will be supported at up to $1,000,000 total for up to 2 years.

Cognizant Program Officer(s):

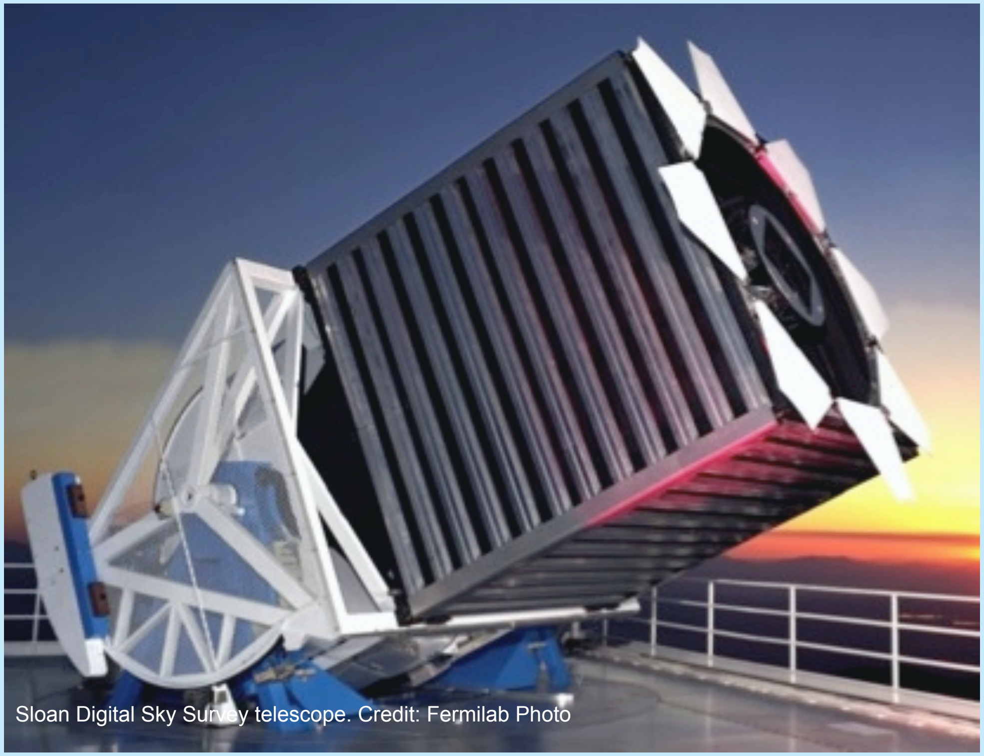
Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Kevin Thompson, OCI Program Director, telephone: (703) 292-4220, email: kthompso@nsf.gov
- Joseph B. Lyles, CNS Program Director, telephone: (703) 292-7152, email:

Applicable Catalog of Federal Domestic Assistance (CFDA)

- 47.070 --- Computer and
- 47.080 --- Office

Looking Forward

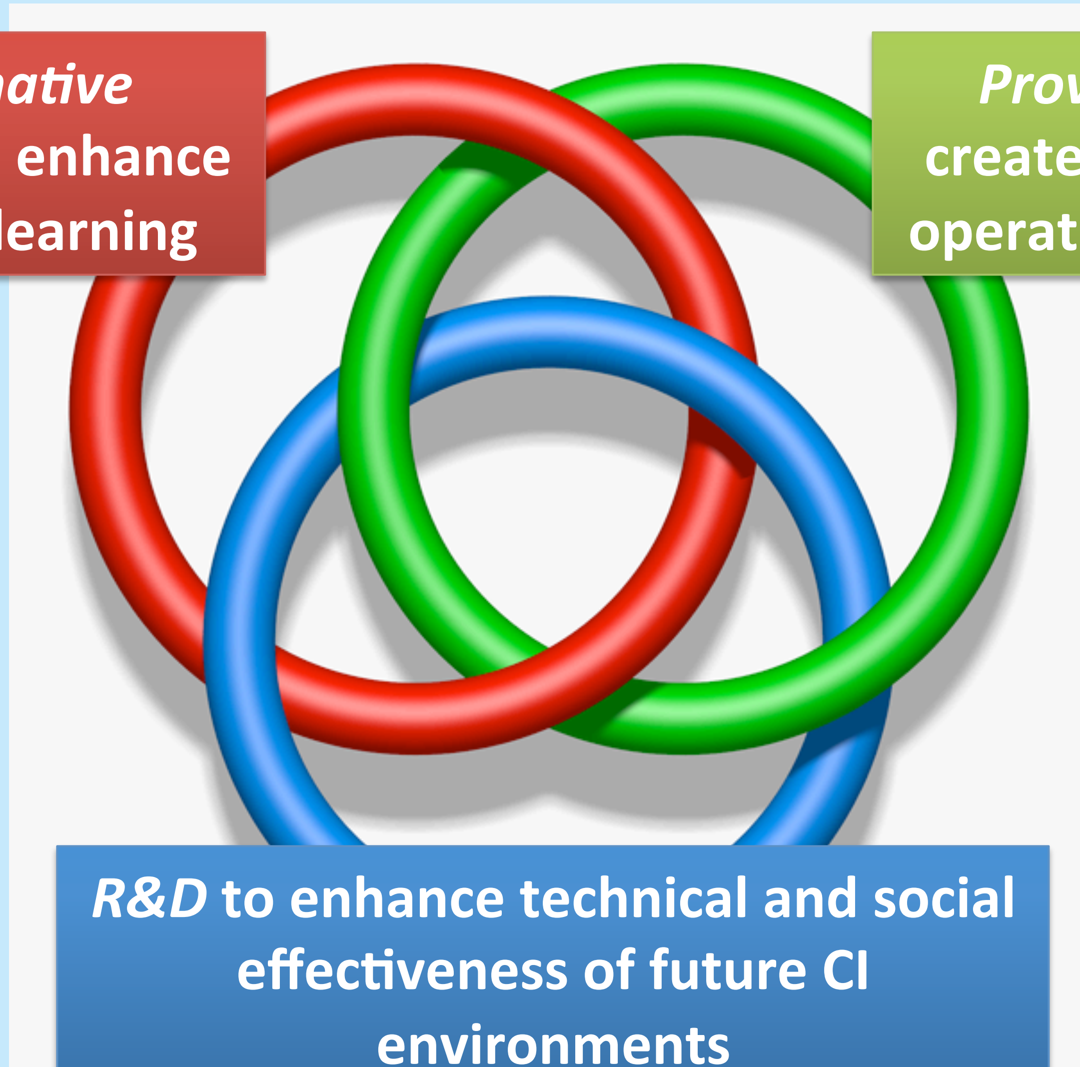


Sloan Digital Sky Survey telescope. Credit: Fermilab Photo

Advanced Cyberinfrastructure

Transformative Application to enhance discovery & learning

Provisioning to create, deploy, and operate advanced CI

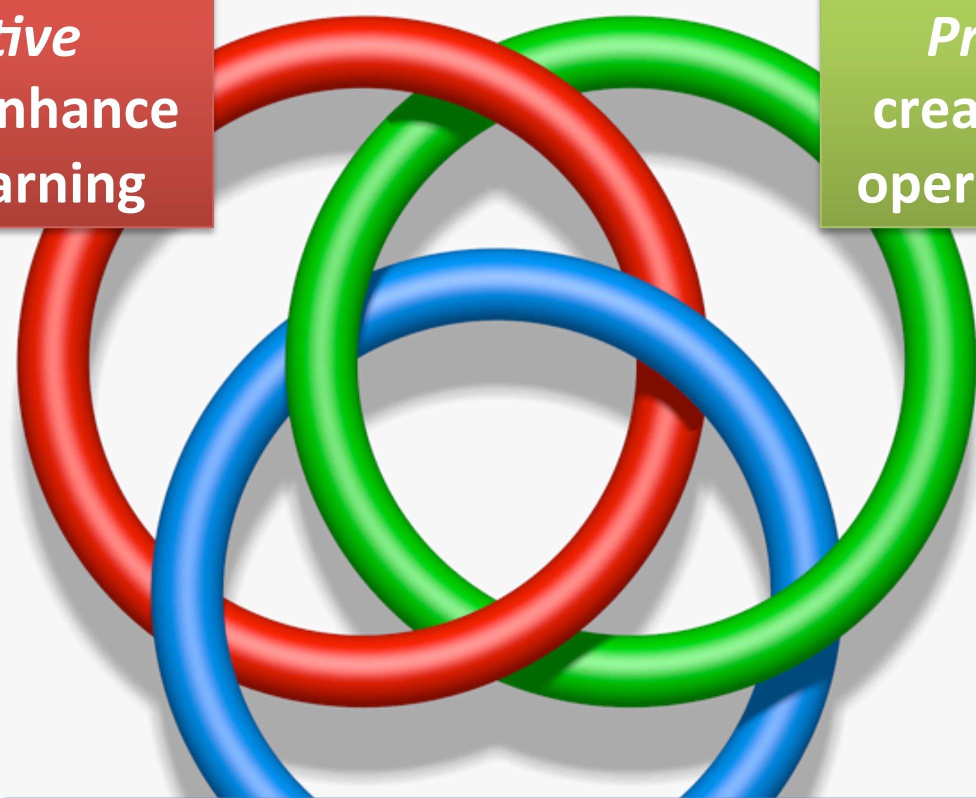


R&D to enhance technical and social effectiveness of future CI environments

Advanced Cyberinfrastructure

Transformative Application to enhance discovery & learning

Provisioning to create, deploy, and operate advanced CI



R&D to enhance technical and social effectiveness of future CI environments

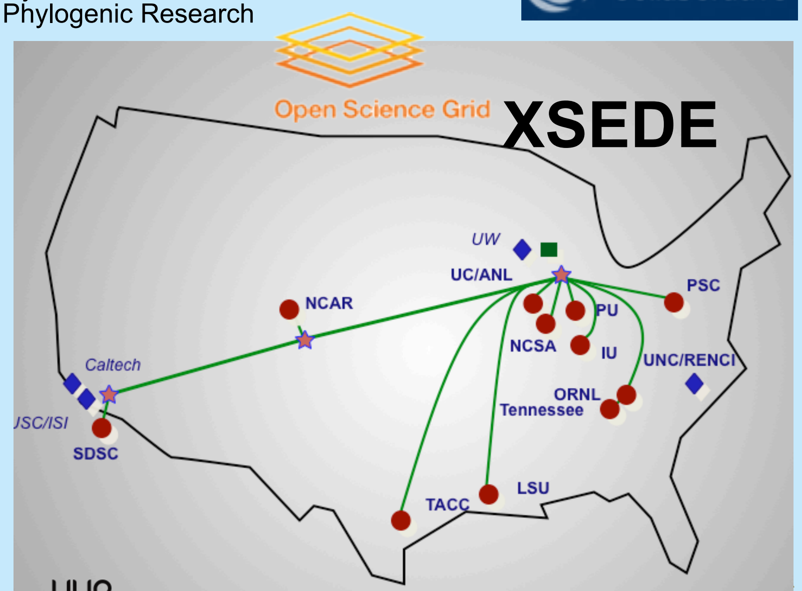
Cyberinfrastructure Investments

- High Performance Computing
- Network Infrastructure
- Mid-scale Research Infrastructure (i.e., GENI and US Ignite)

Advanced Computational Infrastructure

- Anticipate and invest in diverse and innovative national scale shared resources, outreach and education complementing campus and other national investments
- Leverage and invest in collaborative flexible “fabrics” dynamically connecting scientific communities with computational resources and services at all scales (campus, regional, national, international)

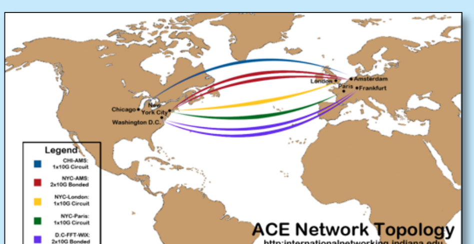
CIPRES – Cyberinfrastructure for Phylogenic Research

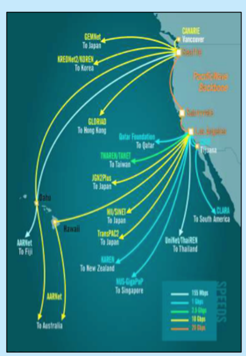


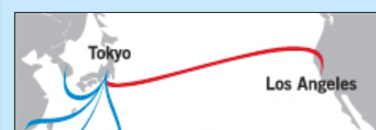
nanoHUB.org

Network Infrastructure

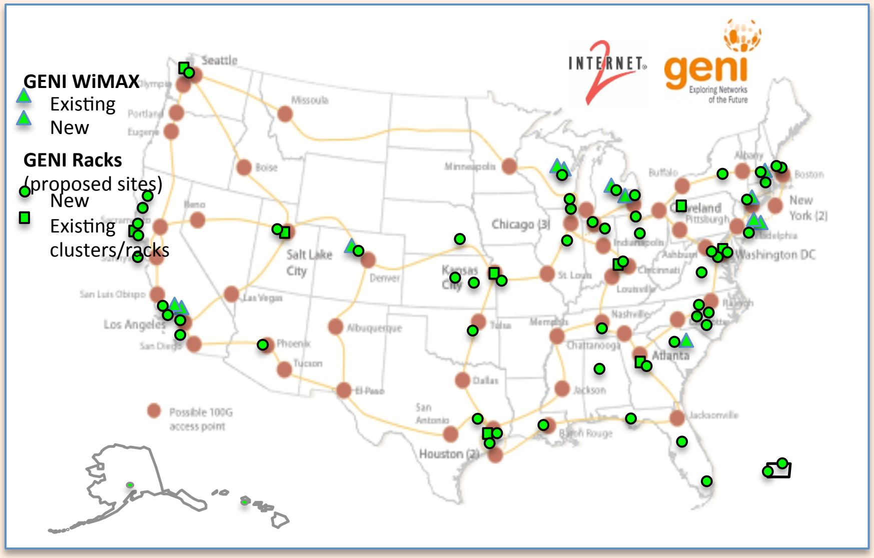
- **Campus Cyberinfrastructure–Network Infrastructure and Engineering (CC-NIE)**
  - Network infrastructure improvements at campus level (re-architecting for large data science flows, upgrades within campus and external connectivity)
  - Network integration and applied innovation (e.g., experimental deployment of SDN/openflow)
  - See Kevin Thompson's Wed. afternoon talk
- **International Research Network Connections (IRNC)**
  - Continues NSF's long commitment to directly supporting international network connectivity dedicated to research and education
  - Mid-way through 5-year awards supporting multi-gig connectivity to Europe, Asia, Americas, Australia
  - New approach under consideration for a globally coordinated International Research Network Backbone to meet science and education demands into 2020, stay tuned







Mid-scale Research Infrastructure



Advancing networking, distributed systems, cloud computing and cybersecurity research through experimentation at scale

Global Environment for Networking Innovations (GENI)

- A virtual laboratory for exploring future internets at-scale, now taking shape in prototype form across the U.S.
- Key GENI concepts:
  - Slices & deep programmability
  - Federation and enabling “at scale” experiments

US Ignite

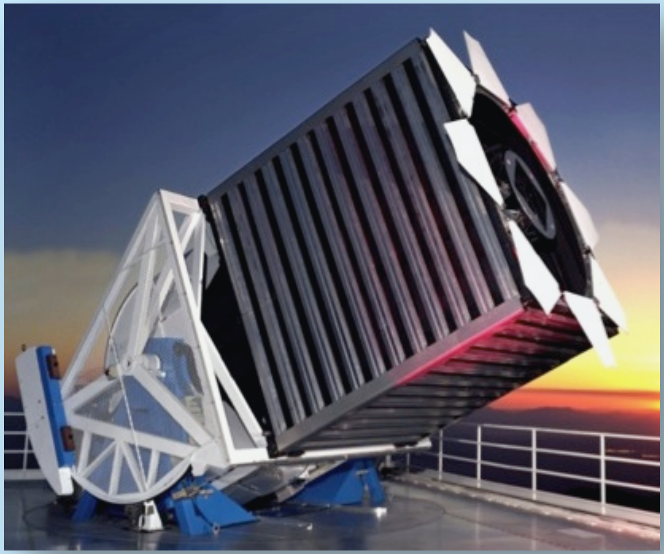
- Launched June 14, 2012 at the White House
- NSF leadership
  - Leveraging GENI investments
  - Stitching together testbeds and network resources across the country
  - Jumpstarting gigabit public sector application development
- Public Private Partnership
  - Bringing industry and foundations into the mix

The future?

The Promise

- Our investments in **research and education** have returned exceptional dividends to our nation.
- A thriving discovery and innovation ecosystem is the foundation for sustained **economic prosperity** and **national security**.
- To keep those benefits flowing, we need to constantly **replenish** the wellspring of **new ideas** and train **new talent**.
- "Foster an environment that encourages students to imagine, think broadly, collaborate, and capture serendipity, as well as the freedom to take risks and create." -*Grown up Digital* by Don Tapscott

New Era of Science and Engineering



New Era of Observation

(theory, experiment, computation, "citizen science")

New Era of Data and Information

Key Trends of the New Era

- Global Challenges need Global Solutions: Pandemics, natural and man-made disasters, displaced populations, water shortages, rising sea levels, food security, etc.
  - NAE Grand Challenges
- Borderless Knowledge Enterprise: National borders no barrier to instant information access, talent recruitment
- Shifting Demographics: Rapidly increasing concentration of engineers and scientists in Asia
- Shifting Economics: Science and engineering research and education seen as ticket to economic prosperity in large and small developing countries

Moving ahead

Nurture and Support a Culture of Engagement and Service

- Help shape the future directions of the field, priorities for the nation, and formulate a research and education agenda to address societal challenges.

Embrace a Collaborative Culture Enabled by Foundational Research

- Advances in IT and CI are pushed by long-term investment in foundational research and cross- and inter-disciplinary research and pulled by expanding complexity, scope, and scale of global priorities.

Educate and Empower the Next Generation

- Lead a cyber- and technology-enabled transformation in education and learning to develop the next generation IT workforce and contribute to universal, transparent, and affordable participation in a knowledge-based society.

NSF

Long-Term Investment in Basic Research is Imperative

- There is often a **long, unpredictable incubation period** – requiring sustained investment – between initial exploration and impact.
- Interactions of research ideas **multiply their impact** and **seed new ideas** with the potential to lead to unanticipated advances.
- **Unanticipated outcomes** are often as important as the anticipated ones.

The Growing Imperative of Research and Education

- Our investments in **research, education** and **infrastructure** have returned exceptional dividends to our nation.
- A thriving basic research community is the foundation for long-term **discovery** and **innovation**, **economic prosperity**, and **national security**.
- As a field of inquiry, computer, communication and information science and engineering has a **rich intellectual agenda** – highly creative, highly interactive, with enormous possibilities for changing the world!
- To keep those benefits flowing, we need to constantly **replenish** the wellspring of **new ideas** and train **new talent**.

Thanks!

fjahania@nsf.gov

1. Nurture and Support a Culture of Engagement and Service

- Why Serve?
  - Opportunity to shape the future directions of the field and priorities for the nation
  - Formulate research and education agenda to address societal challenges

- How?
  - Community engagement at many levels

University and industry leadership: encourage and reward national service

Many Opportunities for Community Engagement

- **Come to NSF**
- Proposal merit review
- Program review - Committee of Visitors
- CISE Advisory Committee (Subcommittees and Working Groups)
- Community Visioning Activities
- CCC, CRA, CSTB and ACM Interactions
- Studies with the National Academies
- Program Webinars
- CAREER Proposal Writing Workshops
- CS Bits & Bytes
- CI Fellows Program
- PI Meetings & Conferences
- Broadening Participation in Computing Alliances (CRA-W, NCWIT, etc.)
- Public outreach

Recent Rotators from across the US

- Carnegie Mellon University
- Case Western Reserve University
- Catholic University of America
- Cornell University
- Duke University
- Florida Institute of Technology
- Florida State University
- George Mason University
- Georgetown University
- Georgia Institute of Technology
- Iowa State University
- Oak Ridge National Laboratory
- Old Dominion University
- Oregon Health and Science University
- Penn State University
- Purdue University
- Rensselaer Polytechnic Institute
- Rutgers University
- SRI International
- University of Arizona
- UC Davis
- UCLA
- UC San Diego
- University of Chicago
- University of Denver
- University of Kansas
- University of Maryland
- University of Massachusetts
- University of Michigan
- University of Minnesota
- University of Oklahoma
- University of Pennsylvania
- University of Southern California
- University of Texas at Arlington
- University of Texas at Austin
- University of Toledo
- University of Utah
- University of Vermont
- Virginia Tech

2. Embrace a Collaborative Culture Enabled by Foundational Research

- **Long-term investment in foundational research is imperative**
  - There is often a long, unpredictable incubation period – requiring sustained investment – between initial exploration and impact.
  - Interactions of research ideas multiply their impact and seed new ideas with the potential to lead to unanticipated advances.
  - Unanticipated outcomes are often as important as the anticipated ones.

- **A strong foundation fuels cross- and inter-disciplinary research**
  - Tremendous opportunity for the CISE community to work with other disciplines in true collaborations and to address challenges facing humanity.

2. Embrace a Collaborative Culture Enabled by Foundational Research

- **Long-term investment in foundational research is imperative.**
  - There is often a long, unpredictable incubation period – requiring sustained investment – between initial exploration and impact.
  - Interactions of research ideas multiply their impact and seed new ideas with the potential to lead to unanticipated advances.
  - Unanticipated outcomes are often as important as the anticipated ones.

- **Advanced cyberinfrastructure will accelerate the pace of discovery and innovation in all areas of inquiry.**

- **Cross- and inter-disciplinary research is pushed by advances in IT and pulled by the expanding complexity, scope, and scale of global priorities.**

3. Educate and Empower the Next Generation

- Develop the next generation of the computing and information technology workforce.
- Empower citizens by promoting understanding of the principles and uses of computation- and data-intensive techniques.
- Lead a cyber- and technology-enabled transformation in education and learning.
- Contribute to universal, transparent, and affordable participation in a knowledge-based society.