

Grand Challenges, Federal Priorities and Funding an NSF/CISE view

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**Big Data and Cybersecurity: Grand Challenges,
Partnerships, and Policy**

December 2015



Overview

- Introduction: NSF/CISE, computing
 - Big Data
 - Cyber security
 - Concluding thoughts
- } context, opportunities



National Science Foundation's Mission

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

NATIONAL SCIENCE FOUNDATION

CISE research: Addressing national priorities

White House Initiatives



Image Credit: CCC and SIGACT/GATCS

**Data Science: From
Data to Knowledge to
Action**



**National Strategic
Computing Initiative**



**Manufacturing,
Robotics, & Smart
Systems**



Image Credit: ThinkStock

**Understanding the
Brain**



Smart Cities



CISE research: Addressing national priorities

Continuing CISE Priorities



Image Credit: ThinkStock

**Secure and
Trustworthy
Cyberspace**

Image Credit: @Georgia Computers | Georgia Tech Tech



**Food, Energy, & Water
Systems**



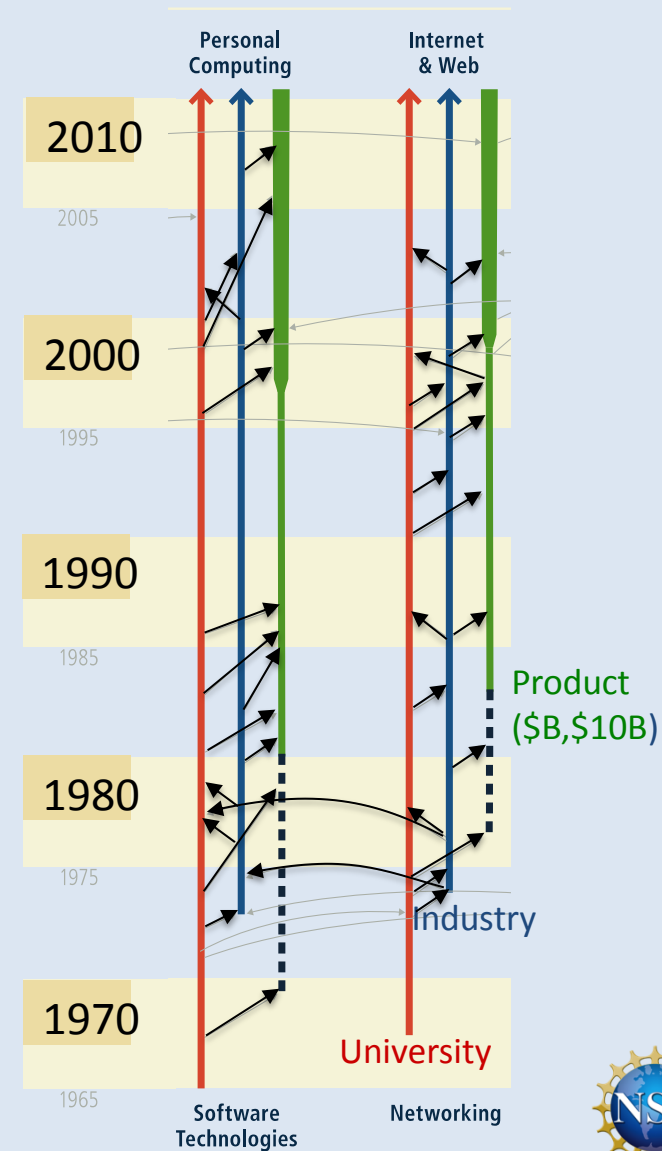
**Education &
Workforce: CS10K,
Alliances**



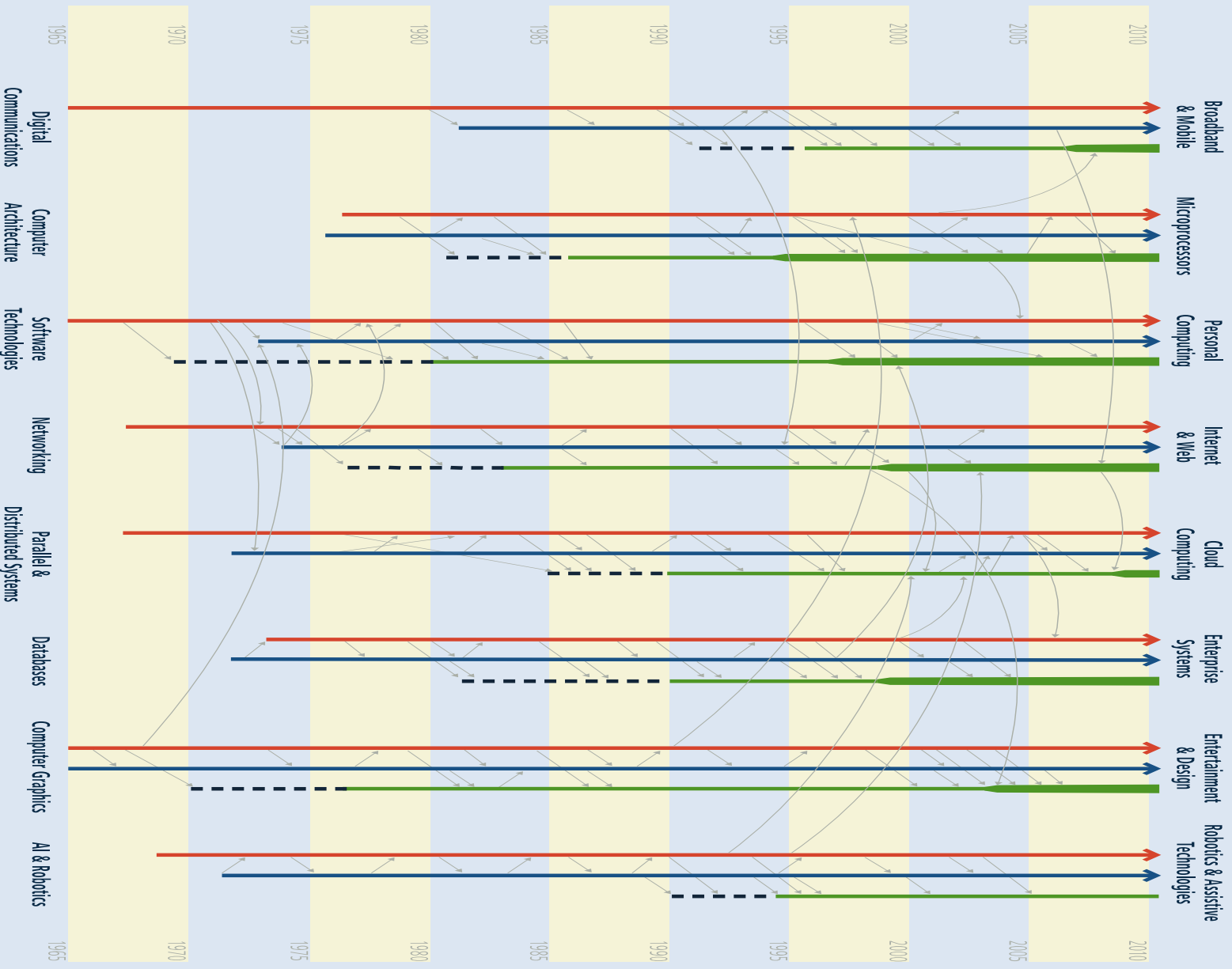
From federally-funded research to \$B industries

Advances in computing, communications, information technologies, cyberinfrastructure:

- drive U.S. competitiveness, sustainable economic growth (IT: 25% of economic growth since 1995)
- underpin national security
- have profound impacts on our daily lives



.... across many industries















- Motola
- Qualcomm
- Texas Instruments
- Nvidia
- Apple
- Dell
- Cisco
- Amazon
- Google
- Oracle
- Pod
- Inuitive Surgical
- AMD
- Intel
- HP
- Symantec
- Juniper
- Facebook
- Twitter
- Microsoft
- VMware
- HP
- Apple
- Autodesk
- XBox
- IBM
- Electronic Arts
- Nuance
- Robot
- iPhone
- RoboT

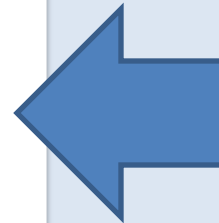


... and this impact will continue

Top twelve economically disruptive technologies (by 2025)

	Mobile Internet		Next-generation genomics
	Automation of knowledge work		Energy storage
	The Internet of Things		3D printing
	Cloud technology		Advanced materials
	Advanced robotics		Advanced oil and gas exploration and recovery
	Autonomous and near-autonomous vehicles		Renewable energy

SOURCE: McKinsey Global Institute analysis



McKinsey & Company

McKinsey Global Institute

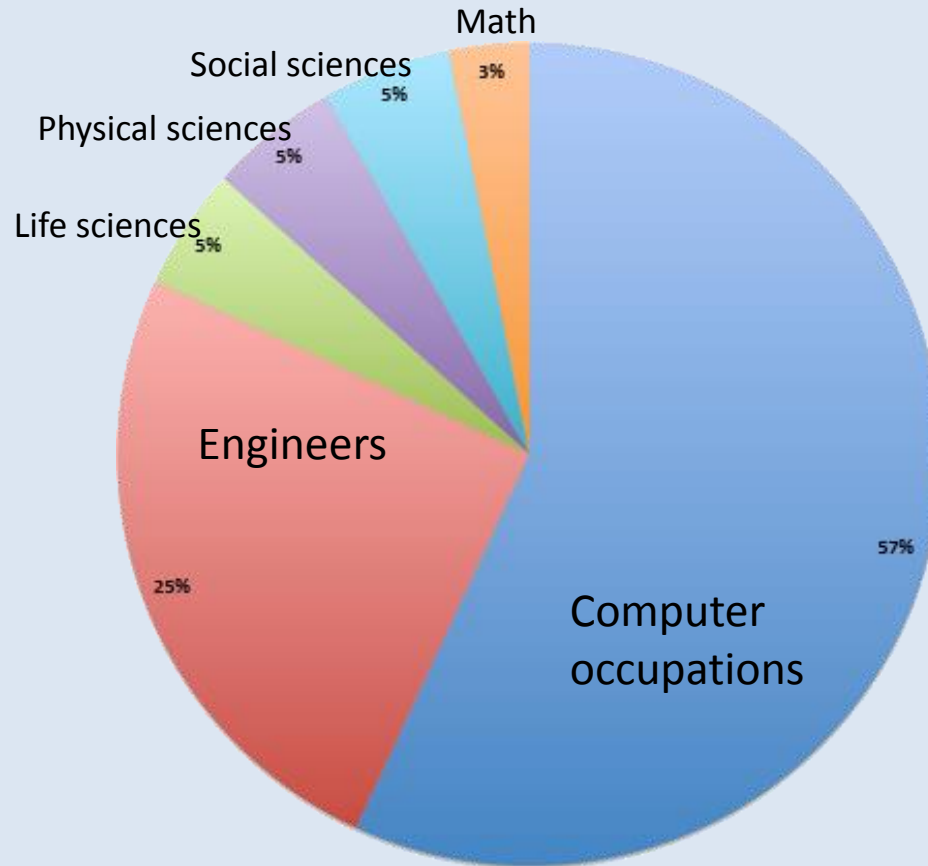
May 2013



Disruptive technologies:
Advances that will transform life, business, and the global economy



Many STEM jobs are in computing



Job Openings 2012 – 2022 (growth and replacement)

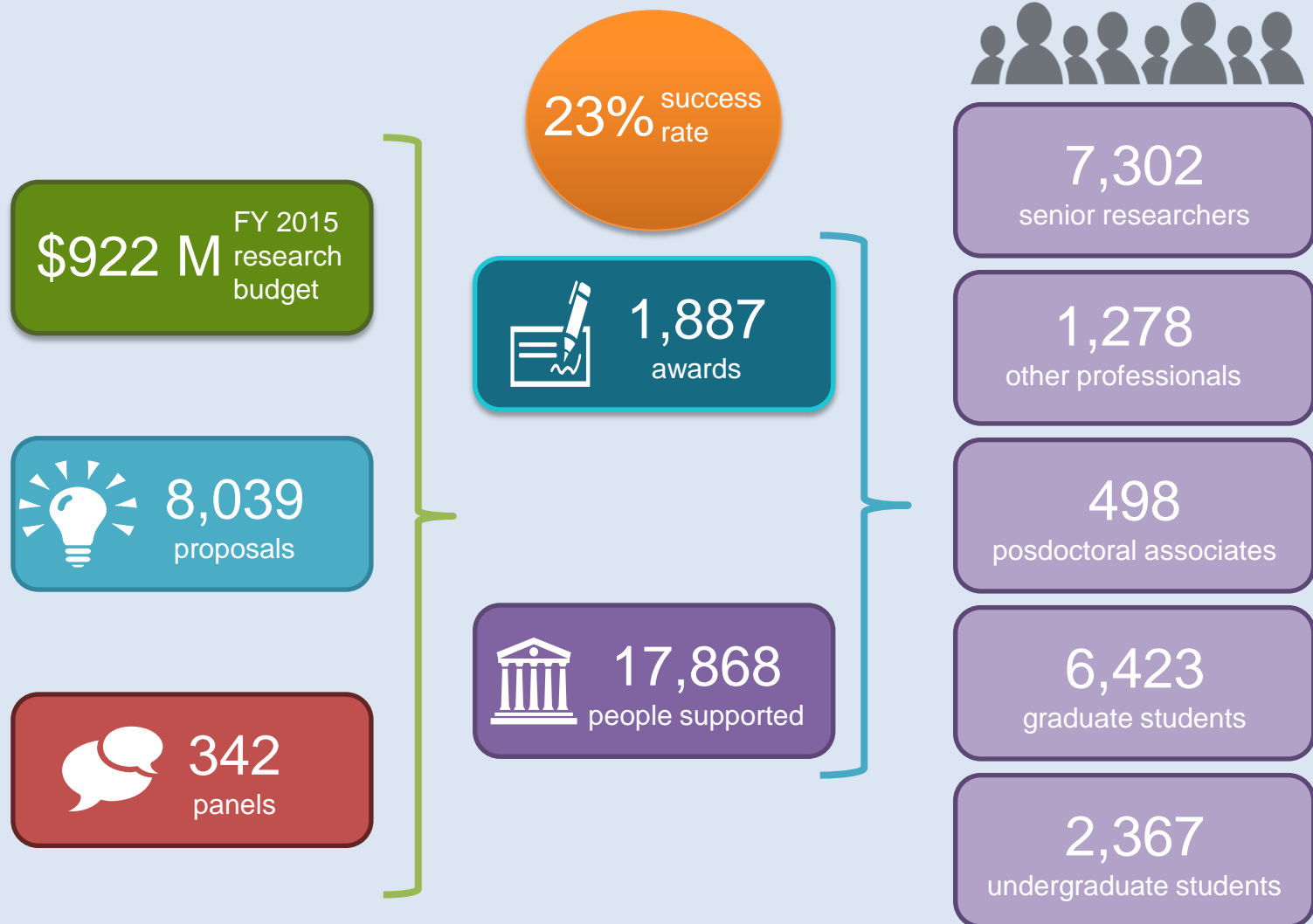
US Bureau of Labor Statistics



**It is an
exciting, impactful and important time
to be in
computer and information science and
engineering!!**

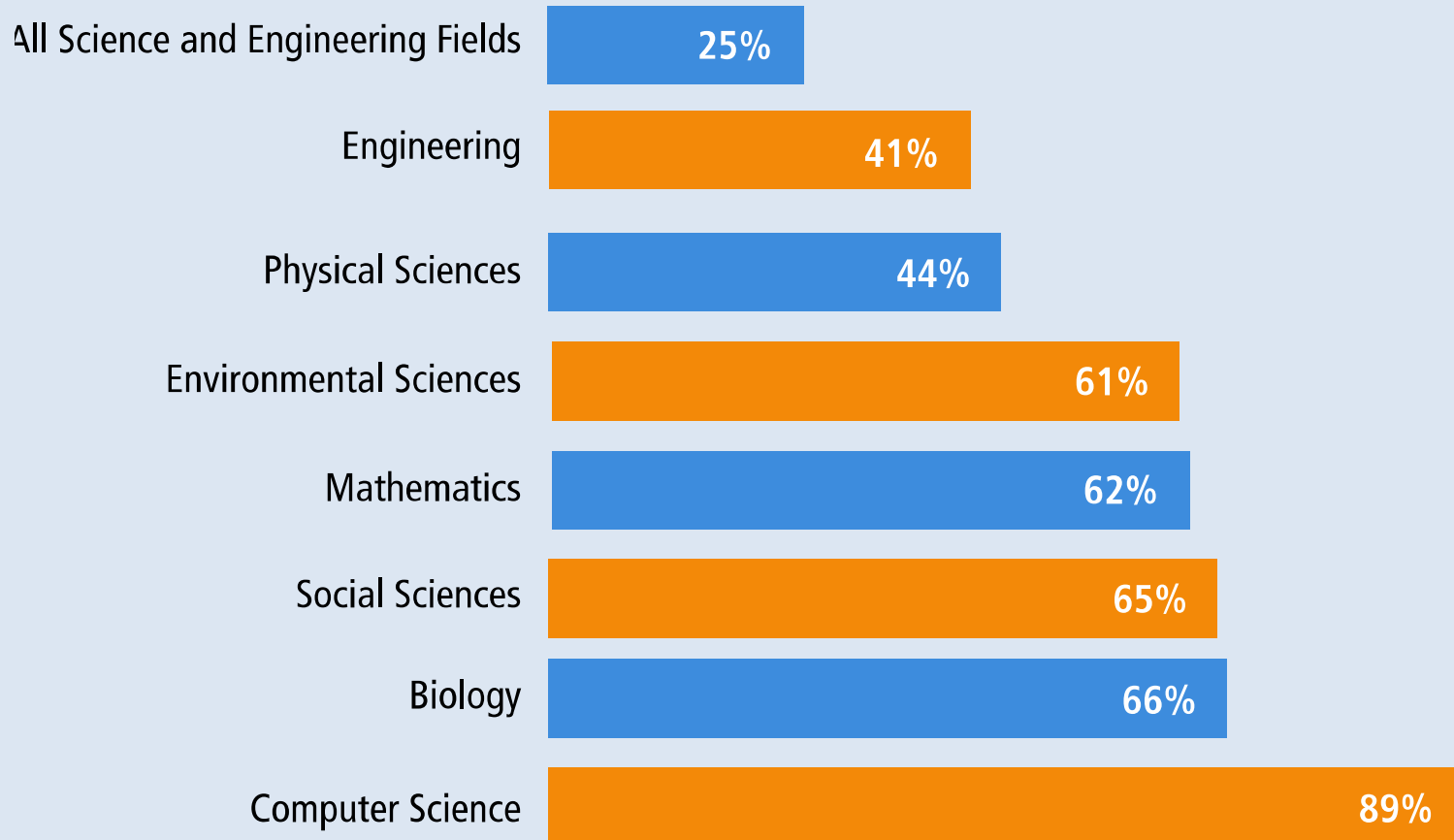


NSF CISE by the Numbers: FY 2015



NSF Support of Academic Basic Research

(as a percentage of total federal support)



Source: NSF/NCSES, "Survey of Federal Funds for Research & Development, FY 2013. From NSF FY2016 Budget Request to Congress Request

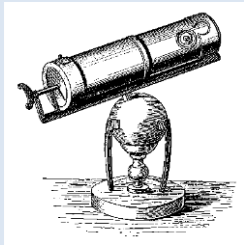


Overview

- NSF/CISE: overview
- **Big Data**
 - Data initiatives
 - Public access
- Cyber security
- Conclusion



Evolving research paradigms



$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{enc}}{\epsilon_0}$$

$$\oint \mathbf{B} \cdot d\mathbf{A} = 0$$

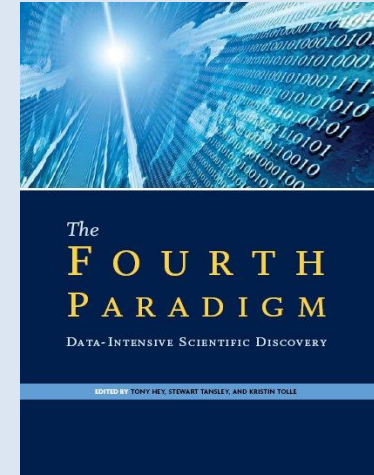
$$\oint \mathbf{E} \cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$$

$$\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 \epsilon_0 \frac{d\Phi_E}{dt} + \mu_0 i_{enc}$$

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x_i}(\rho u_i) = S_m$$

$$\frac{\partial}{\partial t}(\rho u_i) + \frac{\partial}{\partial x_j}(\rho u_i u_j) =$$

$$-\frac{\partial p}{\partial x_i} + \frac{\partial \tau_{ij}}{\partial x_j} + \rho g_i + F_i$$



The Emerging Data Science Landscape

- Data and the domains:
 - Domains: science, engineering, social science, education, business, finance, ...
 - Systematic approaches to data management, curation
 - Use of advanced statistical, machine learning
- Data Science as a discipline:
 - Computer Science, Statistics, Policy & Ethics, application domains
 - Data collection, management, curation, analysis, decision making
 - Novel approaches to data collection and use
 - E.g. Internet of Things (IoT)



NSF Data Science: recent, ongoing activities

FOUNDATIONAL RESEARCH:

CDS&E
BIGDATA
III core program
Data Pilots

CYBERINFRASTRUCTURE:

DIBBS
Wrangler, Comet, Jetstream
CC*DNI
Data Pilots

EDUCATION & WORKFORCE DEVELOPMENT

NRT
Data Pilots

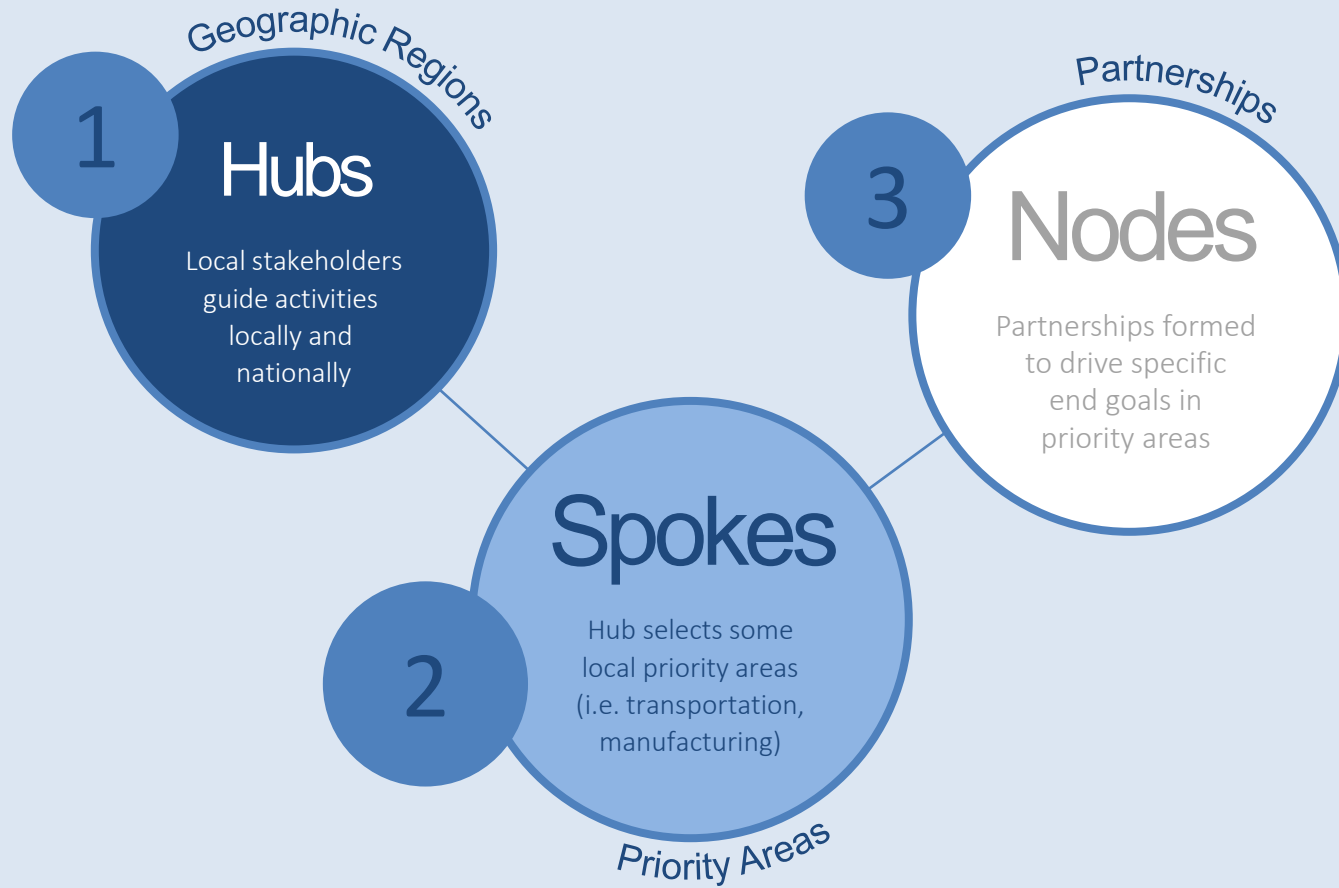
COMMUNITY BUILDING

White House BD Partners WS
Data to Knowledge to Action
BD Strategic Initiatives WS
BD Regional Innovation Hubs
EarthCube
RDA

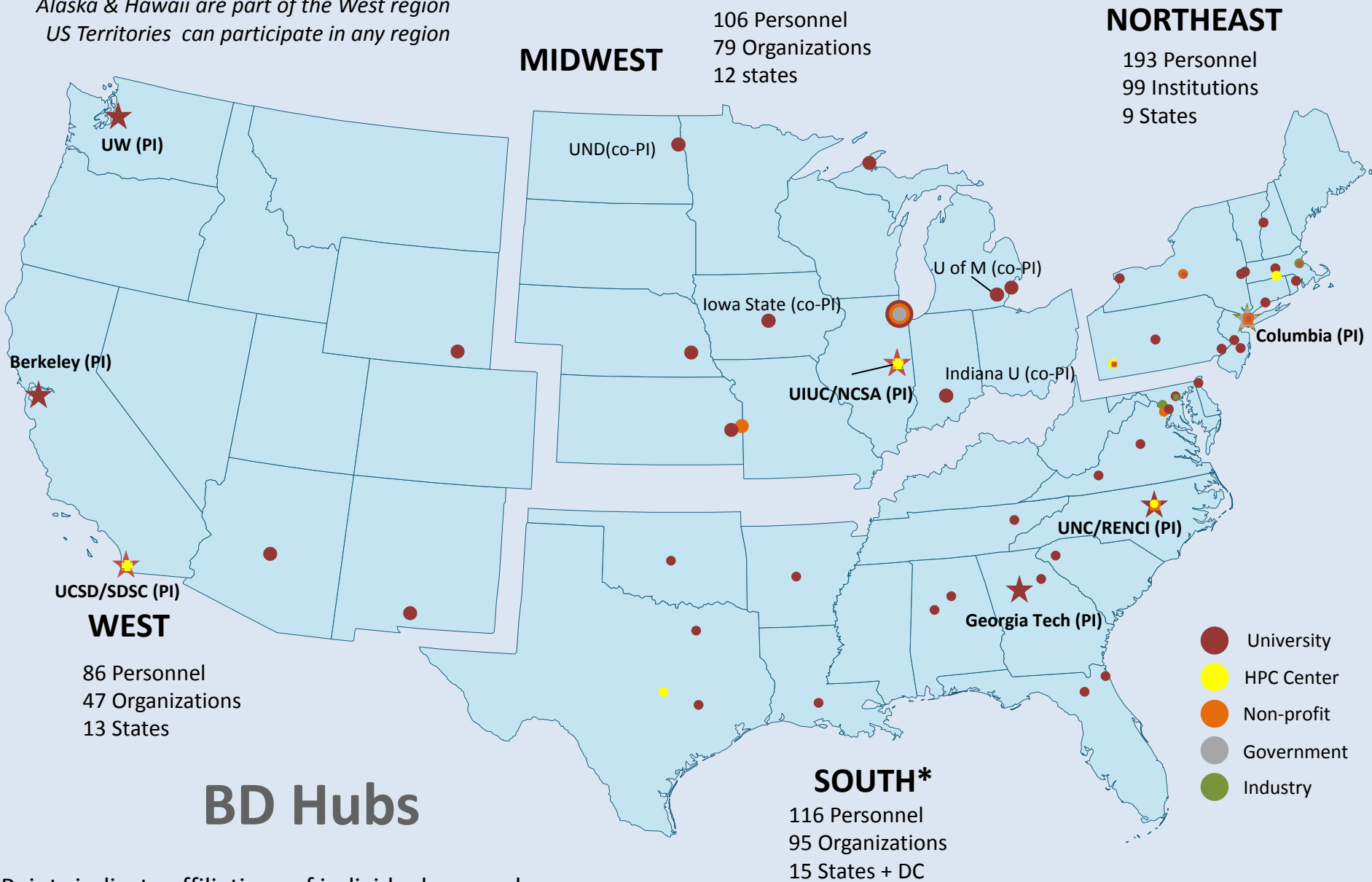


Big Data Regional Innovation Hubs

“Hub and Spoke” – A Nation-Wide Network for Data Innovation



Alaska & Hawaii are part of the West region
US Territories can participate in any region



Points indicate affiliations of individuals named as steering council members and/or task leads.

*South points indicate Senior Personnel



Education & Workforce Development



“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

.... more thoughts shortly on workforce development



UMass Amherst Center For Data Science

UMASS
AMHERST

COLLEGE OF INFORMATION AND COMPUTER SCIENCES Center for

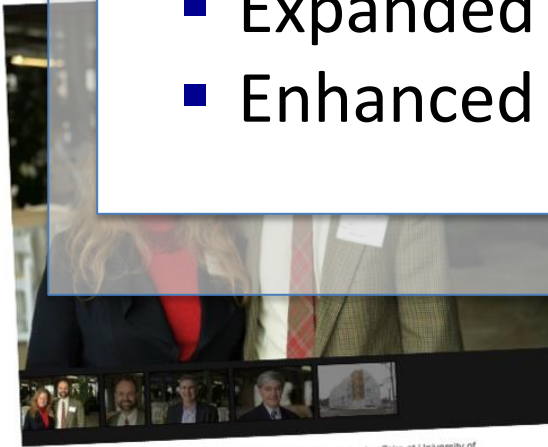
Data Science

Launch Event, April 9, 2015

Center goals:

- Expanded data science education
- Expanded data science research
- Enhanced industry engagement

UMass
Center
to har



Katherine Newman, left, provost and senior vice chancellor for academic affairs at University of Massachusetts Amherst and Andrew McCallum, professor and director of Center for Data Science Thursday at launch symposium for the CDS, April 9, 2015. (Michael S. Gordon / The Republican)

The Boston Globe



“80 new faculty, \$100m”



Federal Agency Activities, Programs

- NSF: BIGDATA , CDS&E, DIBBS, NRT
- NIH: BD2K (Big Data to Knowledge)
- DARPA Information Innovation Office (I2O)
- NIST Big Data Public Working Group
- DOE SciDAC Program

- NITRD Big Data Senior Steering Group
 - Membership: 18 federal R&D agencies
 - Co-chaired by NSF and NIH

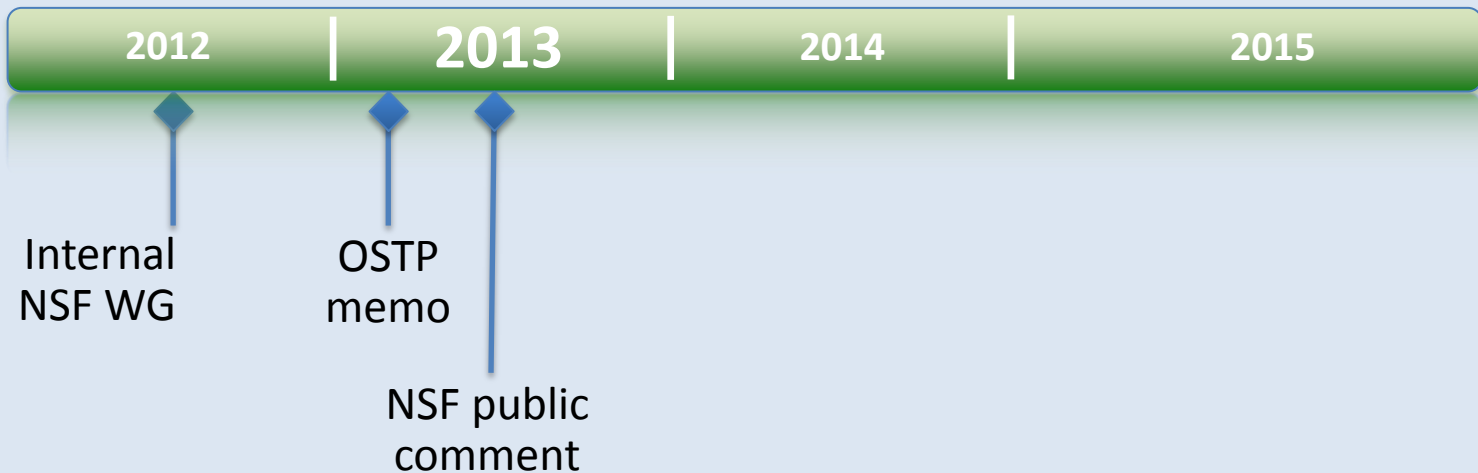


NITRD (Program)

- primary mechanism by which US Government coordinates its unclassified Networking and IT R&D (NITRD) investments
- supports NIT-related policy making in the White House Office of Science and Technology Policy (OSTP)



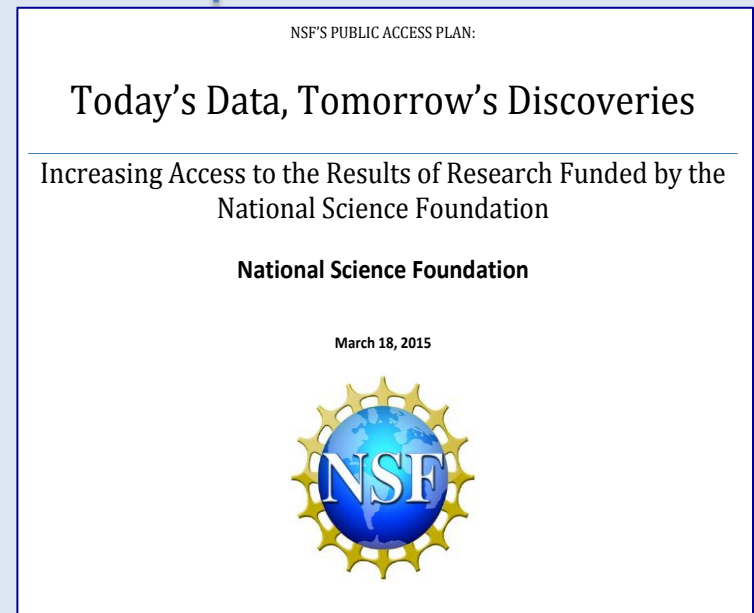
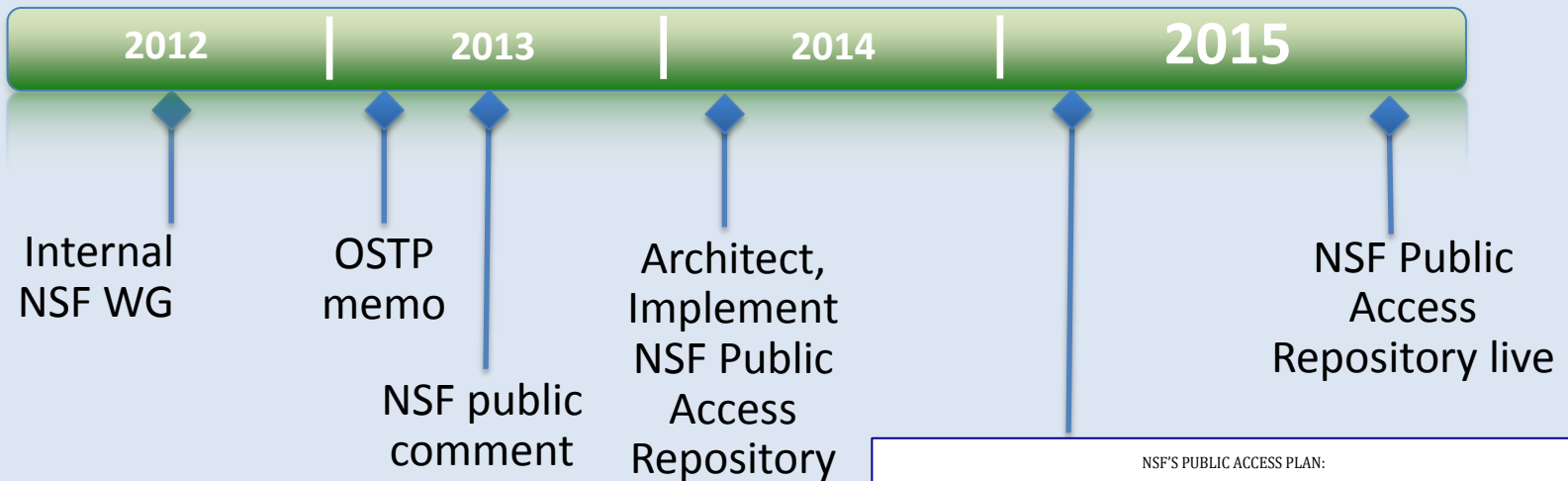
NSF Public Access: a brief history



OSTP: directs federal agencies to develop plans to make *publicly available* to the “greatest extent and with the fewest constraints possible and consistent with law” *the “direct results of federally funded scientific research.”*



NSF Public Access: a brief history



NFS Public Access Plan: publications

- NSF Public Access Repository: par.nsf.gov
 - public access to journal, refereed conference publications from awards starting in FY16
 - PI deposit, public search
- Extensible for data, other research products



NFS Public Access Plan: data

Data Management Plans:

- “data management is dynamic and practices vary substantially across the broad range of scientific disciplines supported by NSF” [NSF 15-52]
- “What constitutes reasonable data management and access will be determined by the community of interest through the process of peer review and program management. In many cases, these standards already exist, but are likely to evolve as new technologies and resources become available” [Data Management & Sharing Frequently Asked Questions (FAQs)]



NFS Public Access Plan: data

- Individual NSF directorates (e.g., BIO, CISE) have released updated DMP guidance
- Longer term:
 - continued discussion, consultation with multiple agencies
 - roles, responsibilities, business models for data repositories



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Federal Cybersecurity R&D Strategic Plan



TRUSTWORTHY CYBERSPACE:
STRATEGIC PLAN FOR THE
FEDERAL CYBERSECURITY
RESEARCH AND
DEVELOPMENT PROGRAM

Executive Office of the President
National Science and Technology Council

DECEMBER 2011



- Research Themes
 - Tailored Trustworthy Spaces
 - Moving Target
 - Cyber Economic Incentives
 - Designed-In Security
- Science of Cyber Security
- Support for National Priorities
- Transition to Practice

<http://www.whitehouse.gov/blog/2011/12/06/federal-cybersecurity-rd-strategic-plan-released>



Secure and Trustworthy Cyberspace (SaTC)

Securing our Nation's cyberspace

- Broad, interdisciplinary partnership: CISE, SBE, EHR, ENG, MPS
- Aligns with President's *Strategic Plan for the Federal Cybersecurity Research and Development Program* (2011)
- Partnerships with industry:
 - Trustworthy Computing program (including STARSS SRC)
 - NSF/Intel Partnership on Cyber-Physical Systems Security and Privacy
- education
- *an inter-disciplinary, socio-technical challenge*



Image Credit: ThinkStock



Image Credit: ThinkStock



SaTC Overview

- \$75-80M/year in research funding, ~700 active projects
- Comprehensive & Multifaceted: Soup to Nuts
 - grass-roots proposals of research from the community (as usual for NSF) guided by a framework of national needs and priorities
- Broad scope of research encompassing technical, social, and educational perspectives to improving cybersecurity
- Encourage inter-disciplinary and cross-disciplinary research
- Advance education in K-12, undergrad, grad, professional, and general society
- Technology transition to NSF research, industry, government

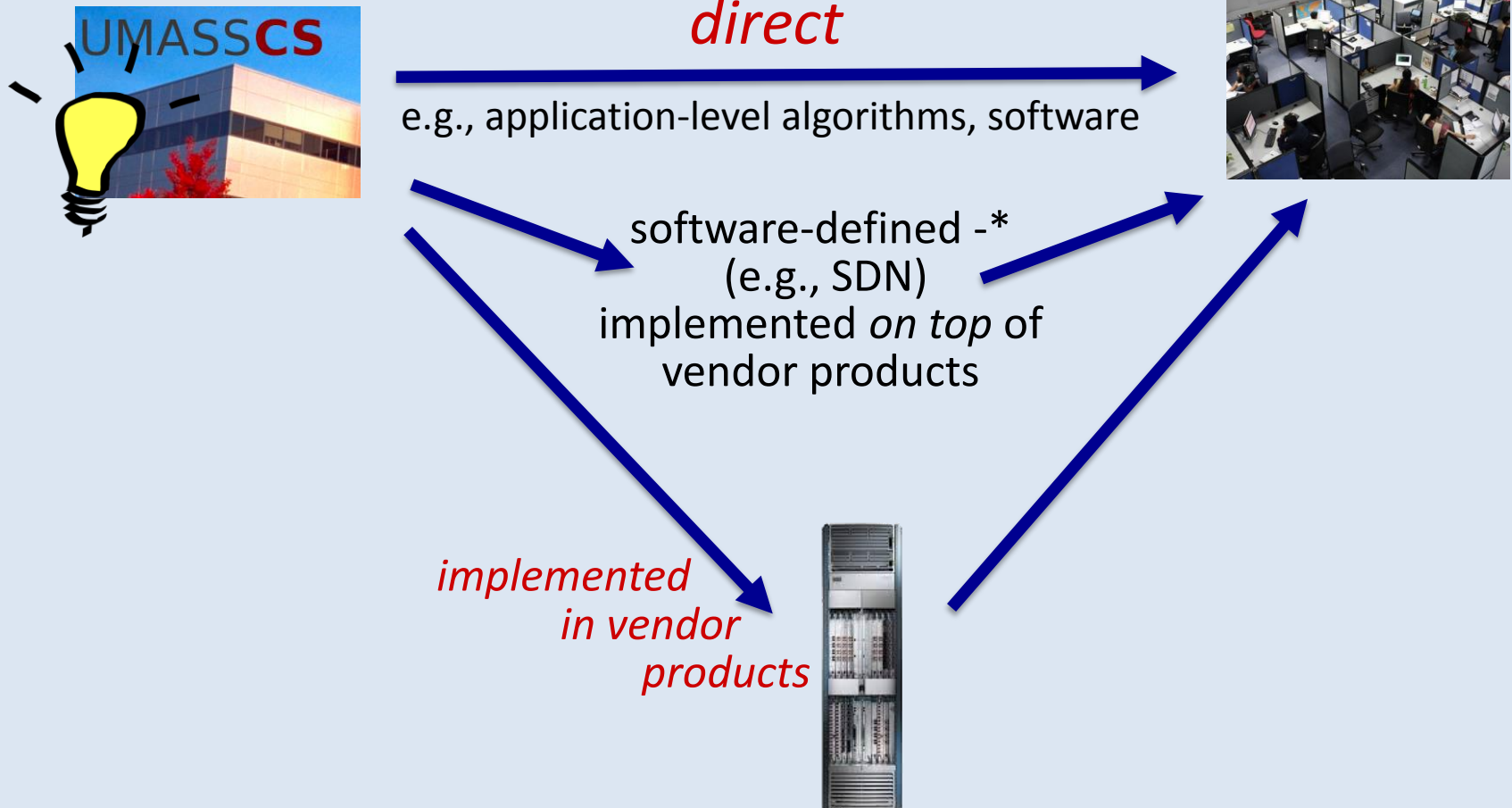


Selected NITRD Agency CSIA Budgets

Selected Agencies	Cyber Security & Information Assurance (CSIA) R&D (Unclassified)	
	FY 2014 Actual	FY 2016 Requests
DARPA	\$265M	\$298M
OSD, DoD Service Research Organizations	\$182M	\$156M
NSF	\$103M	\$112M
DHS S&T	\$78M	\$69M
NIST	\$62M	\$73M
DOE	\$31M	\$30M
Total	\$721M	\$738M

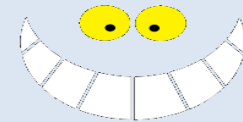
Industry/academic research collaboration

... in cybersecurity ... from idea to solution



Industry/academic research collaboration

people!

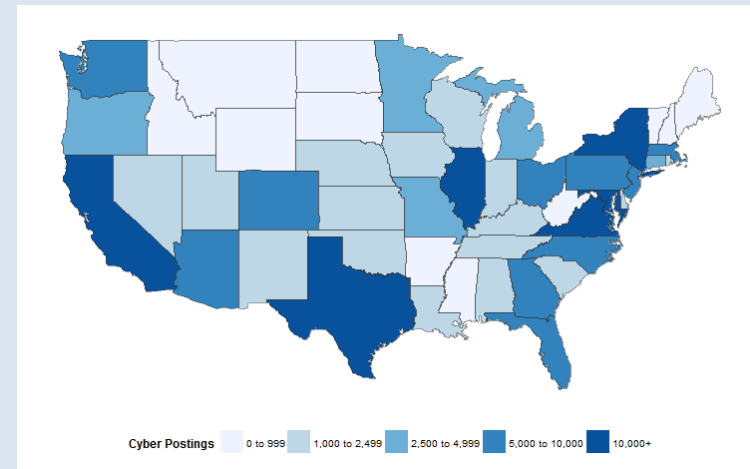


Cybersecurity Job Postings by State

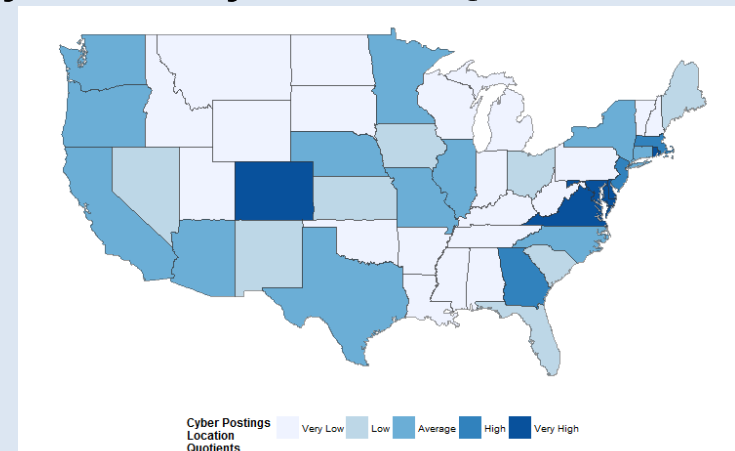
Top States by Total Postings*

	State	Total Postings	Location Quotient**	% Growth (2010-2014)
1	California	28,744	1.02	75%
2	Virginia	20,276	3.09	38%
3	Texas	18,525	0.92	113%
4	New York	14,089	0.97	104%
5	Illinois	11,428	1.16	163%
6	Maryland	11,406	2.40	39%
7	Florida	9,847	0.67	135%
8	Georgia	8,757	1.22	121%
9	New Jersey	8,268	1.21	80%
10	Massachusetts	7,911	1.45	92%
11	Colorado	7,688	1.77	111%
12	North Carolina	7,503	1.06	127%
13	Ohio	6,281	0.72	141%
14	Pennsylvania	5,745	0.59	69%
15	Arizona	5,502	1.18	87%

Cybersecurity Job Postings in 2014 By State



Cybersecurity Location Quotient in 2014



*See Appendix 1 for state-level data tables on total postings and postings growth.

**Location quotients show how concentrated demand is in a particular geography relative to employment in that area. National location quotient equals 1.0; an LQ of 1.2 indicates that demand is 20% more concentrated than nationally.

Cybersecurity Ed: meeting the challenge

- *Challenge*: changing undergrad curriculum difficult (no knobs)
 - cybersecurity: typically, advanced undergrad elective
 - integration throughout curriculum?
- *learning from our (MA) past*: Commonwealth Information Technology Initiative (CITI)

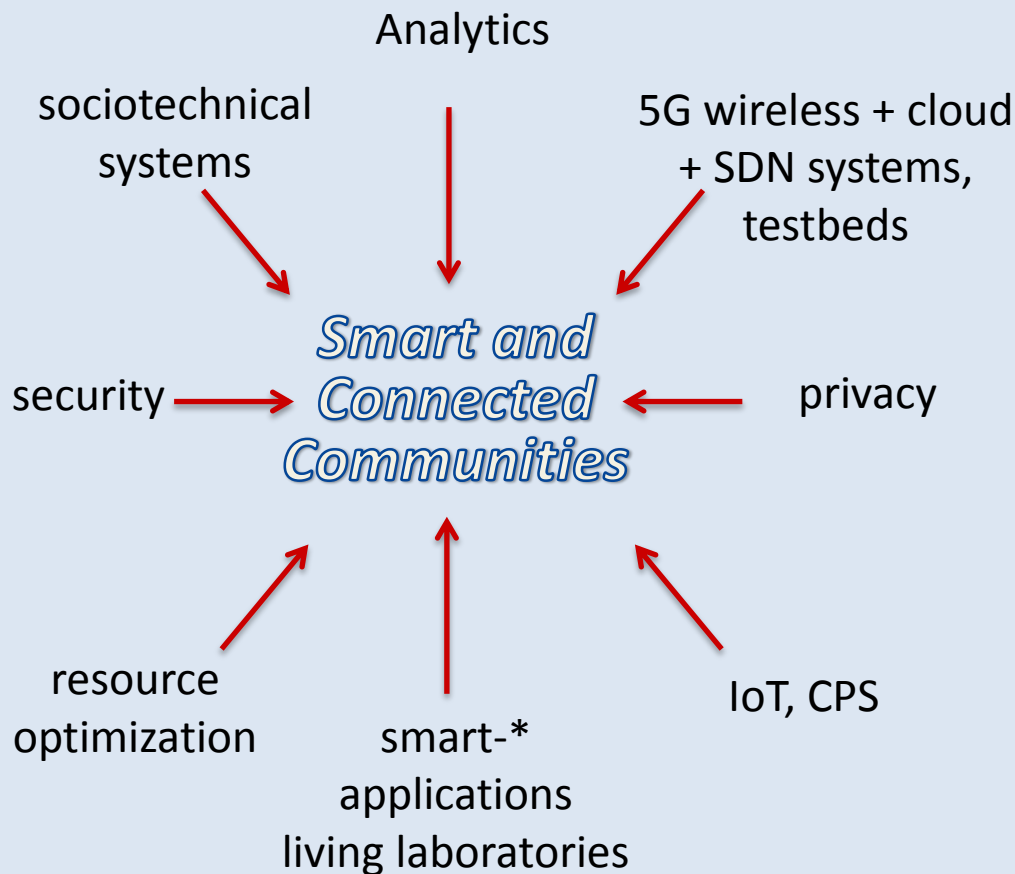
CITI

- launched in 2000, funded by BHE
- All segments of public higher education, with industry
- “strengthen and modernize computer science and IT programs” in MA public higher ed.



Smart and Connected Communities

Computing embedded around us



Press Release 15-103

Cultivating smart and connected communities

NSF exhibits commitments in support of White House Smart Cities Initiative



NSF has long supported the fundamental research that underlies smart and connected communities.

[Credit and Larger Version](#)

September 14, 2015

The White House today kicked off the first-ever [Smart Cities Week](#) (Sept. 15-18, 2015), announcing new steps in support of a National Smart Cities Initiative.

As part of this initiative, the National Science Foundation (NSF) committed nearly \$40 million to help intelligently and effectively design, adapt and manage the smart and connected communities of the future at today's event.



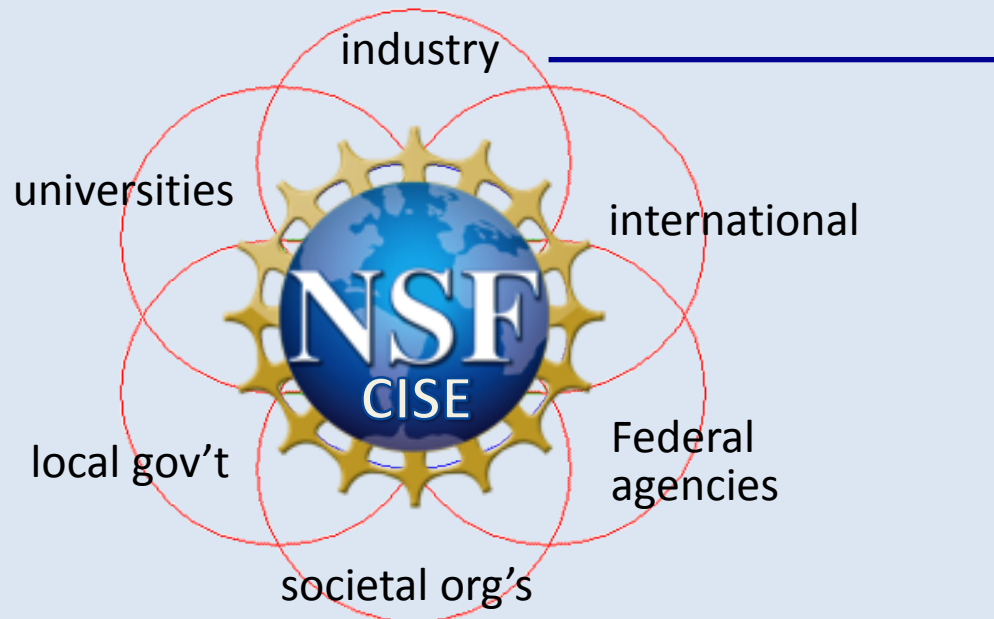
Overview

- NSF/CISE: overview
- Big Data
- Cyber security
- **Concluding thoughts**

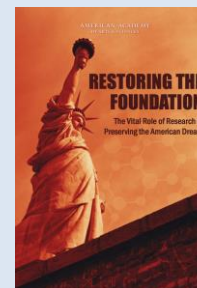


Partnerships: Many dimensions

Partnerships **build capacity, leverage resources, increase the speed of translation** from discovery to innovation



- SaTC STARRS; SRC
- VEC & CPS Security: Intel
- Innovation Transition (InTrans) DCL for Expeditions & Frontiers



Prescription 3: Regain America's Standing as an Innovation Leader by Establishing a More Robust National Government-University-Industry Research Partnership



Partnerships: Many dimensions

Partnerships **build capacity, leverage resources, increase the speed of translation** from discovery to innovation



- Cyber Physical Systems (CPS): DHS, DOT, NASA, NIH
- National Robotics Initiative (NRI): DOD, NASA, NIH, USDA
- Smart and Connected Health (SCH): NIH
- Collaborative Research in Computational Neuroscience (CRCNS): NIH

(all joint with other NSF directorates)



Partnerships: Many dimensions

Partnerships **build capacity, leverage resources, increase the speed of translation** from discovery to innovation



- Collaborative Research in Computational Neuroscience (CRCNS): Germany, France, Israel
- USICCS: Israel
- SaTC DCL: Israel
- Automation design DCL: Germany
- Big Data and Disaster Research (BDD): Japan,
- NeTS JUNO: Japan
- WiFiUS: Finland
- + more



Conclusion

- incredible opportunities in data science, cybersecurity
- areas of critical national, societal importance and need
- partnerships crucial



An amazing time to be in CISE!

- ***Ubiquity:*** computing seems to be everywhere
 - science and engineering, workforce, societal
- ***Engagement:*** with many communities
- ***Urgency:***
 - rapidly expanding and evolving field in a time of fiscal uncertainty
 - sustainability, acceleration of research and education investments



THANKS!



SATC Frontiers Portfolio: 2012-2014

Redo this slide to make visually more appealing

Data Privacy

- Privacy Tools for Sharing Research Data (2012)
- Harvard University
- \$4.8M for 4 years

Socio-economic

- Beyond Technical Security: Developing an Empirical Basis for Socio-Economic Perspectives (2012)
- UCSD, Berkeley, GMU
- \$10M for 5 years

Healthcare

- Enabling Trustworthy Cybersystems for Health and Wellness (2013)
- Dartmouth, UIUC, JHU, Michigan
- \$10M for 5 years

Web Privacy

- Towards Effective Web Privacy Notice and Choice: a Multi-disciplinary Perspective (2013)
- CMU, Fordham, Stanford
- \$3.75M for 4 years

Trust in Cloud

- Rethinking Security in the Era of Cloud Computing (2013)
- UNC, NCSU, Stony Brook, Duke, Wisconsin-Madison
- \$6M for 5 years

Outsourced Computation

- Modular Approach to Cloud Security (2014)
- BU, MIT, Northeastern, U. Connecticut
- \$4.9M for 5 years

Program Obfuscation

- Center for Encrypted Functionalities (2014)
- UCLA, Stanford, Columbia, UT Austin, JHU
- \$10M for 5 years

