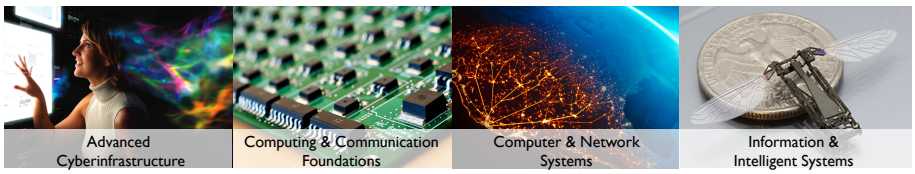
An Expanding and Expansive View of Computer and Information Science and Engineering



Jim Kurose
Assistant Director, NSF
Computer & Information Science & Engineering

Rutgers CS 50th Anniversary, Oct. 2016

RUTGERS
School of Arts and Sciences

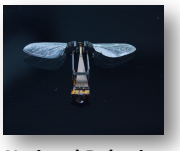
Computer Science Department 50th Anniversary Event

Overview

- CISE: the national imperative
- NSF and CISE
- Future challenges and opportunities (CISE)

CISE Research: Addressing National Priorities

Big Data R&D



National Robotics Initiative

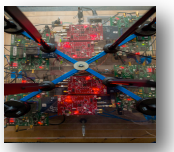
Understanding the Brain

White House Initiatives

National Strategic Computing Initiative

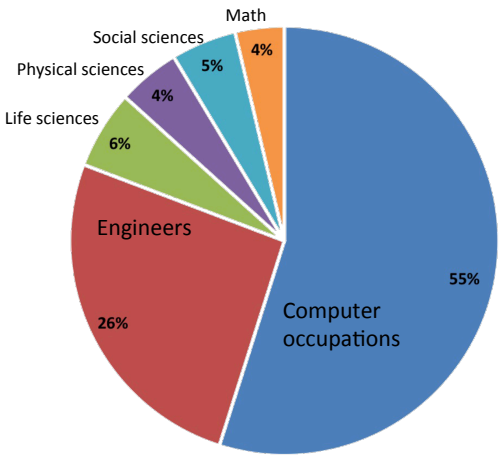
Smart Cities

CS for All



Advanced Wireless Initiative

Many STEM jobs are in computing



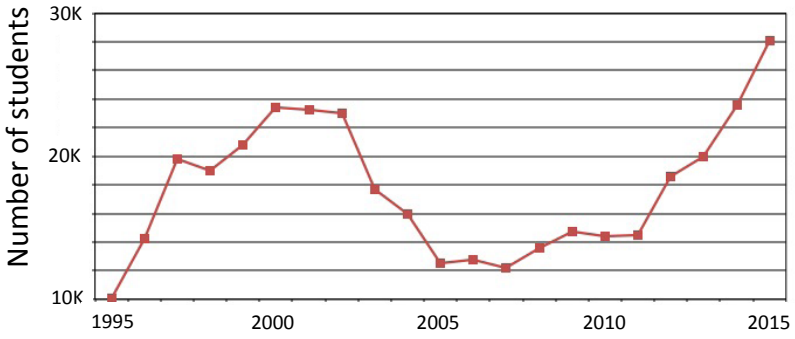
Job Openings 2014 – 2024 (growth and replacement)

US Bureau of Labor Statistics

Data from the spreadsheet linked at http://www.bls.gov/emp/ind-occ-matrix/occupation.xlsx

Growth in CS Undergrad Majors

Newly declared undergrad CS/CE majors

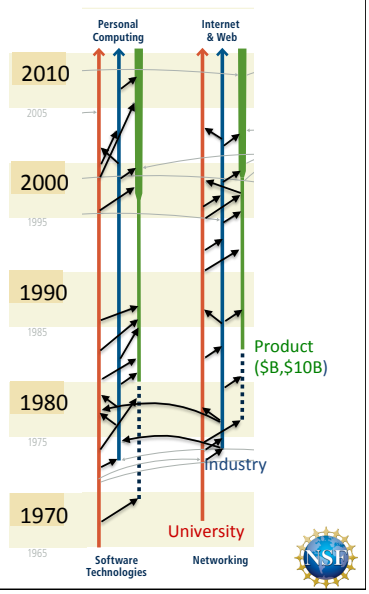


Source: 2015 CRA Taulbee Survey

From federally-funded research to $B industries

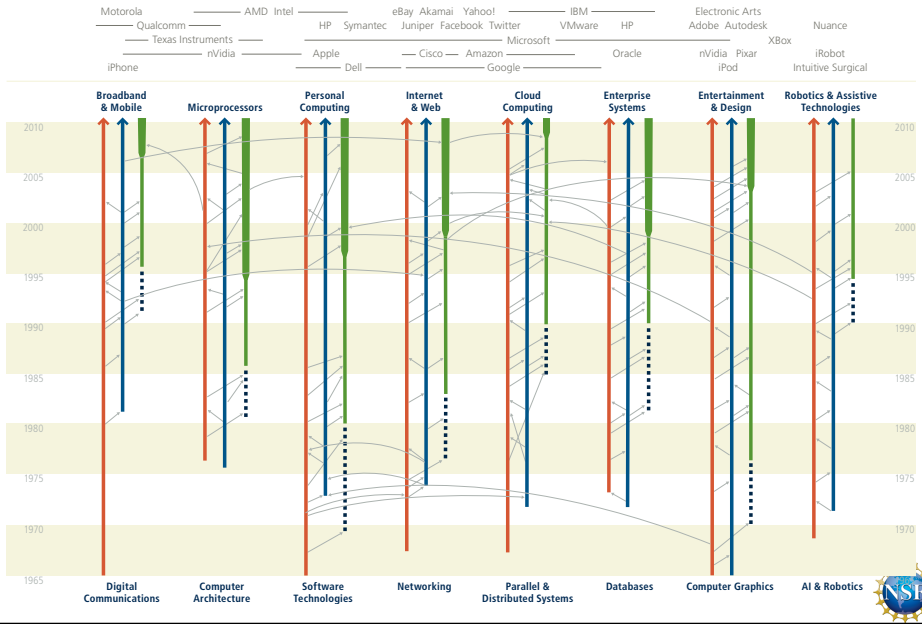
Advances in computing, communications, information technologies, cyberinfrastructure:

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



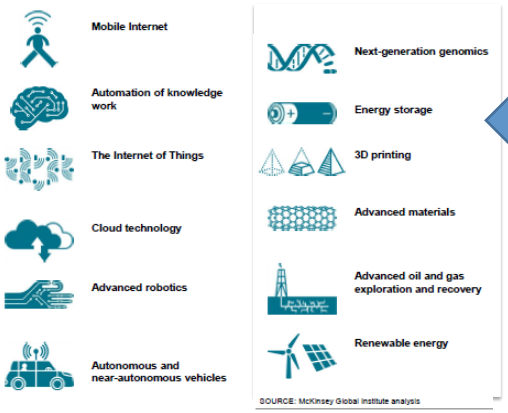
From *Continuing Innovation in Information Technology*, NRC, 2012.

…. across many industries



… and this impact will continue

Top twelve economically disruptive technologies (by 2025)



CS and national economic competitiveness: on beyond the Internet and Google

Machine Learning

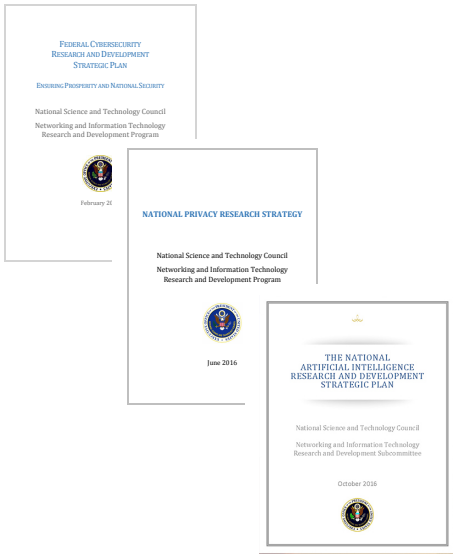
- Big Data Analytics Market: $125B (Forbes)
- Eric Schmidt: (Google/Alphabet):
  - Google Pittsburgh: generated $30-40B in profit for Google
  - NSF: "where all interesting research gets started…"

Software-Defined Networking (SDN)

- $8B in 2018 (IDC)
- Foundational research: "*Open Programmable Mobile Internet 2020," NSF/*CISE Expeditions Award, 2008, N. McKeown, Stanford U.

NSF/CISE: research leadership in government

- *2016 Federal R&D Strategic Plans:*
  - Privacy
  - CyberSecurity
  - Artificial Intelligence
- Networking and Information Technology R&D (NITRD)
  - Coordination among 18 18 federal agencies



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

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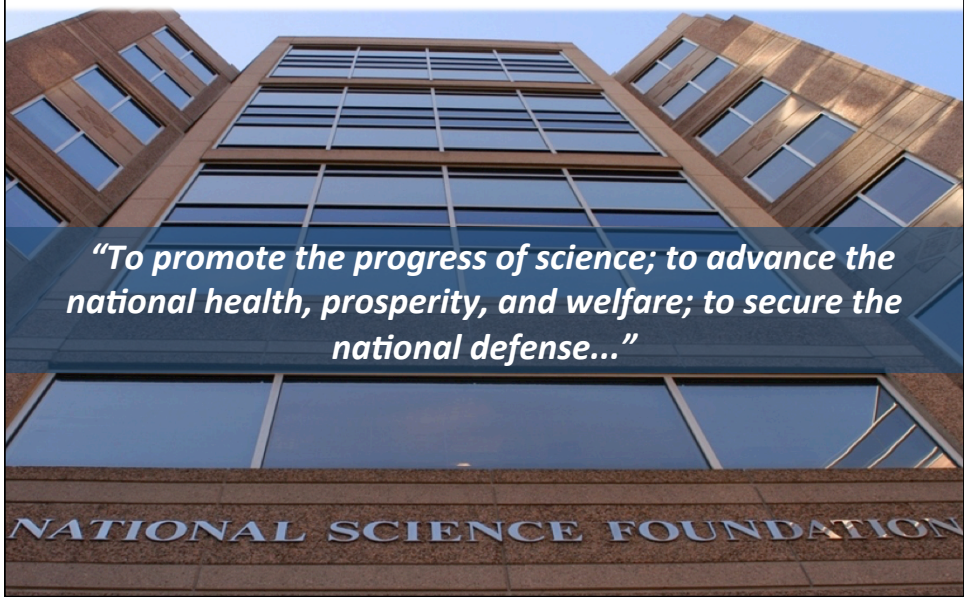
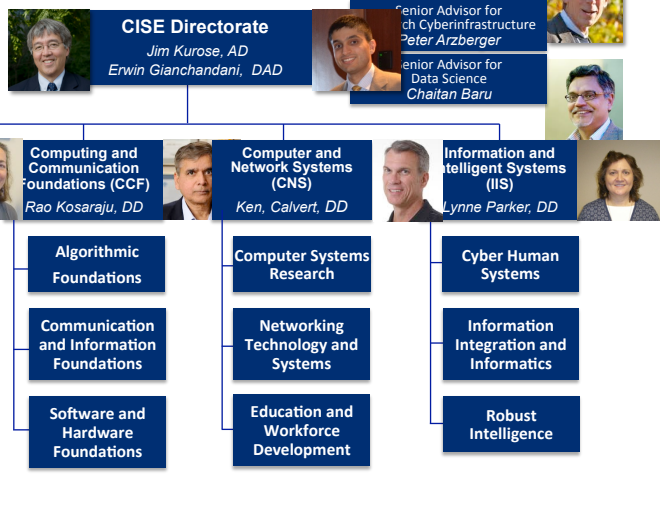
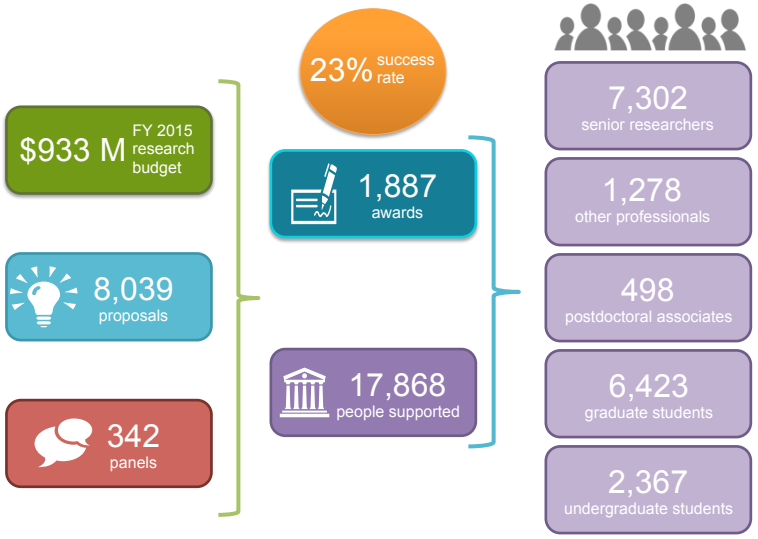
National Science Foundation's Mission



CISE Organization

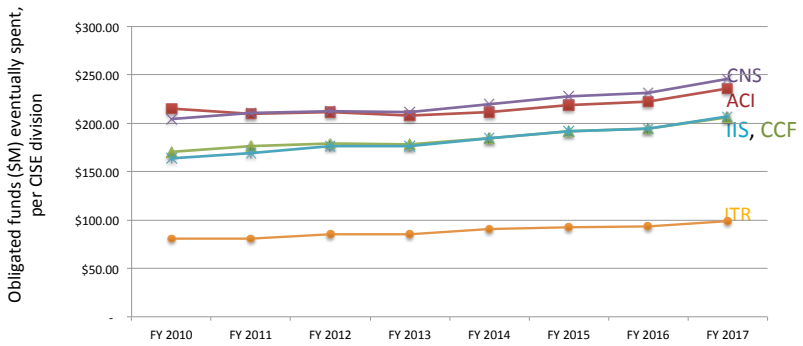


CISE by the Numbers: FY 2015



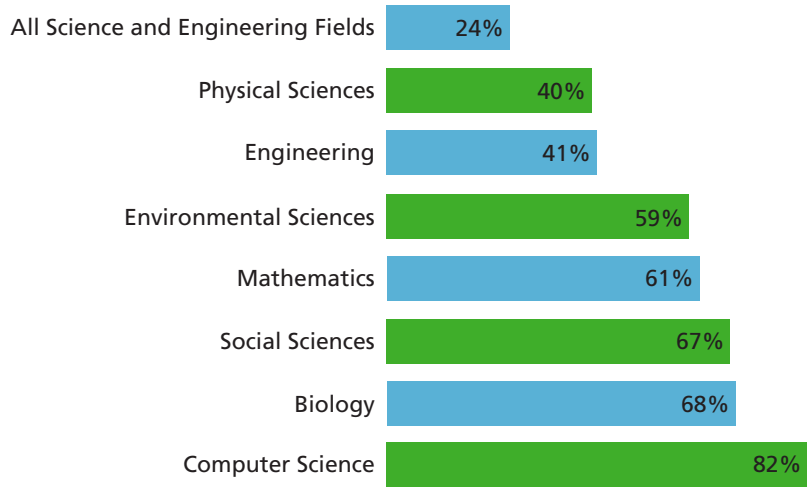
CISE Division Budgets

Modest growth across all CISE divisions



NSF Support of Academic Basic Research

(as a percentage of total federal support)



Source: NSF/NCSES, Survey of Federal Funds for Research & Development, FY 2014

An expanding, expansive view of computing

CISE foundations

Theoretical foundations	Computational science
Algorithms	Software
Programming languages	Security
Learning	Intelligence
Systems: networks, OS, DB	Computational neuroscience
data to knowledge to action	Information sys
Societal impacts	Communication, control

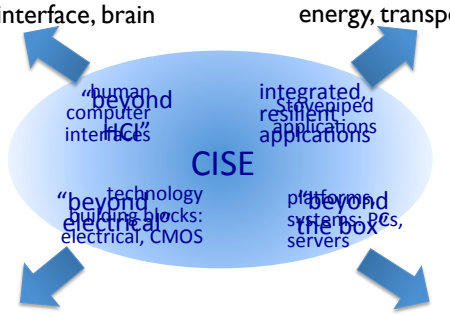
An expanding, expansive view of computing

Human-centered computing

Assistive technologies, affective computing, social informatics, mind/machine interface, brain

Science, societal applications

Science, engineering, humanities health, security, environment. energy, transport, commerce, education



Nano, quantum, molecular, optical

Changing "physicalness" of computing

Smart vehicles & buildings, cyber-physical systems, swarms, mobile/cloud

computing embedded around us

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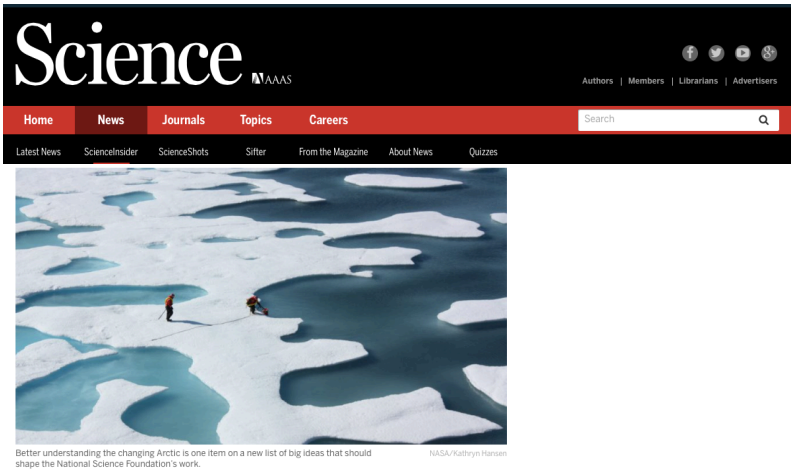
NSF "Big Ideas"



NSF "Big Ideas"

RESEARCH IDEAS

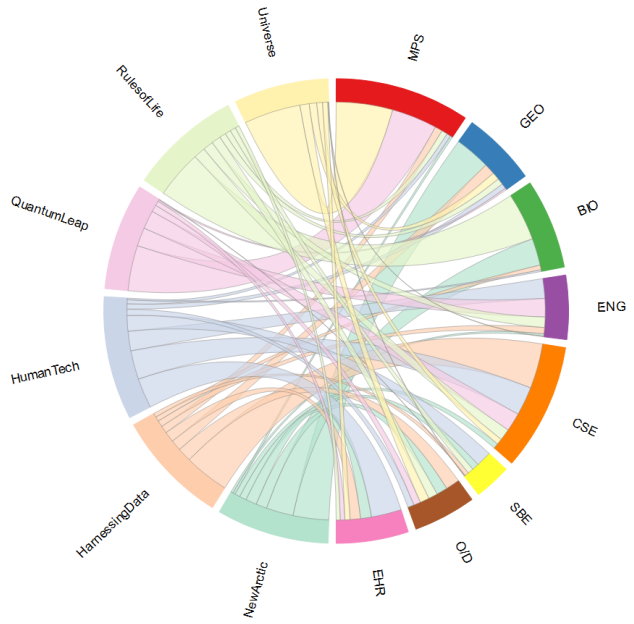
- Harnessing Data for 21st Century Science and Engineering
- Shaping the new Human – Technology Frontier
- Understanding the Rules of Life: Predicting Phenotype
- The Quantum Leap: Leading the Next Quantum Revolution
- Navigating the New Arctic
- Windows on the Universe: The Era of Multi-messenger Astrophysics

PROCESS IDEAS

- Growing Convergent Research at NSF
- Mid-scale Research Infrastructure
- NSF 2050
- INCLUDES

*Video of NSB presentation and discussion is at:
http://www.tvworldwide.com/events/nsf/160505/globe_show/default_go_archive.cfm?gsid=2957&type=flv&test=0&live=0
(the presentation/discussion starts about 20 minutes into this video)

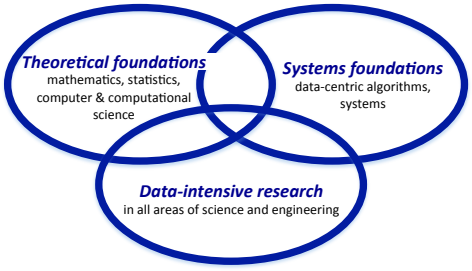
An Interconnected NSF – Solving the Big Idea Challenges Together



D/OIA

Harnessing the Data Revolution

Research across all NSF Directorates



Educational pathways

Innovations grounded in an education-research-based framework

Advanced cyberinfrastructure ecosystem

Accelerating data-intensive research

Work at he Human-Technology Frontier: Shaping the Future

Emerging technologies and human-technology interactions are transforming the world of work and the lives of workers

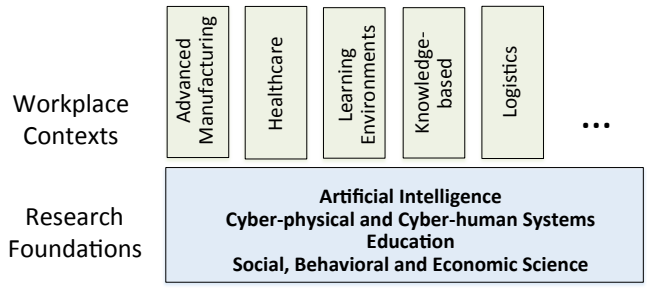
Understanding how constantly evolving technologies are actively shaping our lives and how we in turn can shape those technologies, especially in the world of work

- understand benefits, risks of new technologies: efficiency, quality, productivity, human dynamics
- science and engineering: creating technologies that promise to enhance work lives
- *Education:* changing work*place* demands changing work*force*

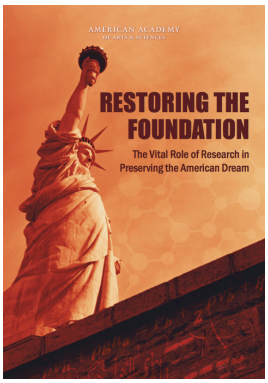
Work at he Human-Technology Frontier: Shaping the Future

Seamless collaboration between human, cyber-enabled systems:

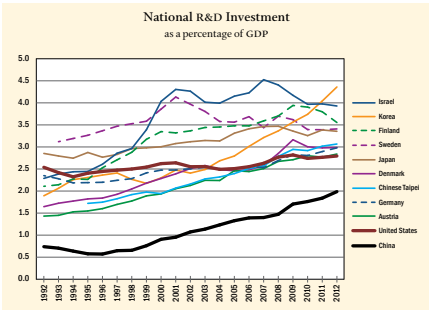
- understanding of reciprocal human-technology interactions;
- Systems: tailored, optimized, continuously adapted for humans; and
- education and lifelong learning to create requisite workforce



Challenge: research investment



American Academy of Arts & Sciences, 2014, available at https://www.aau.edu/WorkArea/DownloadAsset.aspx?id=15491.



- US: now 10th in national R&D (% GDP)
- investment federal support for basic research down 13% from 10 years ago (% of GDP)
- CISE: *growing* field

Partnerships: Many dimensions

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

- NSF/SRC: E2CDA
- NSF/Intel: Information-Centric Networking in Wireless Edge Networks
- NSF/VMware: Software Defined Infrastructure as a Foundation for Clean-Slate Computing Security
- Innovation Transition DCL
- Infrastructure collaborations

Prescription 3: 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): DARPA, NASA, NIH, USDA
- Smart and Connected Health (SCH): NIH
- Collaborative Research in Computational Neuroscience (CRCNS): NIH

all joint with other NSF directorates

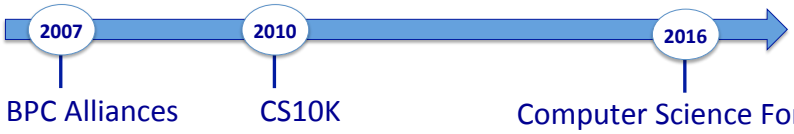
Partnerships: Many dimensions

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

New 2016 activities

- NSF-BSF (Israel): CCF and CNS core, SATC
- US-Japan: interest in BIGDATA, ML
- NSF-Finland: WIFUS
- NSF-India: S&CC
- NSF-Netherlands: privacy
- NSF-Brazil: cybersecurity

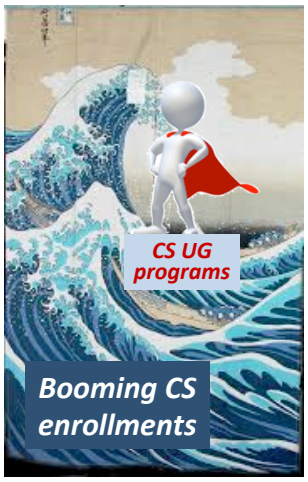
Education: Computer Science for All

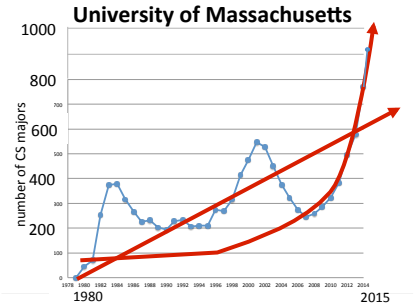


- Enable *all* students to have access to high-quality CS education in K-12:
  - Knowledge base, capacity for rigorous, engaging CS education
  - Teacher PD
- Inter-agency WG under CoSTEM kicking off today!
- Collaboration: industry, non-profits
- NSF: $120 million over five years

"In the new economy, computer science isn't an optional skill – It's a basic skill…"
President's Weekly Address 1/30/2016

Education

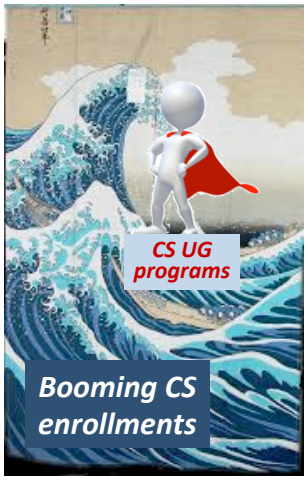




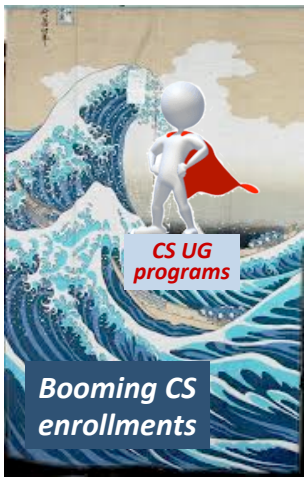
Explosion of interest seems different this time around

- broader interests
- minors, other disciplines

Education

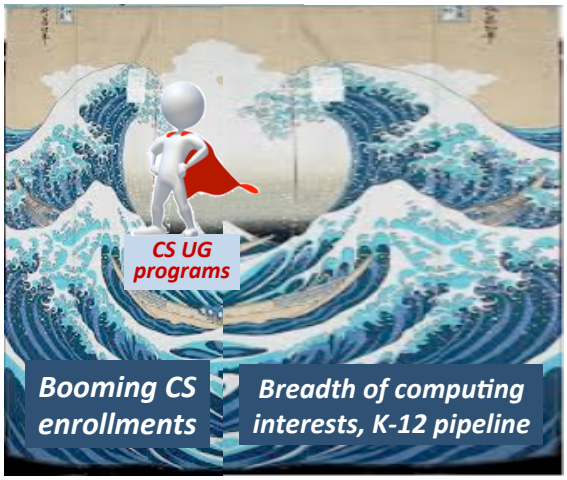


Education



- Increasing CISE footprint, program sizes imply increasing TT faculty sizes?
  - additional grant pressures
  - funding expectations based on history 10+ years ago
  - career pathways for PhD students?
- Interesting reading:
  - "Rescuing US Bio-medical Research from its systemic flaws," Alberts, Kirschner, Tilgham, Varmus, *PNAS*

Education



- *second sea change (tsunami):* broadening interest in computing among incoming students
- success of K-12 activities
- CS+X

An *amazing* time to be in CISE!

Ubiquity — Computing is *everywhere* – across all of science and engineering, and all of society

Engagement — Computing intertwines with many *communities*

Urgency — Computing is *rapidly expanding and evolving*. There is tremendous opportunity … *now!*

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THANKS!