The State of Computing

Dr. Erwin Gianchandani
Director, Computing Community Consortium
Computing Research Association

Consortium for Computing Sciences in Colleges (CCSC)
Eastern Conference 2011
Marymount University | October 14, 2011

Objective

“Future trends in computing”

- Overview of the Computing Research Association and the Computing Community Consortium
- What we’re seeing nationally
- Future directions and drivers

Computing Research Association

Arizona State University - CSE
Auburn University - CSSE
Ball State University - CS
Boston College - CS
Boston University - CS
Bowdoin College - CS
Bowling Green State University - CS
Bradley University - CS
Brandeis University - CS
Brigham Young University - CS
Brown University - CS
Bryn Mawr College - MCS
Bucknell University - CS
California Institute of Technology - CS
California Polytechnic State University - CS
California State University, Chico - CS
Carnegie Mellon University - CS
Case Western Reserve University - EECS
City University of New York, Graduate Center - CS
Clemson University - CS
Colgate University - CS
College of William & Mary - CS
Colorado School of Mines - MCS
Colorado State University - CS
Columbia University - CS
Cornell University - CS
Cornell University - ECE
Dalhousie University - CS
Dartmouth College - CS
DePaul University - CS
Drexel University - CS
Drexel University - IST
Duke University - CS
Emory University - MCS
Florida Atlantic University - CSE
Florida Institute of Technology - CS
Florida International University - CS
Florida State University - CS
Florida State University - IS
George Mason University - CS
George Washington University - CS
Georgia Institute of Technology - CSE
Georgia Southern University - IT
Georgia State University - CIS
Georgia State University - CS
Grinnell College - MCS
Harvard University - CS
Harvey Mudd College - CS
Hofstra Universyt - CS
Illinois Institute of Technology - CS
Illinois State University - ACS
Indiana University - CS
Indiana University - I
Iowa State University - CS
Iowa State University - ECE
Johns Hopkins University - CS
Johns Hopkins University - SI
Juniata College - IT & CS
Kansas State University - CIS
Kent State University - CS
Lafayette College - CS
Lehigh University - CSE
Long Island University - ICS
Louisiana State University - CS
Loyola University, Chicago - CS
Massachusetts Institute of Technology - EECS
Miami University - CS
McMaster University - CE&S
Michigan State University - CSE
Michigan Technological University - CS
Mississippi State University - CS
Montana State University - CS
Montclair State University - CS
National University of Singapore - CS/IS
Naval Postgraduate School - CS
New Jersey Institute of Technology - CCS
New Mexico State University - CS
New York University - CS
North Carolina State University - CS
Northeastern University - CIS
Northwestern University - ECE
Nova Southeasern University - CS
Oakland University - CSE
Ohio State University - CSE
Ohio University - EECS
Oklahoma State University - CS
Old Dominion University - CS
Oregon Health & Science University - CSE
Oregon State University - EECS
Pace University - CSIS
Pennsylvania State University - CSE
Pennsylvania State University - IST
Polytechnic University - CIS
Pomona College - MCS
Portland State University - CS
Princeton University - CS
Purdue University - CS
Purdue University - ECE
Rensselaer Polytechnic Institute - CS
Rice University - CS
Rochester Institute of Technology - CS
Roosevelt University - CS&T
Rutgers University, Busch Campus - CS
Saint Louis University - MCS
Santa Clara University - CE
Simon Fraser University - CS
Singapore Management University - IS
Southern Illinois University, Carbondale - CS
Southern Methodist University - CSE
Southern Polytechnic State University - CSE
Stanford University - CS
State University of New York, Albany - CS
State University of New York, Binghamton - CS
State University of New York, Stony Brook - CS
Stevens Institute of Technology - CS
Swarthmore College - CS
Syracuse University - IS
Temple University - CIS
Texas A&M University - CS
Texas State University - CS
Toyota Technological Institute at Chicago - CS
Tufts University - CS
Tulane University - EECS
Union College - CS
University at Buffalo - CSE
University at Buffalo - IS
University of Alabama, Birmingham - CIS
University of Alabama, Tuscaloosa - CS
University of Alberta - CS
University of Arizona - CS
University of Arkansas - CSCE
University of Arkansas at Little Rock - I
University of Calgary - CS
University of California, Berkeley - EECS
University of California, Berkeley - IMS
University of California, Davis - CS
University of California, Irvine - ICS
University of California, Los Angeles - CS
University of California, Riverside - CSE
University of California, San Diego - CSE
University of California, Santa Barbara - CS
University of California, Santa Cruz - CE
University of California, Santa Cruz - CS
University of Central Florida - CS
University of Chicago - CS
University of Cincinnati - ECECS
University of Colorado, Boulder - CS
University of Delaware - CIS
University of Denver - CS
University of Florida - CISE
University of Georgia - CS
University of Hawaii - ICS
University of Houston - CS
University of Houston - ECE
University of Idaho - CS
University of Illinois, Chicago - CS
University of Illinois, Urbana Champaign - CS
University of Illinois, Urbana Champaign - ECE
University of Iowa - CS
University of Kansas - EECS
University of Kentucky - CS
University of Louisiana at Lafayette - CACS
University of Louisville - CECS
University of Maine - CS
University of Maryland - CS
University of Maryland, Baltimore Co - CSEE
University of Maryland, Baltimore Co - IS
University of Massachusetts, Amherst - CS
University of Massachusetts, Boston - CS
University of Michigan - EECS
University of Michigan - I
University of Michigan, Dearborn - CIS
University of Minnesota - CSE
University of Minnesota, Duluth - CS
University of Mississippi - CIS
University of Missouri, Columbia - CS
University of Missouri, Rolla - CS
University of Montana - CS
University of Montreal - CS
University of Nebraska at Omaha - CS/IST
University of Nebraska, Lincoln - CSE
University of Nevada, Las Vegas - CS
University of Nevada, Reno - CSE
University of New Brunswick - CS
University of New Hampshire - CS
University of New Mexico - CS
University of New Mexico - ECE
University of North Carolina at Chapel Hill - CS
University of North Carolina at Chapel Hill - SILS
University of North Carolina, Charlotte - IT
University of North Dakota - CS
University of North Texas - CS
University of Notre Dame - CSE
University of Oklahoma - CS
University of Oregon - CIS
University of Pennsylvania - CIS
University of Pittsburgh - CS
University of Pittsburgh - IS
University of Puget Sound - MCS
University of Rochester - CS
University of South Alabama - CIS
University of South Carolina - CSE
University of South Florida - CSE
University of Southern California - CS
University of Southern California - EES
University of Tennessee, Knoxville - CS
University of Texas, Arlington - CSE
University of Texas, Austin - CS
University of Texas, Dallas - CS
University of Texas, El Paso - CS
University of Toronto - CS
University of Tulsa - MCS
University of Utah - CS
University of Virginia - CS
University of Washington - CSE
University of Washington - I
University of Washington, Bothell - CS
University of Washington, Tacoma - CSS
University of Waterloo - CS
University of Wisconsin, Madison - CS
University of Wisconsin, Milwaukee - EECS
University of Wyoming - CS
Utah State University - CS
Vanderbilt University - EECS
Virginia Commonwealth University - CS
Virginia Tech - CS
Wake Forest University - CS
Washington State University - EECS
Washington University in St. Louis - CS
Wayne State University - CS
West Virginia University - CSEE
Western Michigan University - CS
Williams College - CS
Worcester Polytechnic Institute - CS
Wright State University - CSE
Yale University - CS
York University - CS

Sun Microsystems (Sponsoring Member)
Microsoft Corporation (Sustaining Member)
IBM Research (Supporting Member)

Accenture Technology Labs
Argonne National Laboratory
Avaya
CA Labs
Computer Science Research Institute,
Sandia National Labs
Fraunhofer Center for
Experimental Software Engineering
Fujitsu Laboratories of America
Google
Hewlett-Packard Company
IDA Center for Computing Sciences
Intel Corporation
Lawrence Berkeley National Laboratory
Los Alamos National Laboratory
Lucent Technologies, Bell Labs
McAfee Research
Mitsubishi Electric Research Labs
National Center for Atmospheric Research
NCSA
NEC Laboratories America
NTT DoCoMo USA Labs
Pacific Northwest National Laboratory
Panasonic Information &
Networking Technologies Lab
Ricoh Innovations
San Diego Supercomputer Center
SAP Labs
SRI International
Telcordia Technologies

http://cra.org/ccc

Mission and activities

- Strengthen research and education in the computing fields
  - Working to influence **policy** that impacts computing research
  - Encouraging the development of **human resources**
  - Contributing to the cohesiveness of the professional **community**

Gov't. Affairs

CRA-W & CDC

- Collect and disseminate **information** about the importance and state of computing research

Taulbee Survey

Table 1. PhD Production by Type of Department and Rank

Department, Rank	PhDs	Avg. per Dept.	PhDs Next Year	Avg. per Dept.
US CS 1-12	[illegible]	[illegible]	288	26.2
US CS 13-24	215	17.9	241	20.1
US CS 25-36	[illegible]	[illegible]	205	17.1
US CS Other	[illegible]	[illegible]	962	8.4
US CS Total	1,501	10.0	1,696	11.3

What is the CCC?

- Established in 2006 through a multi-year cooperative agreement between the National Science Foundation and CRA
- Provides a voice for the national computing research community
- Facilitates the development of a bold, multi-themed vision for computing research – and communicates this vision to stakeholders

A broad-based Council

Leadership:
- Ed Lazowska, U of Washington (Chair)
- Susan Graham, UC-Berkeley (Vice-Chair)
- Erwin Gianchandani, CRA (Director)

Terms ending 2014:
- Deborah Crawford, Drexel
- Gregory Hager, Johns Hopkins
- John Mitchell, Stanford
- Bob Sproull, Oracle (ret.)
- Josep Torrellas, UIUC

Terms ending 2013:
- Randy Bryant, CMU
- Lance Fortnow, Northwestern
- Eric Horvitz, Microsoft Research
- Hank Korth, Lehigh
- Beth Mynatt, Georgia Tech
- Fred Schneider, Cornell
- Margo Seltzer, Harvard

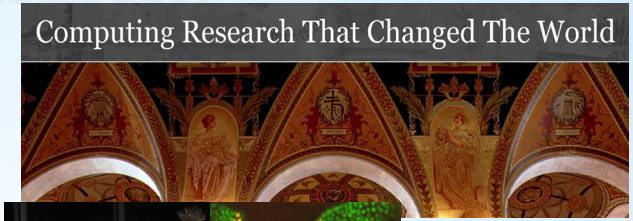
Terms ending 2012:
- Stephanie Forrest, U of New Mexico
- Chris Johnson, U of Utah
- Anita Jones, U of Virginia
- Frans Kaashoek, MIT
- Ran Libeskind-Hadas, Harvey Mudd
- Robin Murphy, Texas A&M

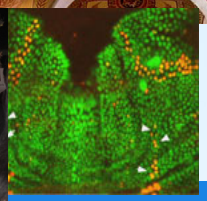
Rotated off:
- Greg Andrews, U of Arizona (ret.) (2009)
- Bill Feiereisen, Intel (2011)
- Dave Kaeli, Northeastern (2011)
- Dick Karp, UC-Berkeley (2010)
- John King, U of Michigan (2011)
- Peter Lee, Microsoft Research (2009)
- Andrew McCallum, U-Mass (2010)
- Karen Sutherland, Augsburg U (2009)
- Dave Waltz, Columbia (2010)

Meets three times a year, including an annual summer meeting in Washington, DC

A multitude of activities

- **Community-initiated visioning:**
  - Workshops that bring researchers together to discuss “out-of-the-box” ideas
  - Challenges & Visions tracks at conferences
- **Outreach to the White House, Federal funding agencies:**
  - Outputs of visioning activities
  - Short reports to inform policy makers
  - Task Forces -- Health IT, Sustainability IT, and Data Analytics



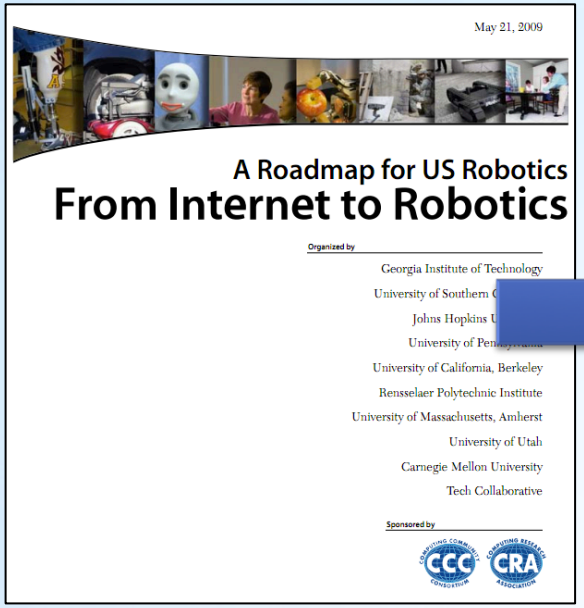


This Week’s Highlight:
Fruit Fly Suggests New Solution to Computer Networking Problem

LANDMARK CONTRIBUTIONS BY STUDENTS IN COMPUTER SCIENCE

undergraduate and graduate students that have made truly game-changing contributions in the course of their studies

Visioning: Robotics success

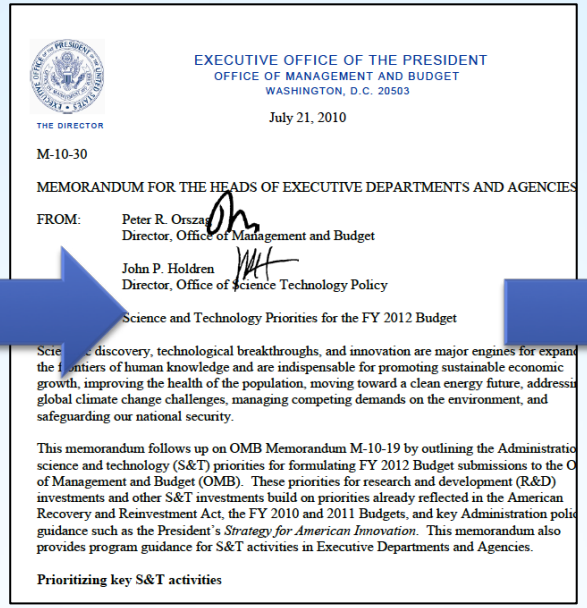

May 21, 2009

A Roadmap for US Robotics
From Internet to Robotics

Organized by

Georgia Institute of Technology
University of Southern C
Johns Hopkins U
University of Pen
University of California, Berkeley
Rensselaer Polytechnic Institute
University of Massachusetts, Amherst
University of Utah
Carnegie Mellon University
Tech Collaborative

Sponsored by


EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

THE DIRECTOR

July 21, 2010

M-10-30

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: Peter R. Orszag
Director, Office of Management and Budget

John P. Holdren
Director, Office of Science Technology Policy

Science and Technology Priorities for the FY 2012 Budget

Scie discovery, technological breakthroughs, and innovation are major engines for expand the f ntiers of human knowledge and are indispensable for promoting sustainable economic growth, improving the health of the population, moving toward a clean energy future, addressi global climate change challenges, managing competing demands on the environment, and safeguarding our national security.

This memorandum follows up on OMB Memorandum M-10-19 by outlining the Administratio science and technology (S&T) priorities for formulating FY 2012 Budget submissions to the O of Management and Budget (OMB). These priorities for research and development (R&D) investments and other S&T investments build on priorities already reflected in the American Recovery and Reinvestment Act, the FY 2010 and 2011 Budgets, and key Administration polic guidance such as the President's *Strategy for American Innovation*. This memorandum also provides program guidance for S&T activities in Executive Departments and Agencies.

Prioritizing key S&T activities


Office of Science and Technology Po

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Developing the Next Generation of Robots

Posted by Tom Kalil and Sridhar Kota on June 24, 2011 at 10:14 AM EDT

Tweet Share +

ch at Carnegie Mellon University, President Obama is launching the Advanc esearch initiative that will promote a renaissance of American manufacturing.

One ex ting element of the President's Advanced Manufacturing Partnership is the National R Robots are working for us every day, in countless ways. At home, at work, and on the battlefie increasingly lifting the burdens of tasks that are dull, dirty, or dangerous.

But they could do even more, and that's what the National Robotics Initiative is all about. So t (the National Science Foundation, the National Institutes of Health, NASA, and the United Sta Agriculture) are issuing a joint solicitation that will provide up to $70 million in research fundin generation robotics.

The focus of this initiative is on developing robots that work with or beside people to extend o capabilities, taking advantage of the different strengths of humans and robots. In addition to i technology needed for next-generation robotics, the initiative will support applications such a

4 meetings during summer 2008

Roadmap published May 2009

Extensive discussions between visioning leaders & agencies

OSTP issues directive to all agencies to include robotics in FY 12 budgets

National Robotics Initiative is announced

Henrik Chistensen
Georgia Tech

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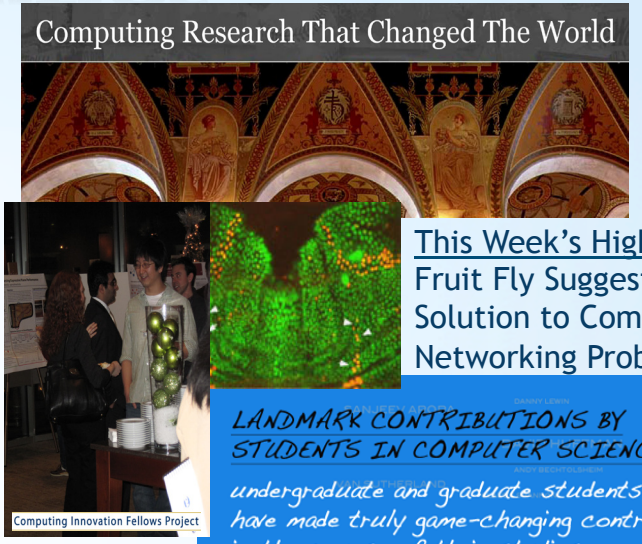

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Fruit Fly Suggests New Solution to Computer Networking Problem

- **Public relations efforts:**
  - Library of Congress symposia
  - Research "Highlight of the Week"
  - CCC Blog [http://cccblog.org/]

- **Nurturing the next generation of leaders:**
  - Computing Innovation Fellows Project
  - "Landmark Contributions by Students"
  - Leadership in Science Policy Institute

Next generation: CIFellows Project

- Established in 2009 with NSF/CISE funding
- Provides recent CS Ph.D.s one- to two-year postdoctoral positions
- Goal is to retain new Ph.D.s in research & teaching during difficult economic times
- 60 CIFellows funded in 2009
  - 19 left the program after year I
  - 39 have now found tenure-track faculty or industrial research positions
- Another 47 CIFellows funded in 2010, 21 in 2011
- A research project in and of itself…

Computing Innovation Fellows Project

Home CRA CCC CISE

The 2009 Computing Innovation Fellows have been selected!

View the press release with the names of the 2009 Fellows and their Mentors.

Congratulations to everyone who was selected for a CIFellow award!
Thank you for your interest in CIFellows. The response has been tremendous!
For up-to- the-minute news on the progress of the selection process, check out the forum.

In the light of the response that the CIFellows has received, we have set up a courtesy website where employers can post available postions suitable for new computing PhD's. This site is available at http://cifellows.org/opportunities.

An additional courtesy site has been set up for computing PhD's to post their profiles and availability. This website is available at http://cifellows.org/profiles. We encourage employers and candidates to make use of these complimentary services.

The Computing Community Consortium (CCC) and the Computing Research Association (CRA), with funding from the National Science Foundation, announce a program for new PhD graduates to obtain one-to-two year postdoctoral positions

Next generation: Undergraduates

http://cra.org/ccc/csgs

A multitude of activities

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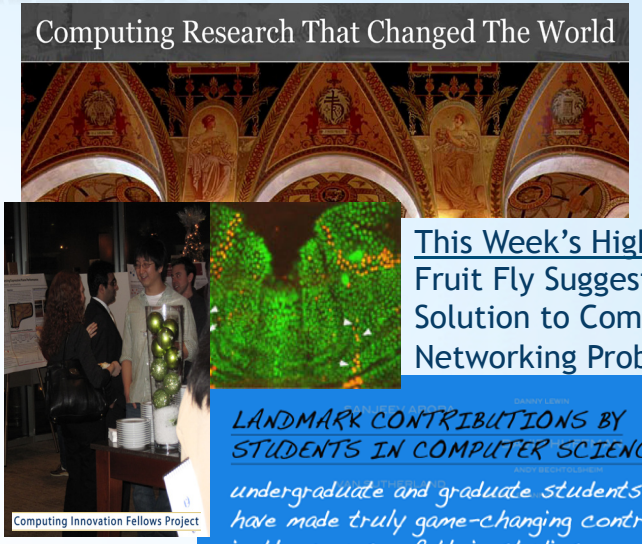

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The CS Job Market

The CS job market is red hot

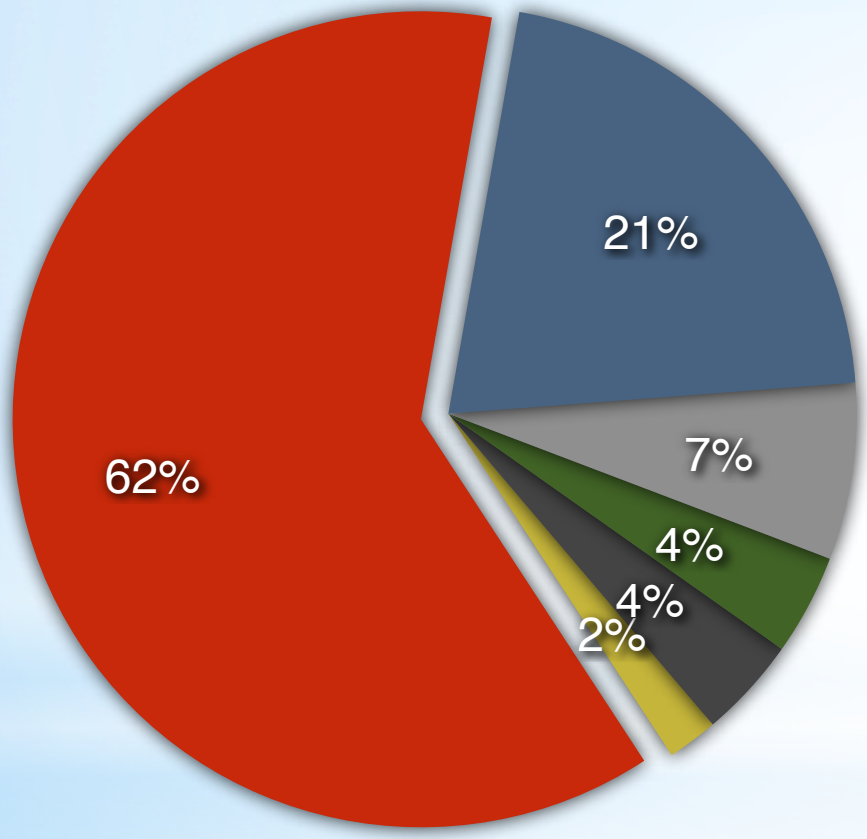
"As the rest of the country fights stubbornly high unemployment, the shortage of qualified engineers has grown acute in the last six months, tech executives and recruiters say, as the flow of personal or venture capital investing has picked up. In Silicon Valley, along the southern portion of the San Francisco Bay in California, and other tech hubs like New York, Seattle and Austin, Tex., start-ups are sprouting by the dozen, competing with well-established companies for the best engineers, programmers and designers. At the same time, all the companies are seeking ever more specialized skills."

The New York Times

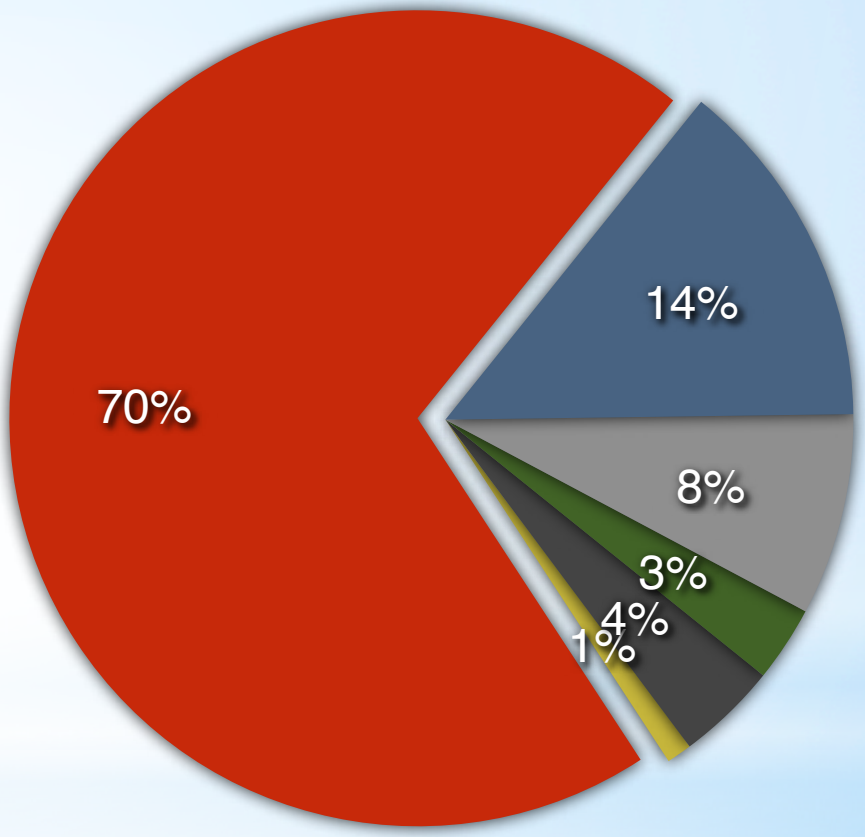
-- "Silicon Valley Hiring Perks," March 25, 2011

Where the jobs are

Projected S&E Job Openings
(new jobs + net replacements, 2006-2016)



Projected S&E Job Creation
(new jobs, 2006-2016)

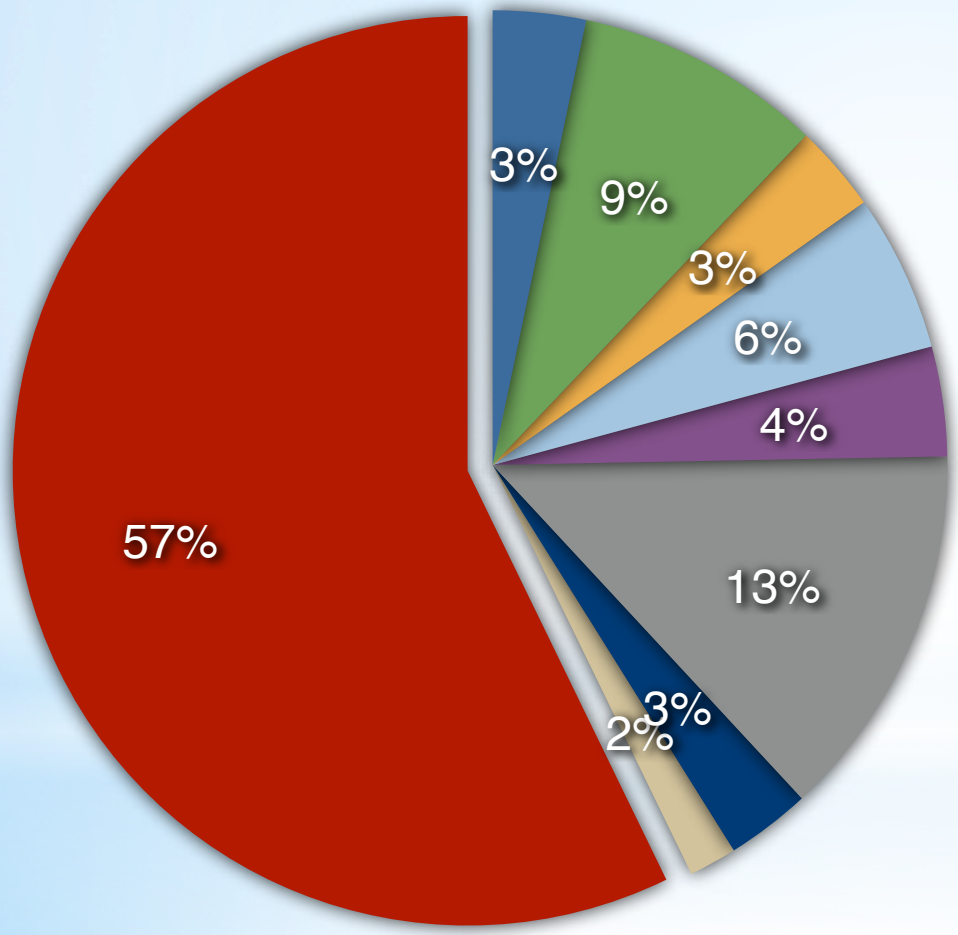


Computer Specialists
Engineers
Social Scientists
Life Scientists
Physical Scientists
Mathematical Scientists

Source: U.S. Bureau of Labor Statistics, 2007

Where the jobs are II

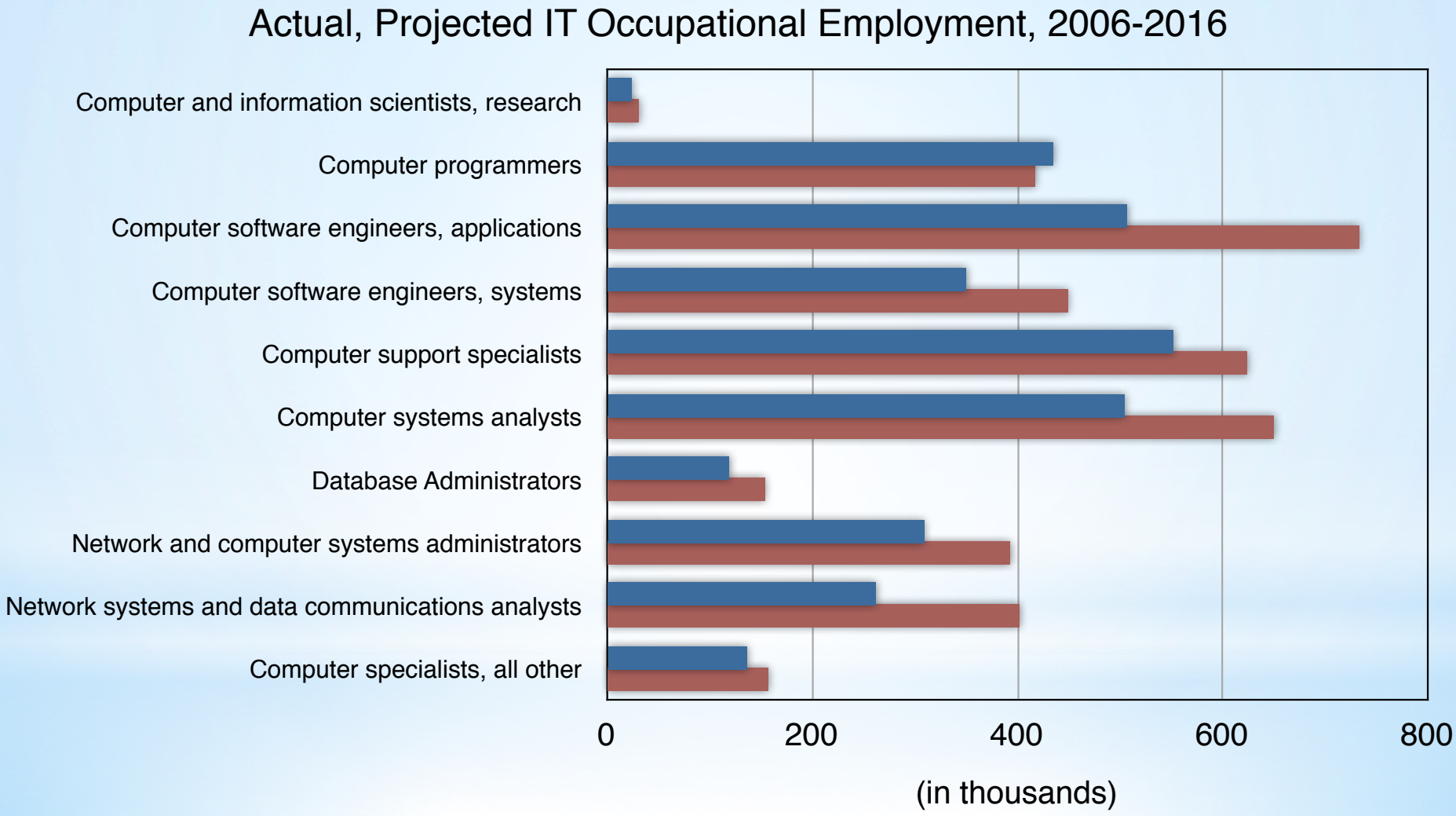
Contribution to Total Growth in S&E Occupations, 2008-18



- Life, physical, and social science technicians
- Social scientists and related
- Physical scientists
- Life scientists
- Drafters, engineers, and mapping technicians
- Engineers
- Architects, surveyors, and cartographers
- Mathematical science
- Computer specialists

Source: U.S. Bureau of Labor Statistics, 2007

Where in computing the jobs are



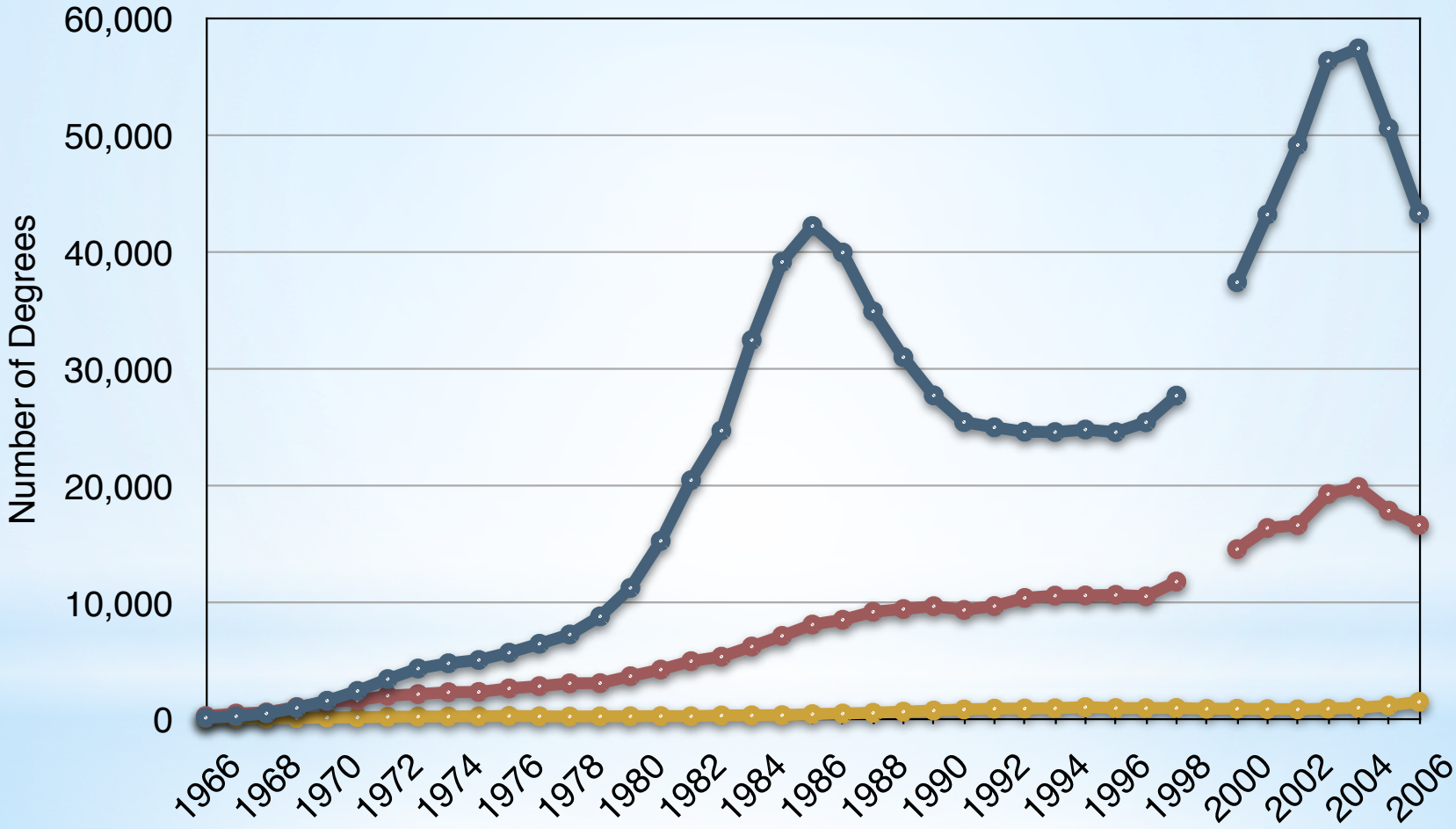
Source: U.S. Bureau of Labor Statistics, 2007

By the ~~numbers~~ perks

* Extraordinary competition for CS majors right now
* Starting salaries as high as $105,000
* Weekly lessons about entrepreneurship
* Free meals, haircuts, iPads, shuttle busses, and stock options

The New York Times

Total CS degrees granted



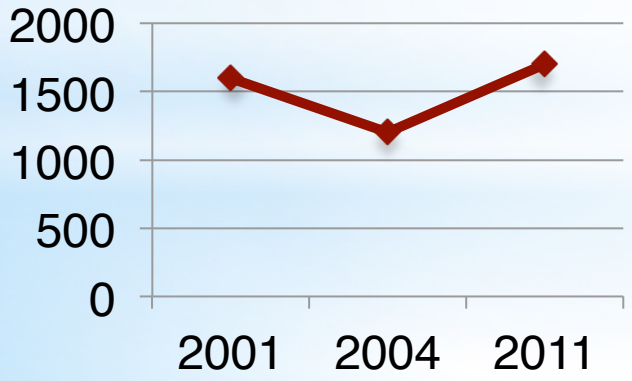
Promising signs: Tale of four cities

CMU (applicants)

Stanford (enrollments)

- Previous record in 1999-2000: 762 students
- Bottomed out in 2006-07
- New record in 2010-11: 1,087
  - Year-to-year growth of 51%
  - Spring enrollment up 120%

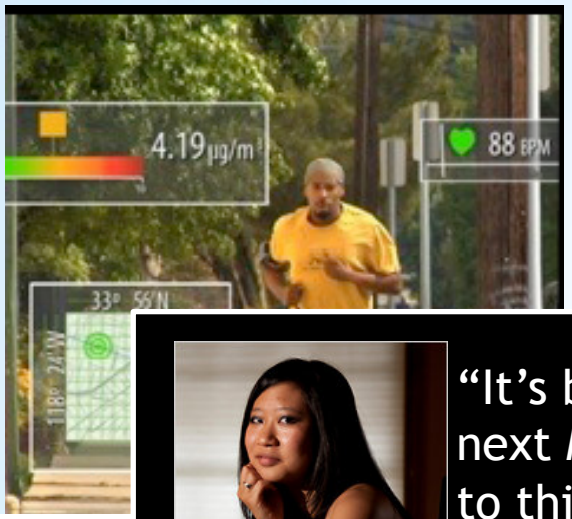
UW (enrollments)

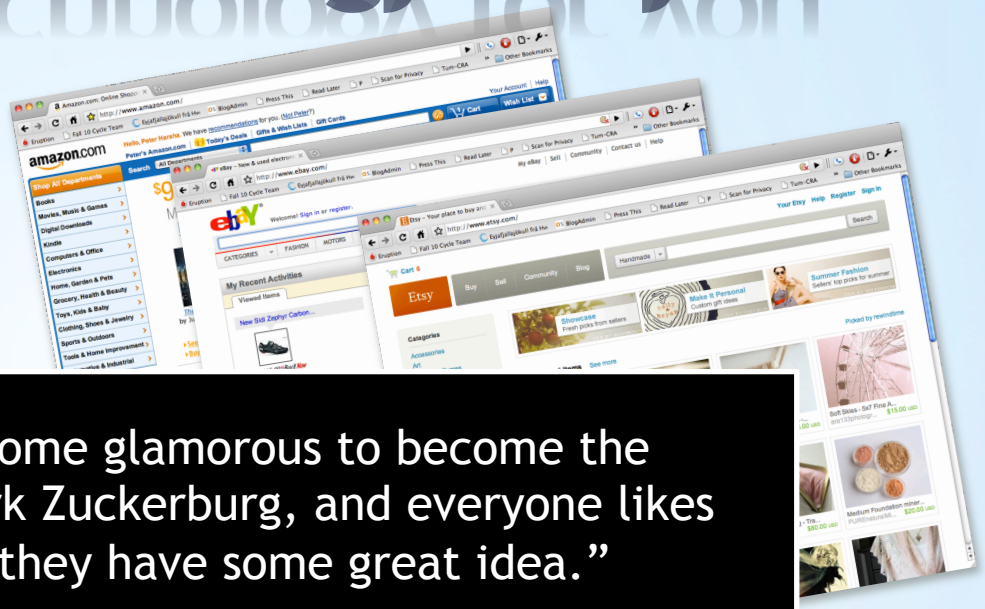


MIT (enrollments)

- Introductory CS course is single most popular course (out of 2,000+ MIT courses in a broad range of fields)

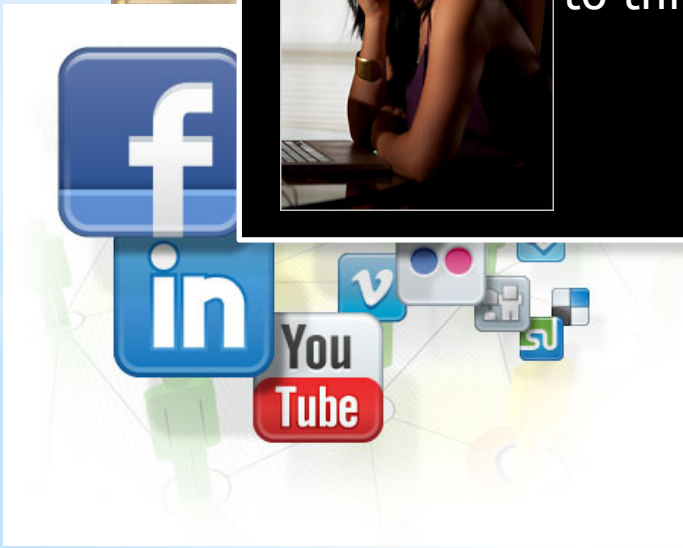
Key drivers: technology for you





"It's become glamorous to become the next Mark Zuckerburg, and everyone likes to think they have some great idea."

--Keila Fong, Yale University undergraduate



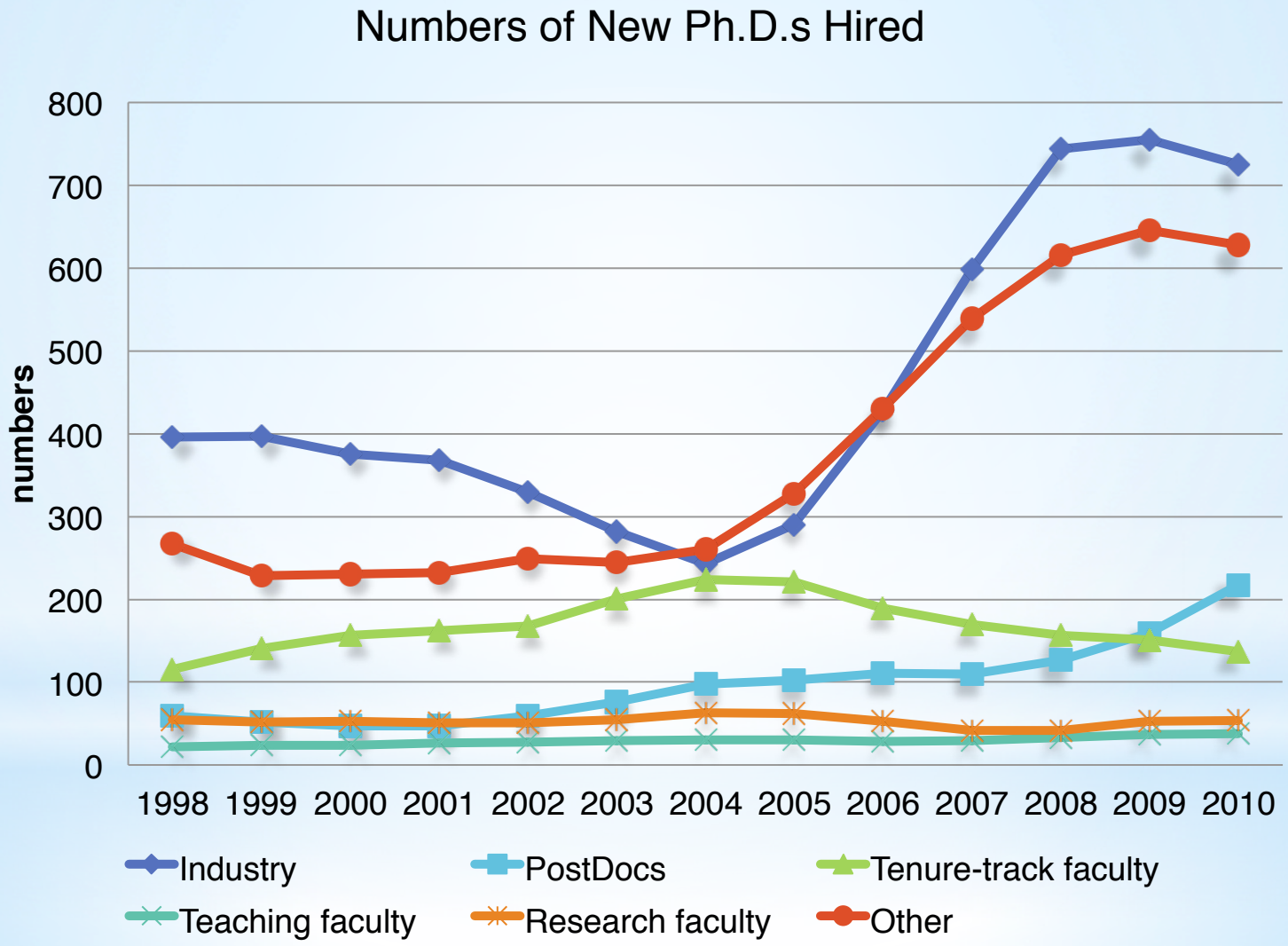
Key drivers: information

* Just about every field is becoming an information field

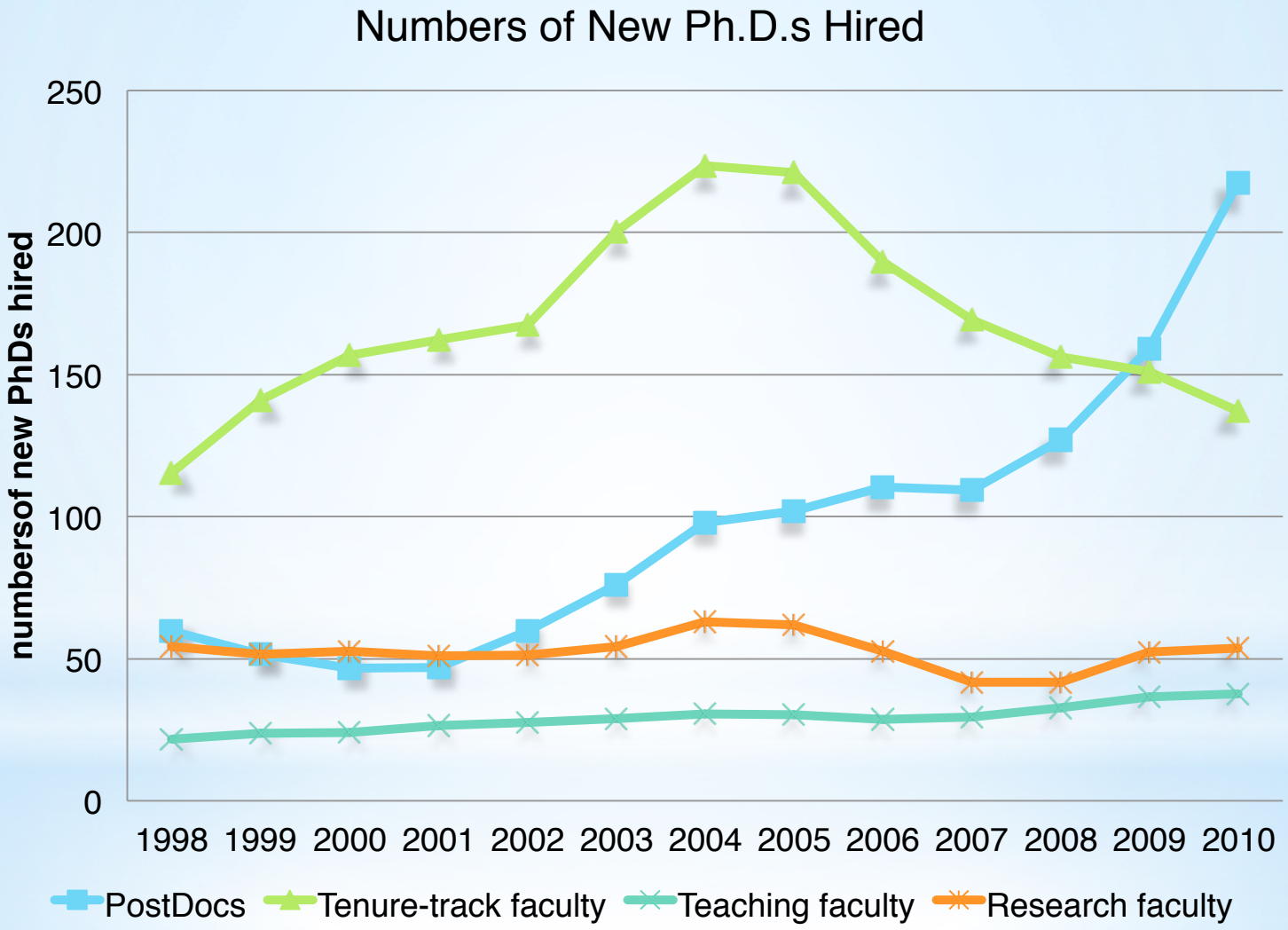
* "NIT is arguably unique among all fields of science and engineering in the breadth of its impact … Recent technological and societal trends place the further advancement and application of NIT squarely at the center of our Nation's ability to achieve essentially all of our priorities and to address essentially all of our challenges … All indicators – all historical data, and all projections – argue that NIT is the dominant factor in America's science and technology employment.

-- *PCAST report, December 2010*

But an important caveat…



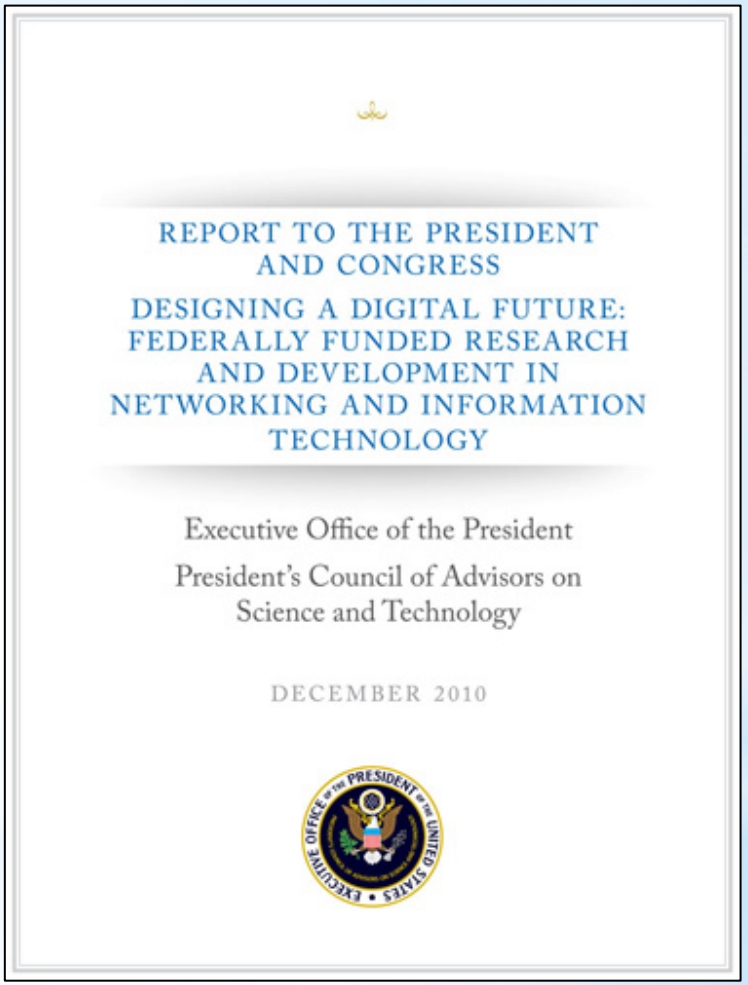
...Postdocs in computing



Future directions

A report on the future of the field

- Issued by the President's Council of Advisors on Science and Technology
- About the nationwide Networking & Information Technology R&D initiative
- An excellent roadmap for the field



Affecting national priorities

- Improving health care
- Enabling the smart grid
- Revolutionizing transportation
- Delivering personalized education
- Empowering the developing world
- Ensuring our national defense
- Enabling the future of networking

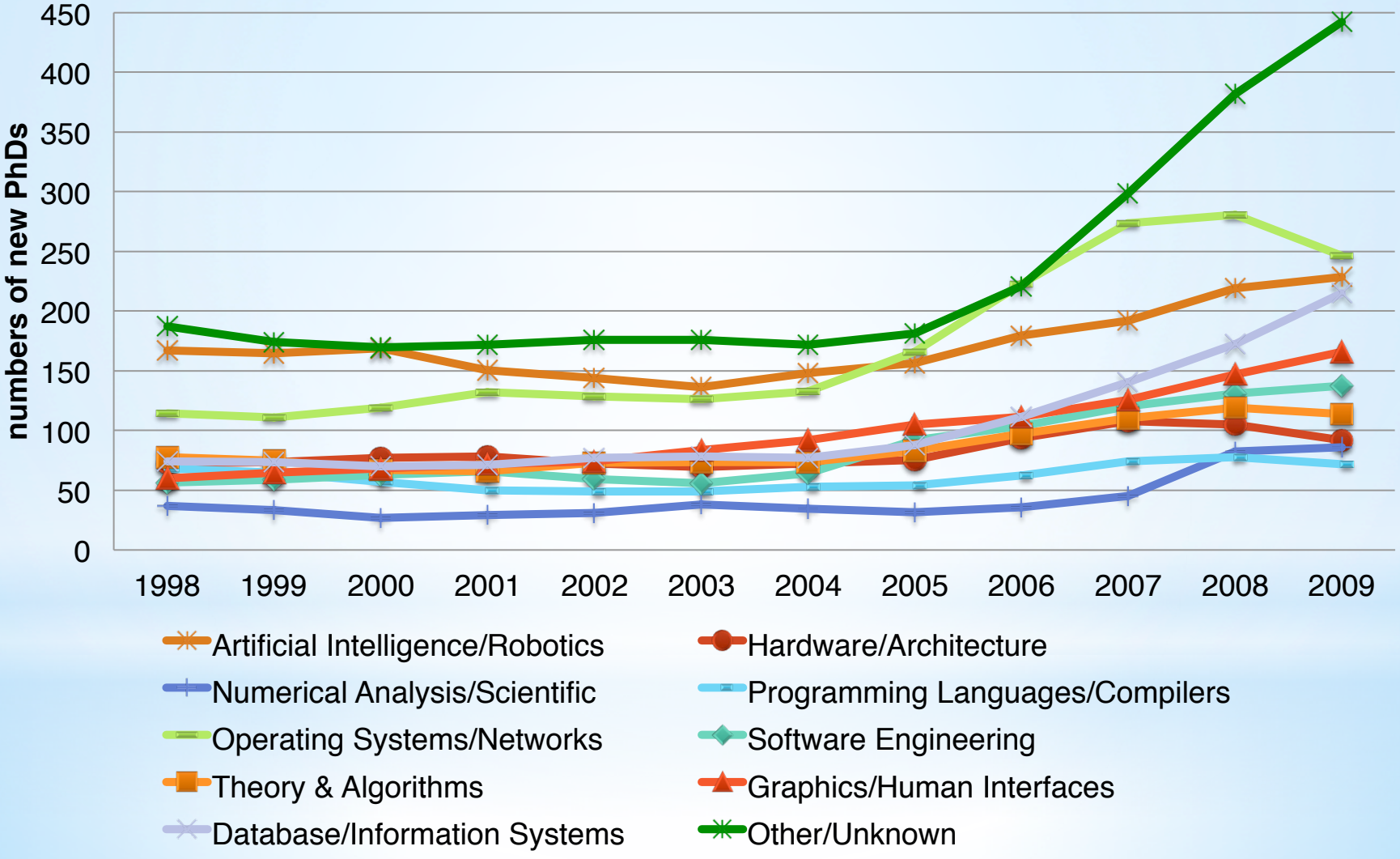
] cybersecurity

- Driving advances in **all** fields of science & engineering

Some examples from PCAST

- Health information technology
  - "Go well beyond the current national program to adopt electronic health records"
  - "Make possible comprehensive lifelong multi-source health records for individuals; enable both professionals and the public to obtain and act on health knowledge from diverse and varied sources as part of an interoperable health IT ecosystem; and provide appropriate information, tools, and assistive technologies that empower individuals to take charge of their own health and reduce costs."
- Energy and transportation
  - "dynamic power management broadly; interoperable standards for real-time control; low-power systems and devices; and improved surface and air transportation."
- Security and robustness of cyber-infrastructure:
  - "more effective ways to build trustworthy computing and communications systems; better defense mechanisms for today's infrastructure; and fundamentally new approaches for making cyber-infrastructure truly resilient to cyber-attack, natural disaster, and inadvertent failure."

The shift toward interdisciplinary



Federal investment

- Health information technology
  - Workshop held in San Francisco in October 2009
  - NSF/CISE initiative on Smart Health & Wellbeing (SHB) announced in FY 2011
- Role of information sciences & engineering in sustainability
  - Workshop in Washington, DC, on Feb. 3-4, 2011
  - Several NSF SEES solicitations in recent weeks for FY 2012
- "Big Data"/Data analytics
  - Series of white papers written for policy makers in summer 2010
  - Anticipating a new initiative in FY 2013
- Education (learning) technologies
  - Roadmap produced in summer 2010
  - Digital Promise and ARPA-ED

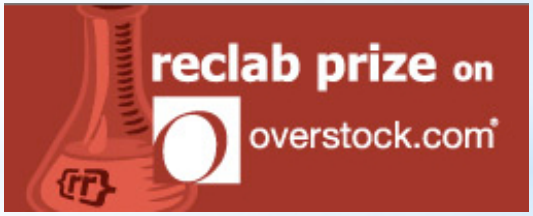
digitalpromise

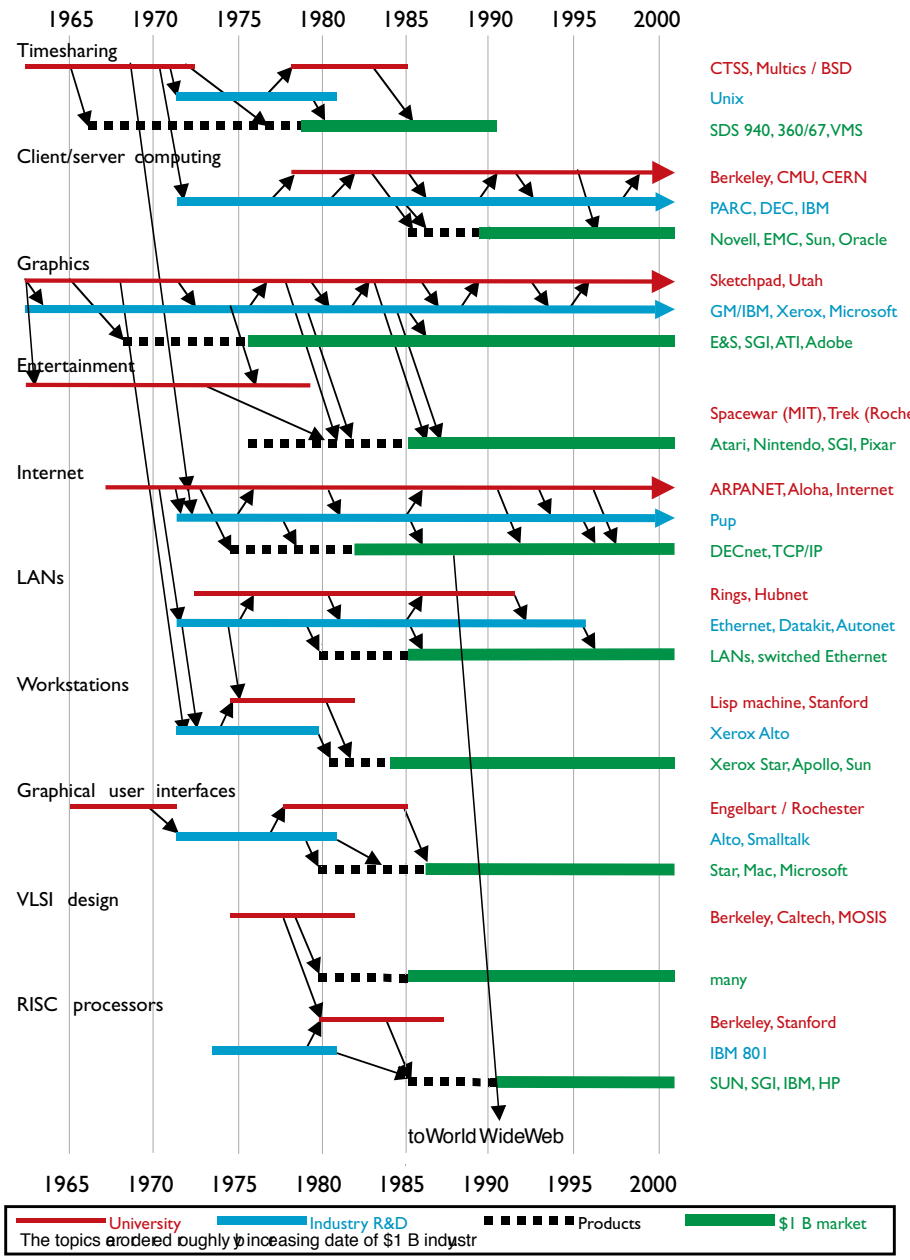
Others

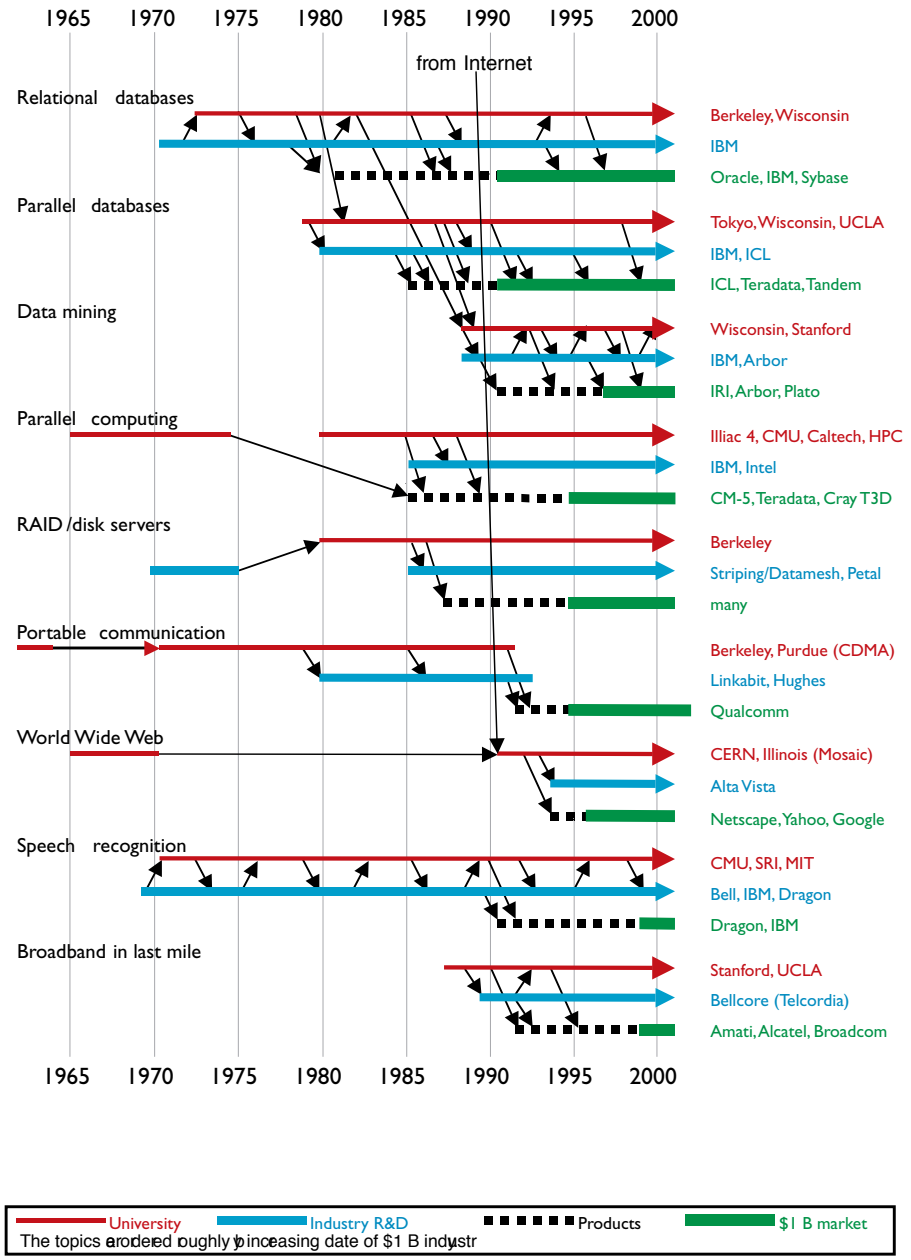
- Hack-a-thons

- Crowdsourcing

- Prize-based (challenge) competitions




1965 1970 1975 1980 1985 1990 1995 2000
Timesharing
CTSS, Multics / BSD
Unix
SDS 940, 360/67, VMS
Client/server computing
Berkeley, CMU, CERN
PARC, DEC, IBM
Novell, EMC, Sun, Oracle
Graphics
Sketchpad, Utah
GM/IBM, Xerox, Microsoft
E&S, SGI, ATI, Adobe
Entertainment
Spacewar (MIT), Trek (Rochester)
Atari, Nintendo, SGI, Pixar
Internet
ARPANET, Aloha, Internet
Pup
DECnet, TCP/IP
LANs
Rings, Hubnet
Ethernet, Datakit, Autonet
LANs, switched Ethernet
Workstations
Lisp machine, Stanford
Xerox Alto
Xerox Star, Apollo, Sun
Graphical user interfaces
Engelbart / Rochester
Alto, Smalltalk
Star, Mac, Microsoft
VLSI design
Berkeley, Caltech, MOSIS
RISC processors
many
Berkeley, Stanford
IBM 801
SUN, SGI, IBM, HP
to World Wide Web
1965 1970 1975 1980 1985 1990 1995 2000
University
Industry R&D
Products
$1 B market
The topics are ordered roughly by increasing date of $1 B industr


1965 1970 1975 1980 1985 1990 1995 2000
from Internet
Relational databases
Berkeley, Wisconsin
IBM
Oracle, IBM, Sybase
Parallel databases
Tokyo, Wisconsin, UCLA
IBM, ICL
ICL, Teradata, Tandem
Data mining
Wisconsin, Stanford
IBM, Arbor
IRI, Arbor, Plato
Parallel computing
Illiac 4, CMU, Caltech, HPC
IBM, Intel
CM-5, Teradata, Cray T3D
RAID /disk servers
Berkeley
Striping/Datamesh, Petal
many
Portable communication
Berkeley, Purdue (CDMA)
Linkabit, Hughes
Qualcomm
World Wide Web
CERN, Illinois (Mosaic)
Alta Vista
Netscape, Yahoo, Google
Speech recognition
CMU, SRI, MIT
Bell, IBM, Dragon
Dragon, IBM
Broadband in last mile
Stanford, UCLA
Bellcore (Telcordia)
Amati, Alcatel, Broadcom
1965 1970 1975 1980 1985 1990 1995 2000
University
Industry R&D
Products
$1 B market
The topics are ordered roughly by increasing date of $1 B industr

A community effort

- Propose visioning activities, white papers, Challenges & Visions tracks at research conferences
- Put together short videos for undergraduates
- Contribute to the CCC Blog
- Send us a research highlight for the Highlight of the Week

Get involved today:

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