



JOHNS HOPKINS
U N I V E R S I T Y

The Future of Computing Research: Enlightenment, Renaissance, or Diaspora

Gregory D. Hager

Professor and Chair

Department of Computer Science

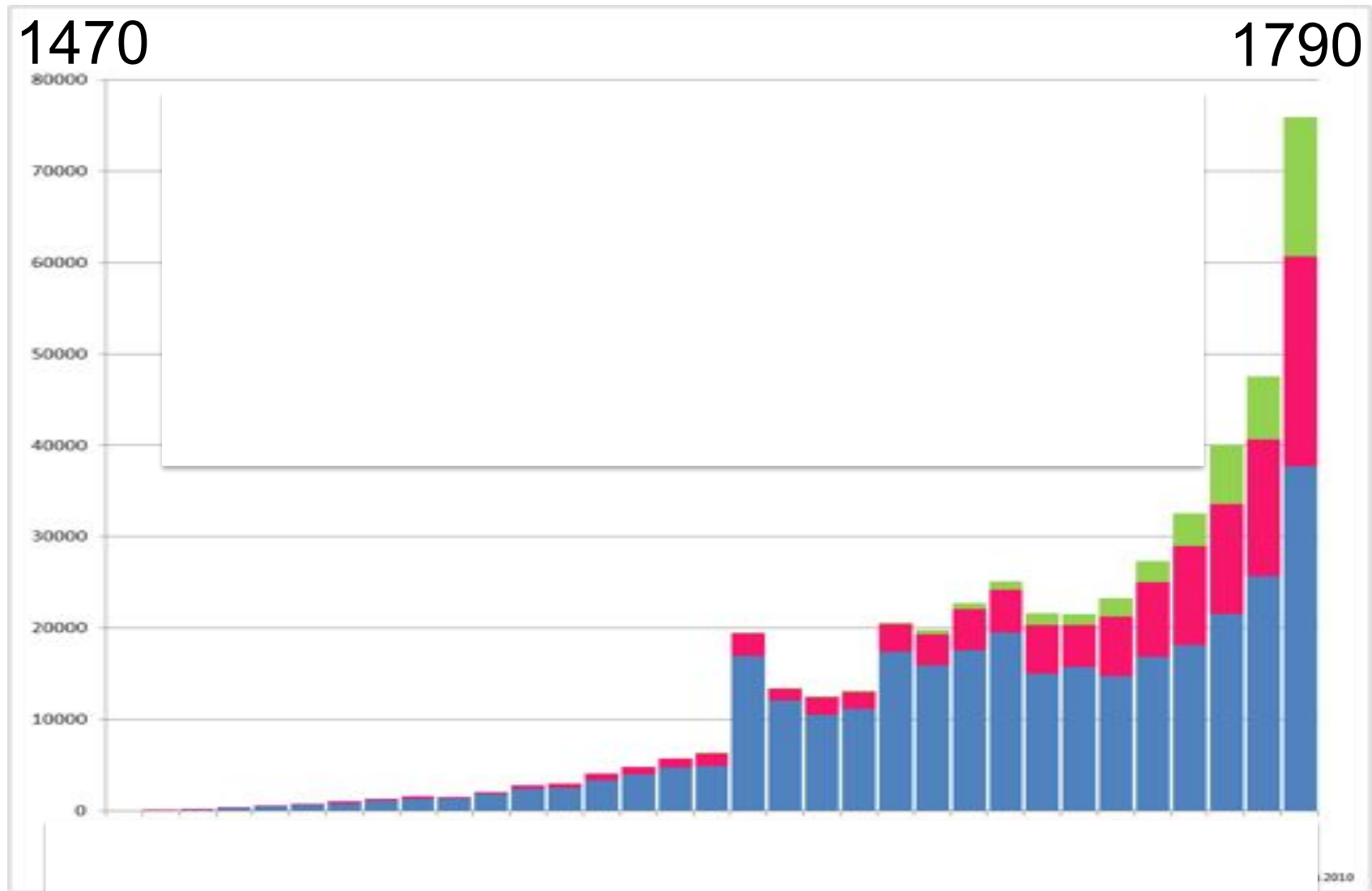
Chair, Computing Community Consortium

<http://cra.org/ccc>

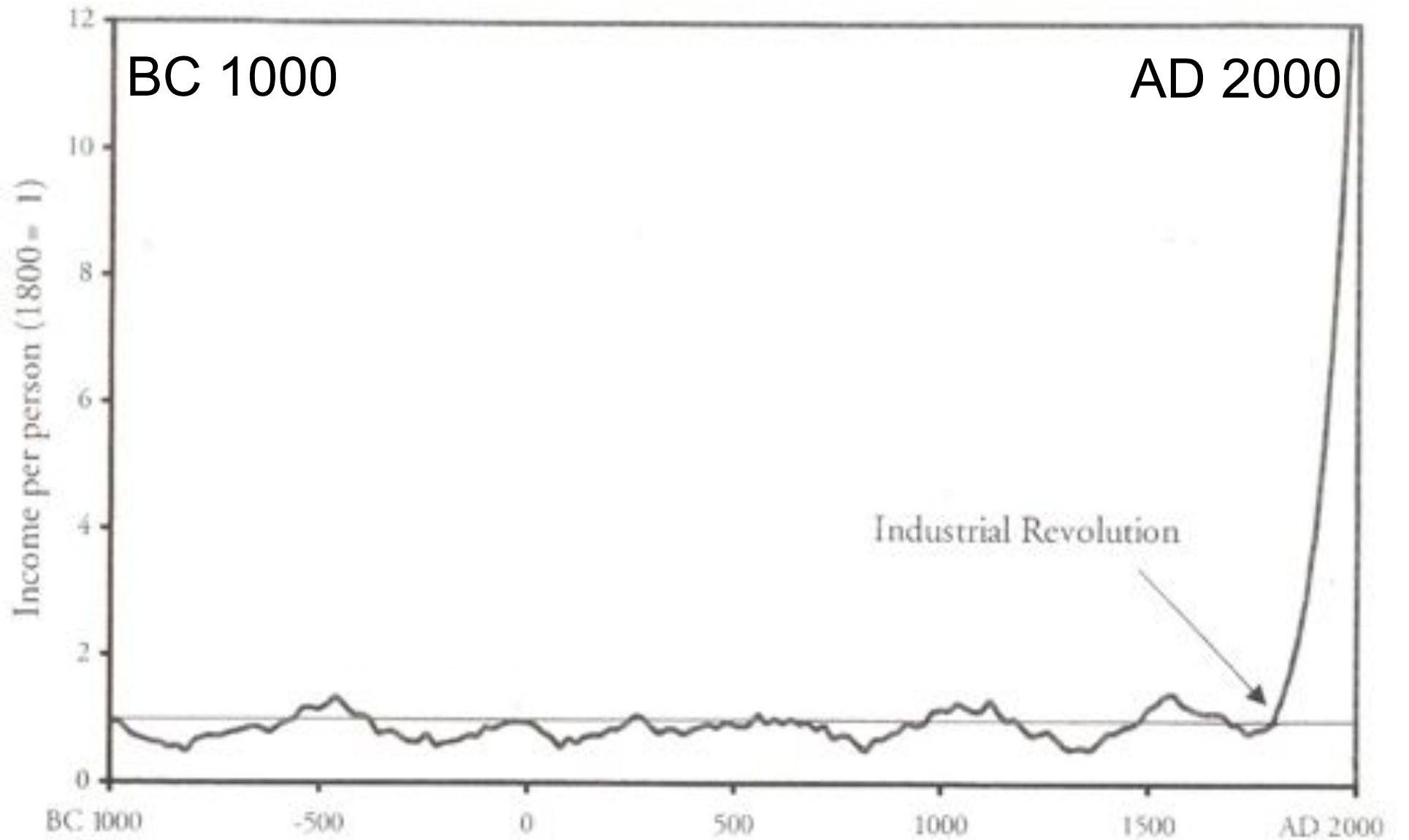
The Plan

- Some observations on the past and current evolution on computing
- Some ideas about some of the forces driving computing today and how they are unique
- Some thoughts on the possible directions for the future
- The CCC and its role in shaping the future

We Aren't The First Exponential!



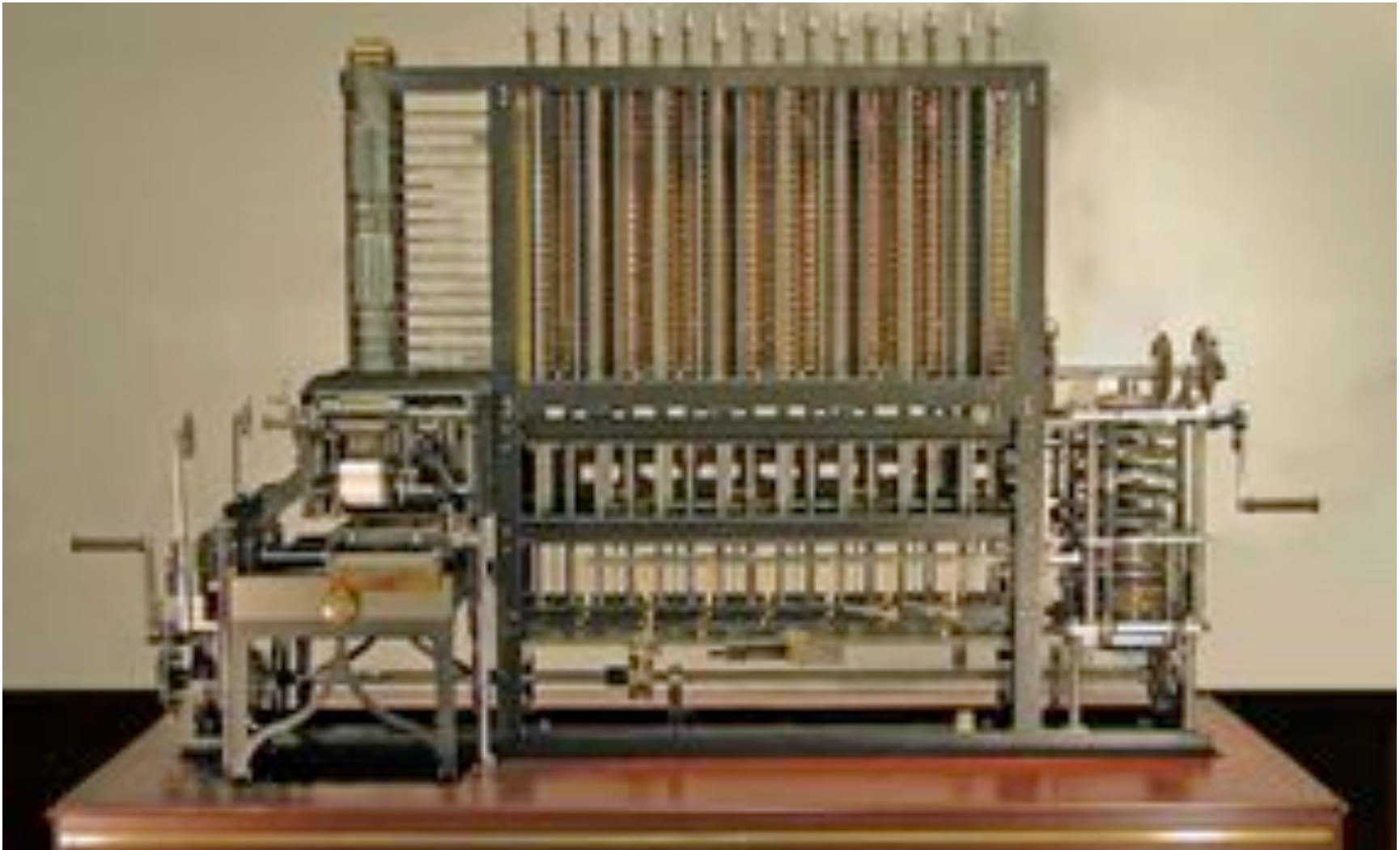
Another Exponential



The Age of Steam



Physical Machines, Virtual Work!



From Concept to Commodity



The WOMEN who first programmed them!



Ada Lovelace

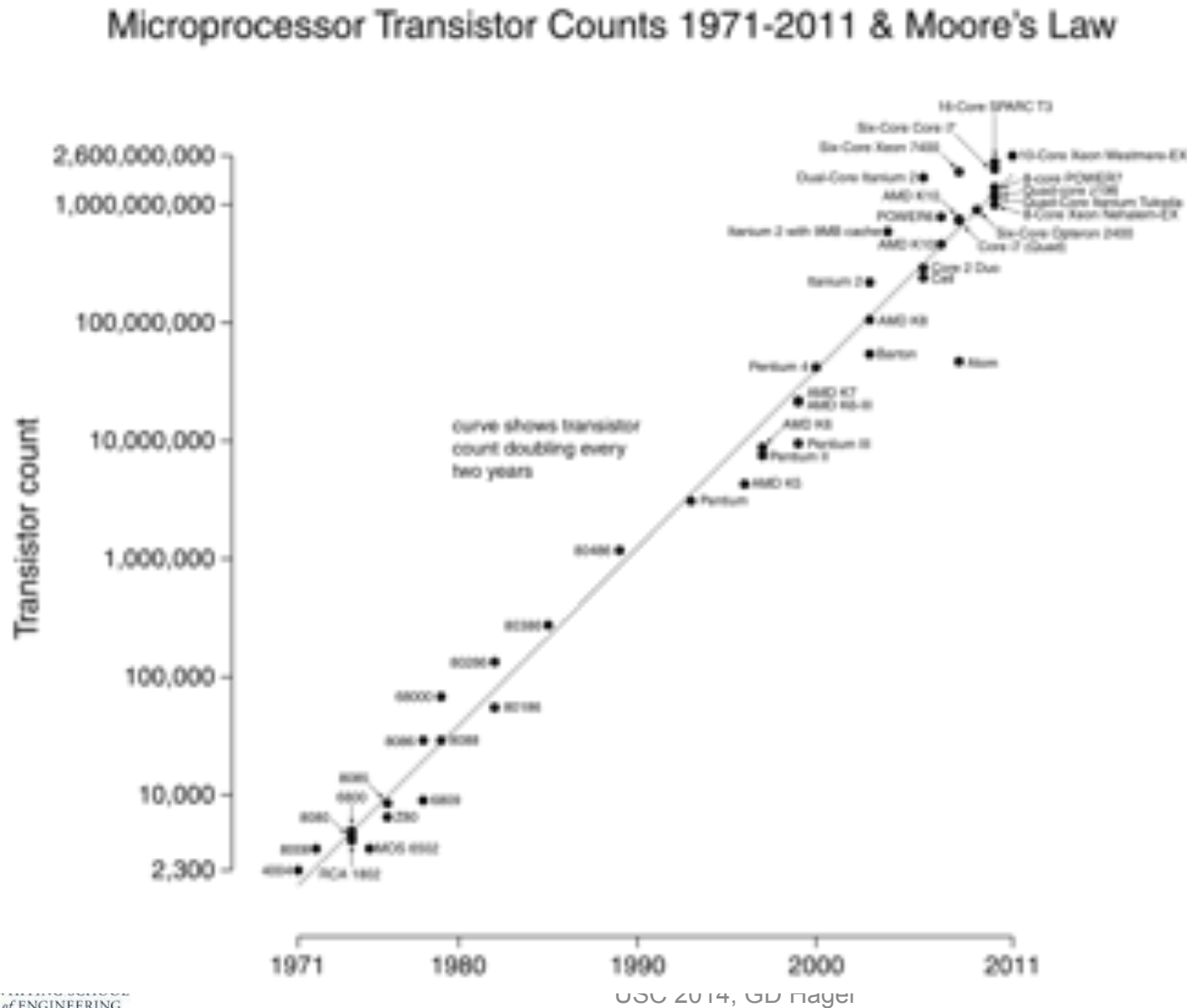


Grace Hopper

*Kathy Kleiman,
Jean Bartik,
Marlyn Meltzer,
Kay Mauchly
Antonelli
Betty Holberton*

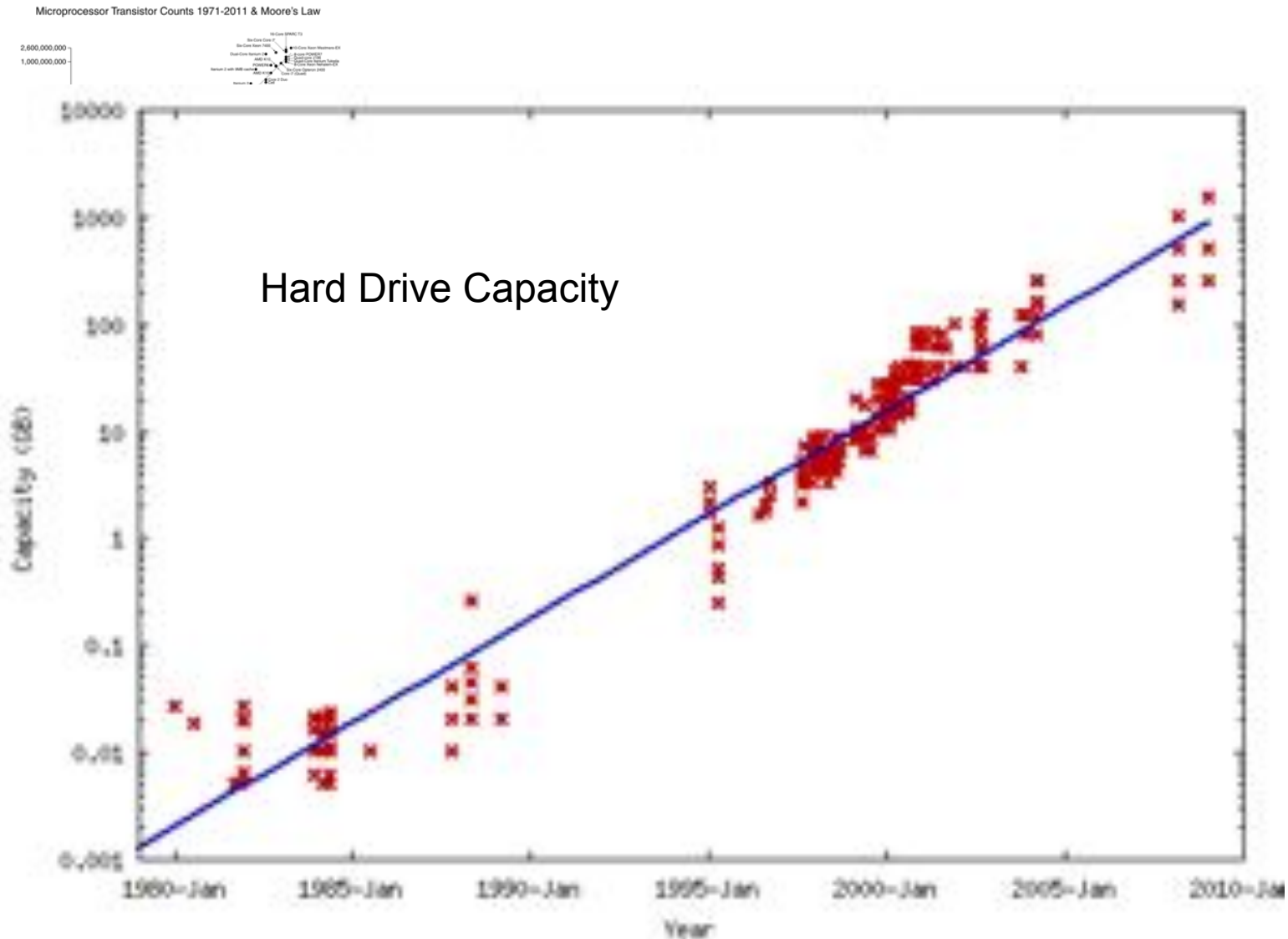


Surfing Exponential (Economic) Waves

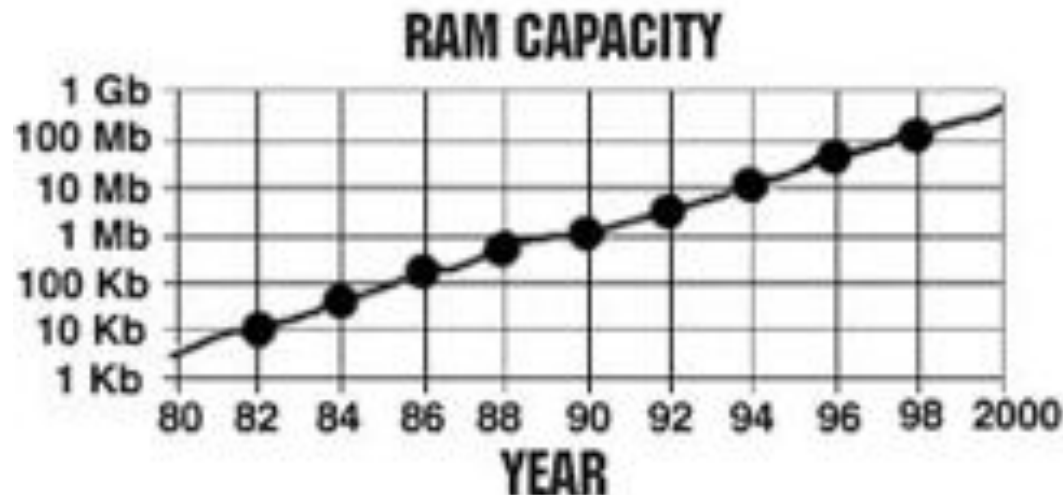
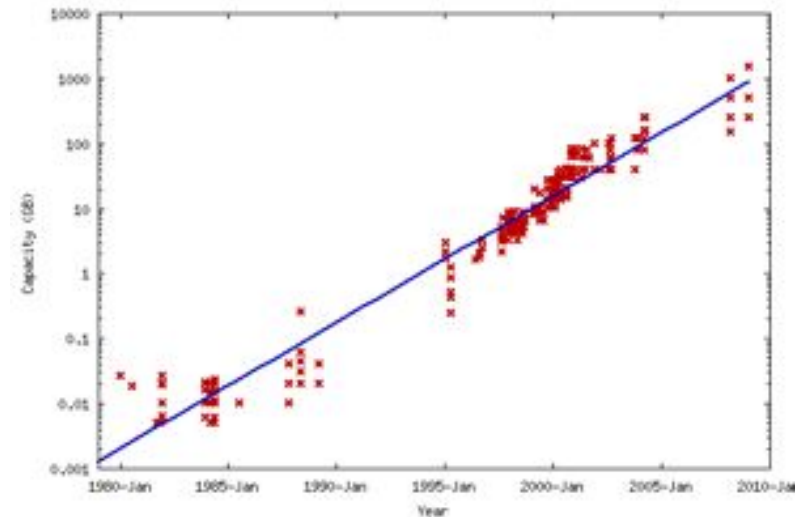
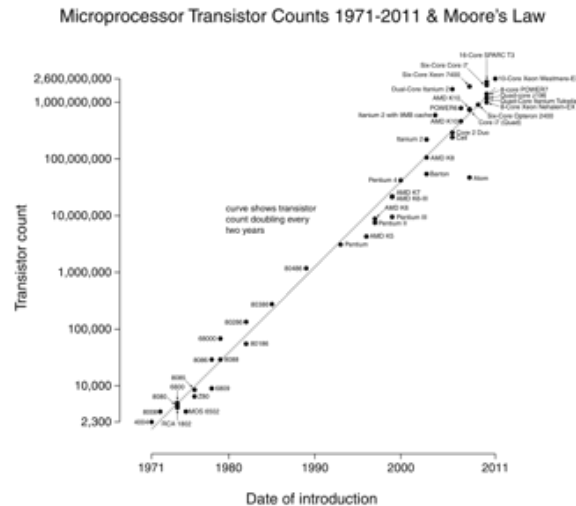


Gordon Moore

Surfing Exponential (Economic) Waves



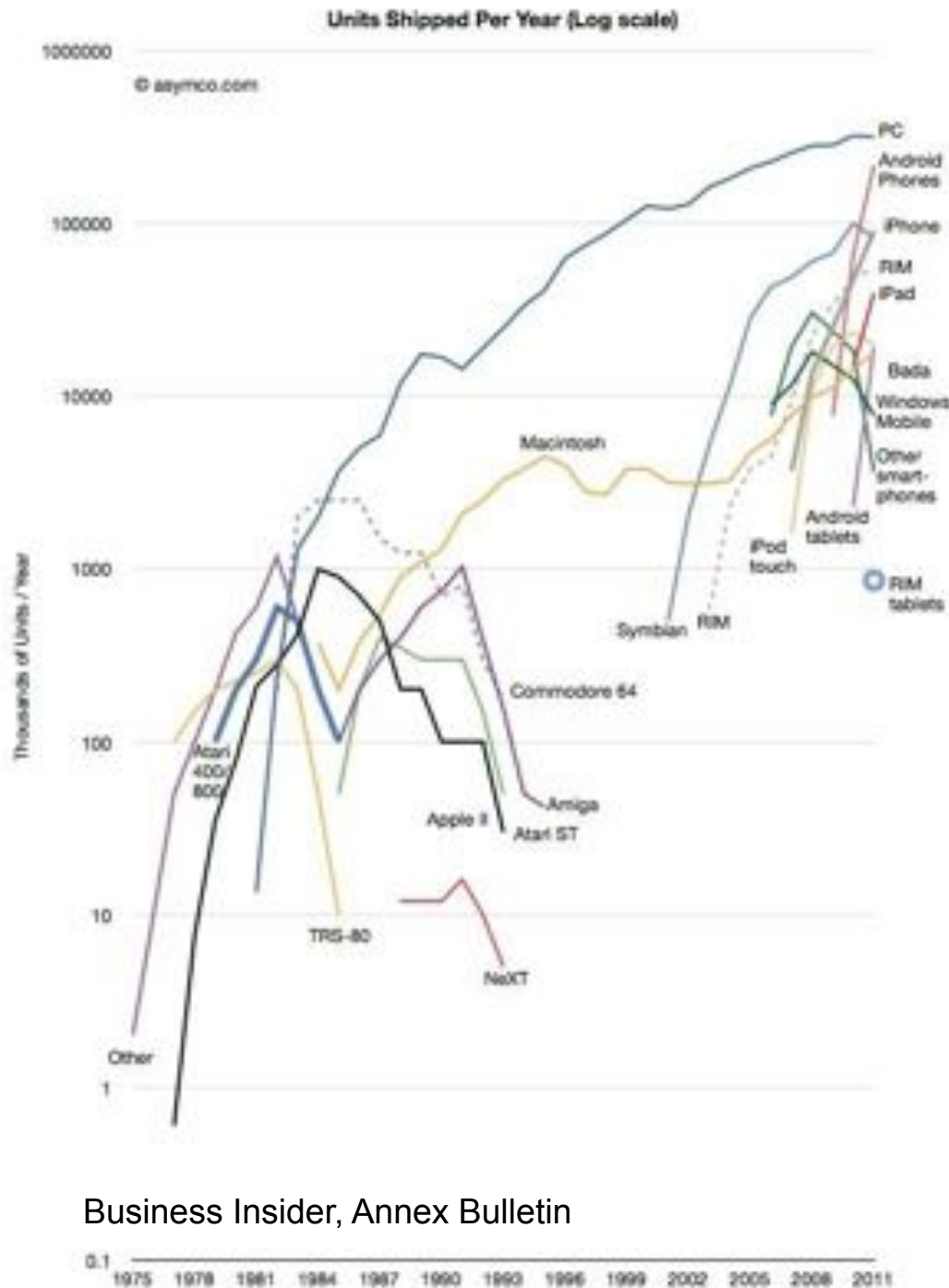
Surfing Exponential (Economic) Waves



The PC Revolution

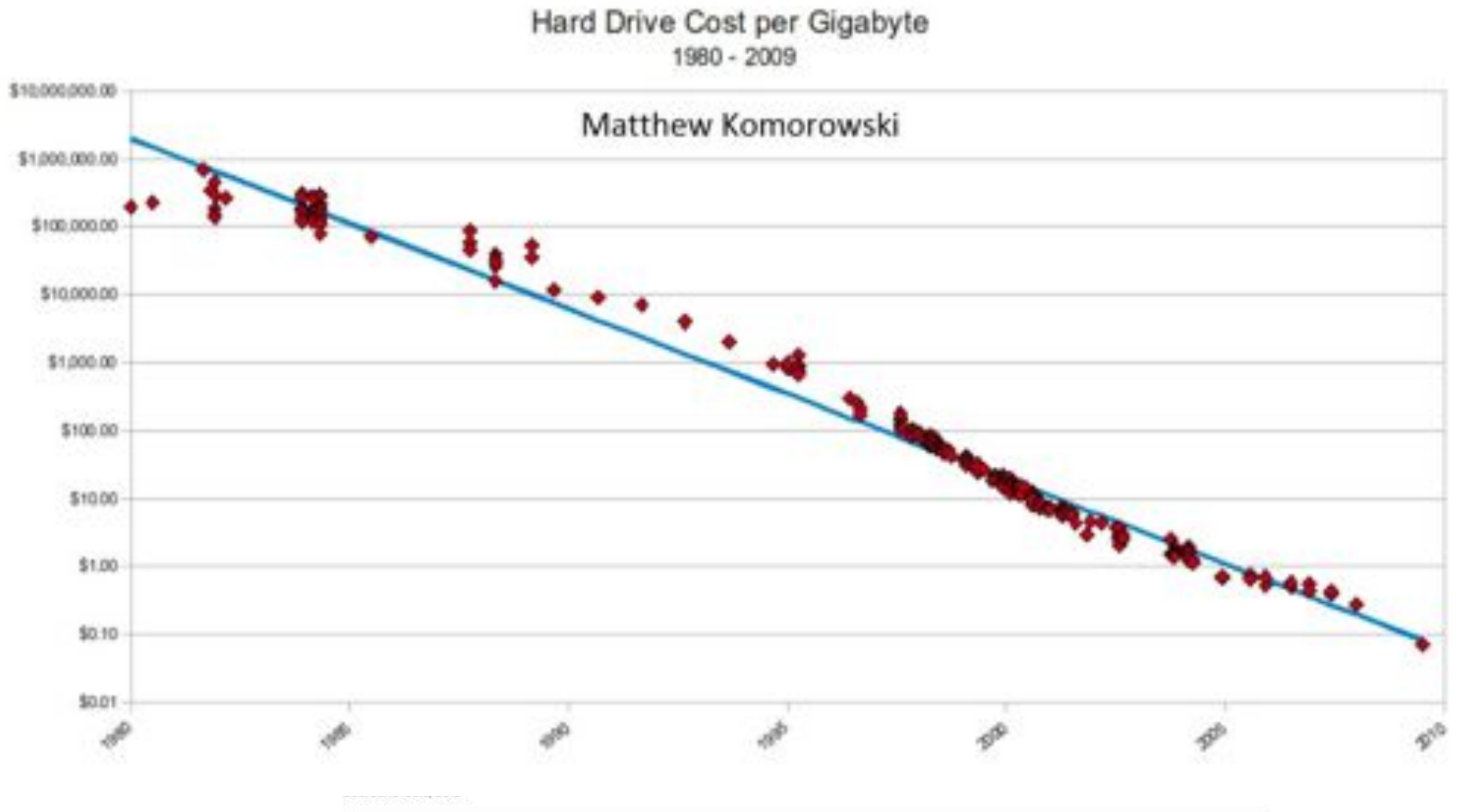


BPwiz.com



CCC
Computing Community Consortium
Catalyst

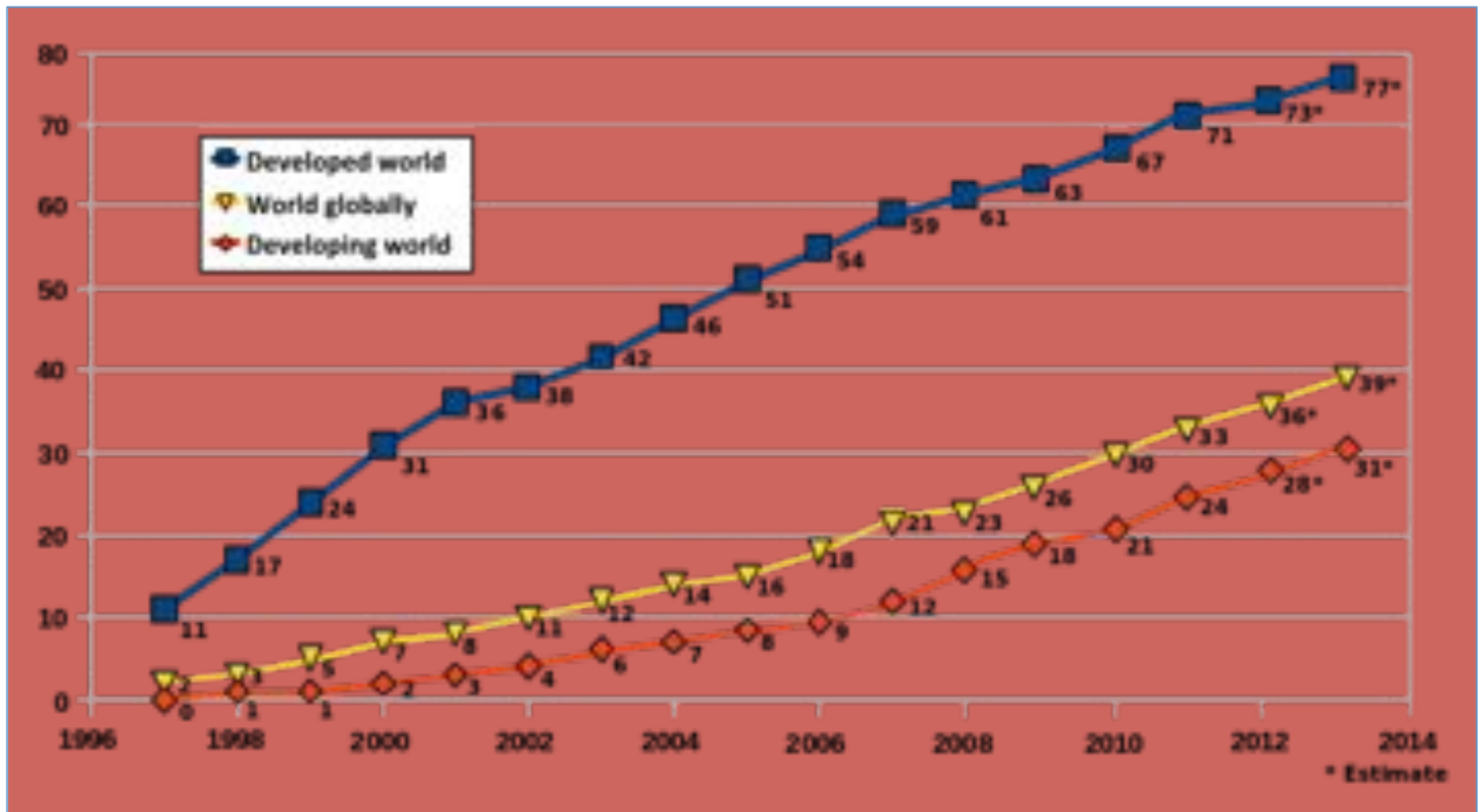
The Corresponding Economics



A World Awash in Computing

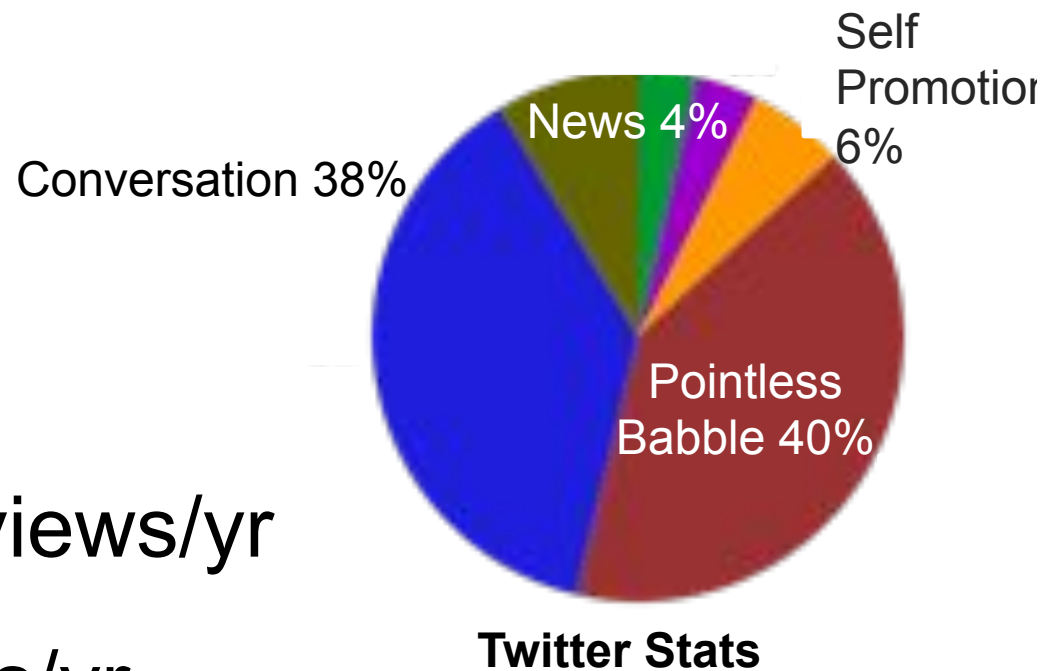
- More than 10B microprocessors sold every year
- Every smartphone includes camera, accelerometer, internet connectivity
- Cloud infrastructure dwarfs many of the world's supercomputers
- Access from practically anywhere ...

A World Awash in Computing



The Current Decade: Online Everything

- Email: 65 trillion/yr
- SMS: 7 trillion/yr
- Youtube: 14trillion views/yr
- Twitter: 200B tweets/yr

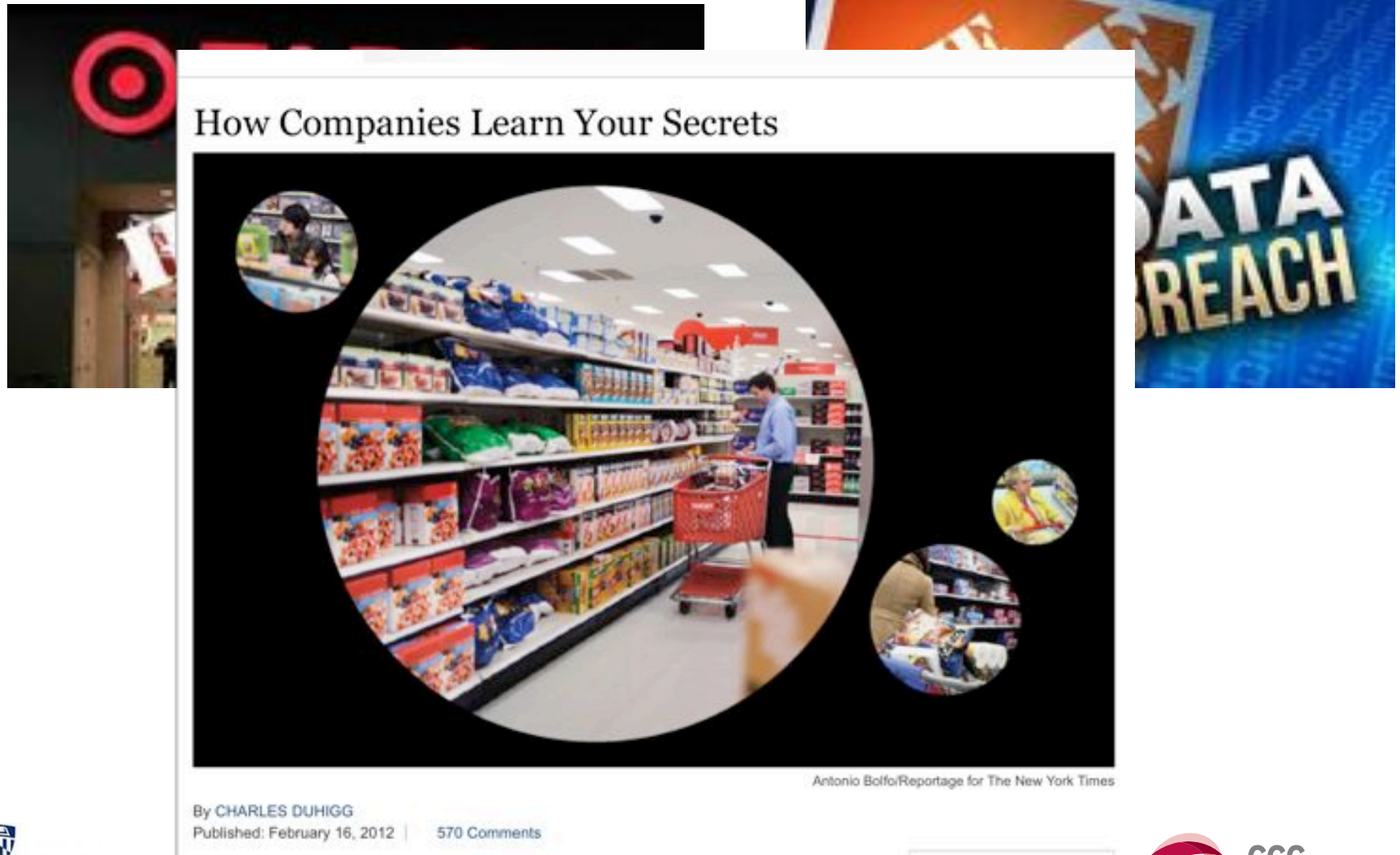


<http://www.internetlivestats.com/one-second/#google-band>

A Big Driver: Us!



Challenge: Security and Privacy



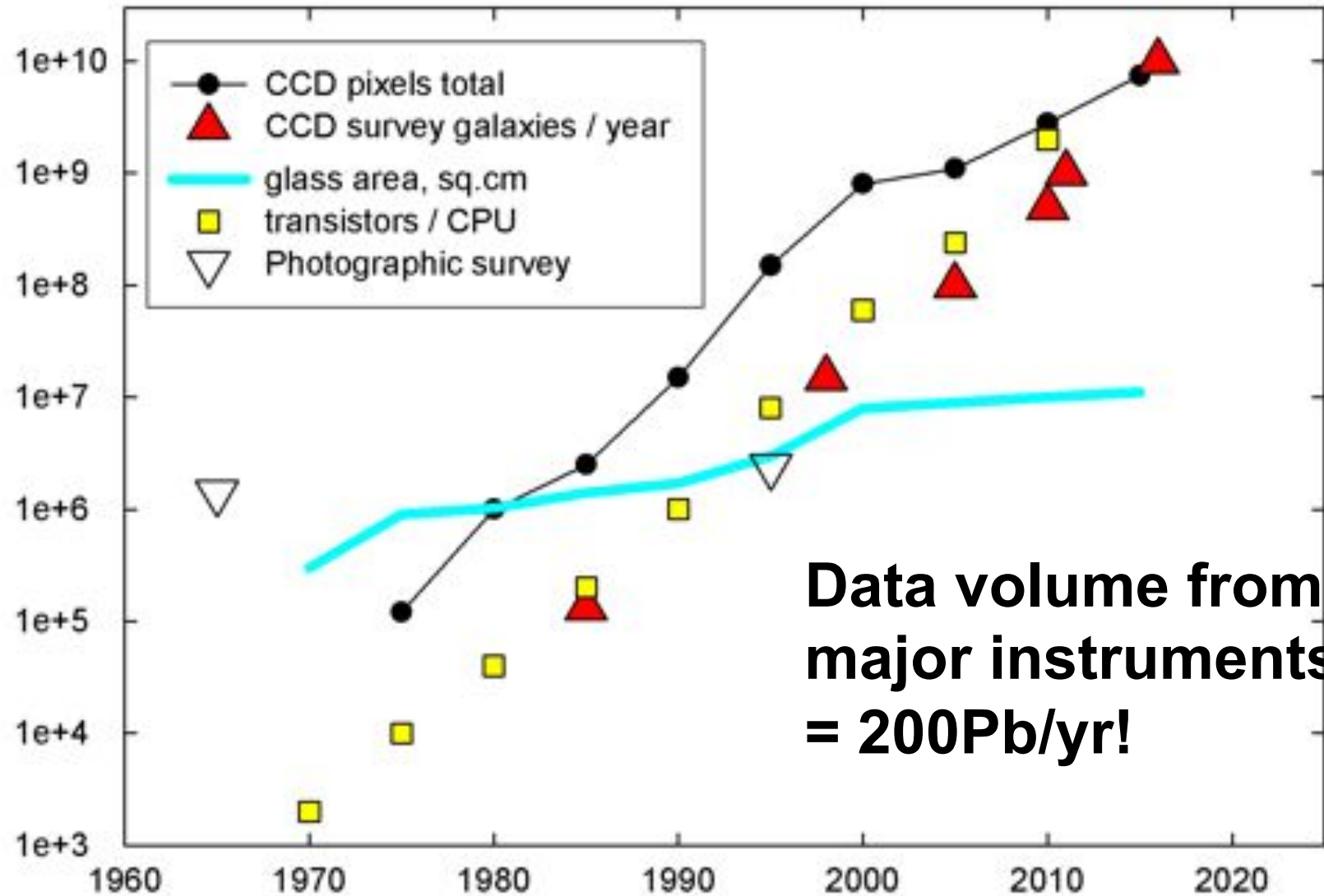
The Current Decade: “Data” Everything

- Creation of almost all information in digital form
- Dramatic cost reductions in storage
 - You can afford to keep all the data
- Dramatic increases in network bandwidth
 - You can move the data to where it's needed
- Blurring of line between computing to create data, and computing to analyze data



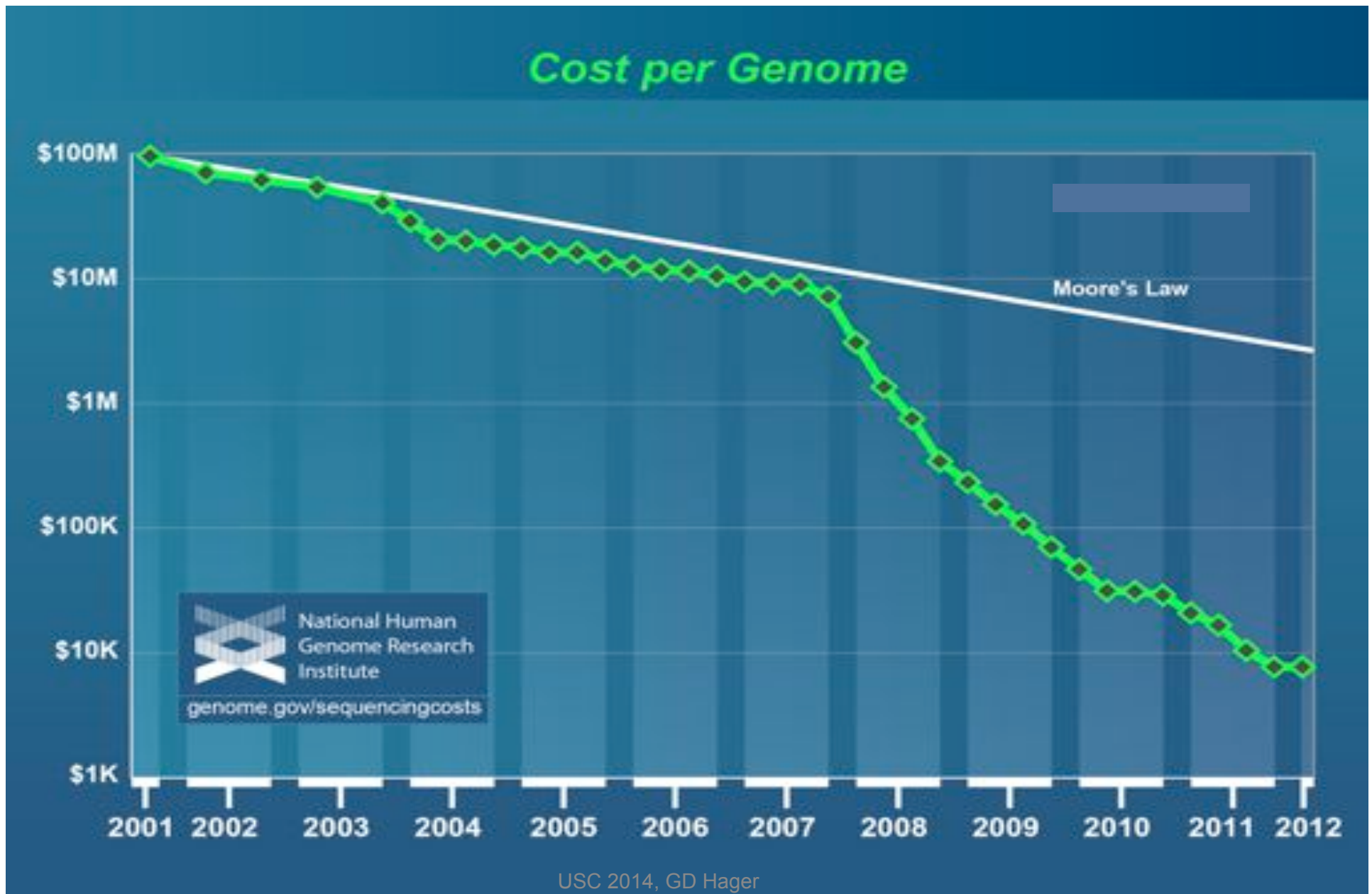
Drivers: Science

Trends in Optical Astronomy Survey Data

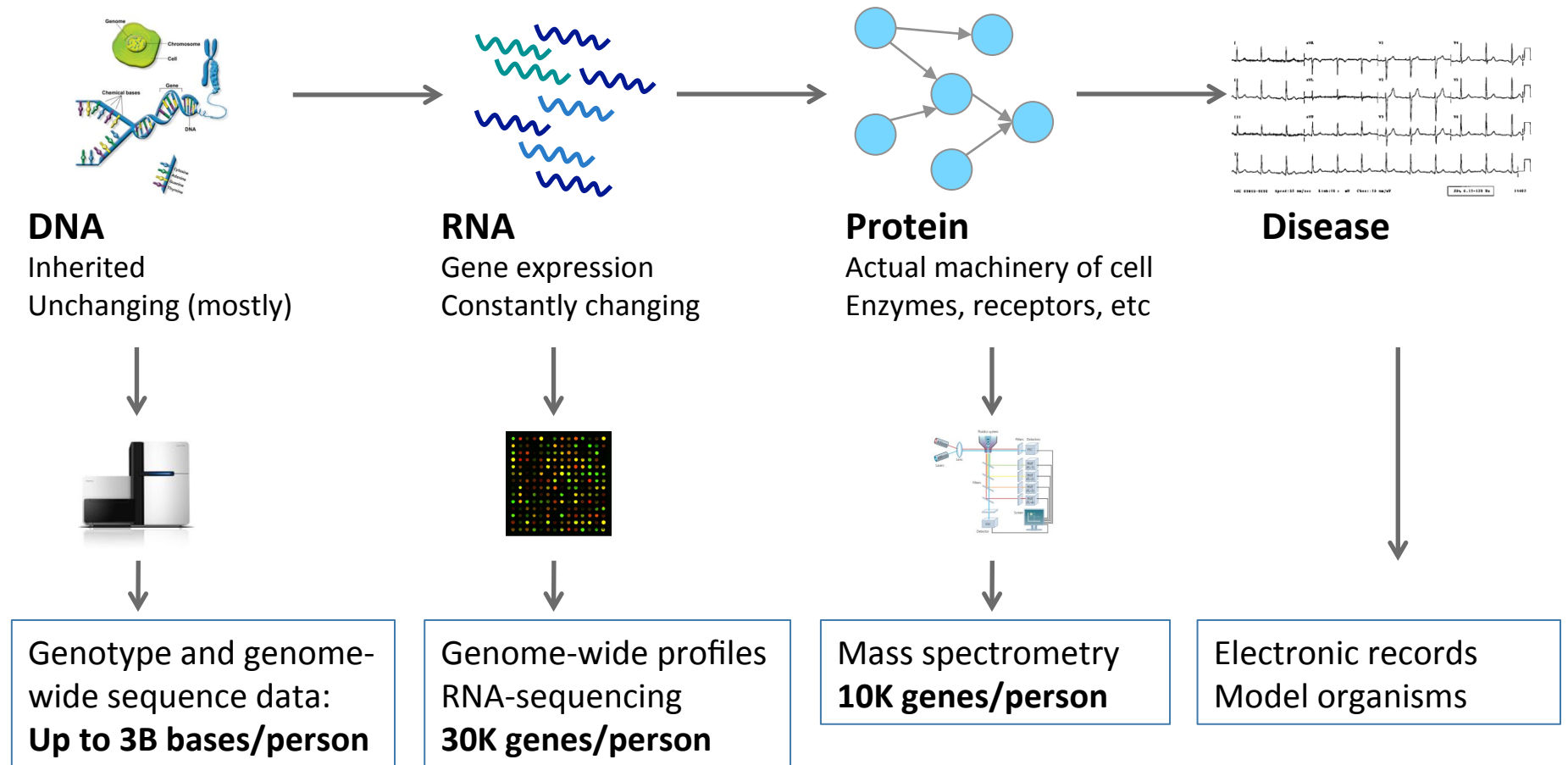


**Data volume from
major instruments
= 200Pb/yr!**

Drivers: Science



A Challenge: Making Sense of Data



The Social Realm Too!

Oct 29 [CS Colloquium: Brian Scassellati \(Yale University\) - Building Models of Self and Task](#)

Wed, Oct 29, 2014 @ 03:30 PM - 05:00 PM

Computer Science

Conferences, Lectures, & Seminars

Speaker: Brian Scassellati, Yale University

Talk Title: Building Models of Self and Task

Series: CS Colloquium

Abstract: This talk is an amalgamation of two topics that came out of research on building socially collaborative systems that focus on building richer representations of both robots and the tasks that they engage in. First, I will discuss methods for building self-trained models of a robot's own kinematic structure and sensory systems. Second, I will describe ongoing efforts to automatically learn hierarchical representations of task structure from observations. These two topics, taken together, present a novel viewpoint of how we can restructure the way in which we view the division between built-in representations and learned methods.

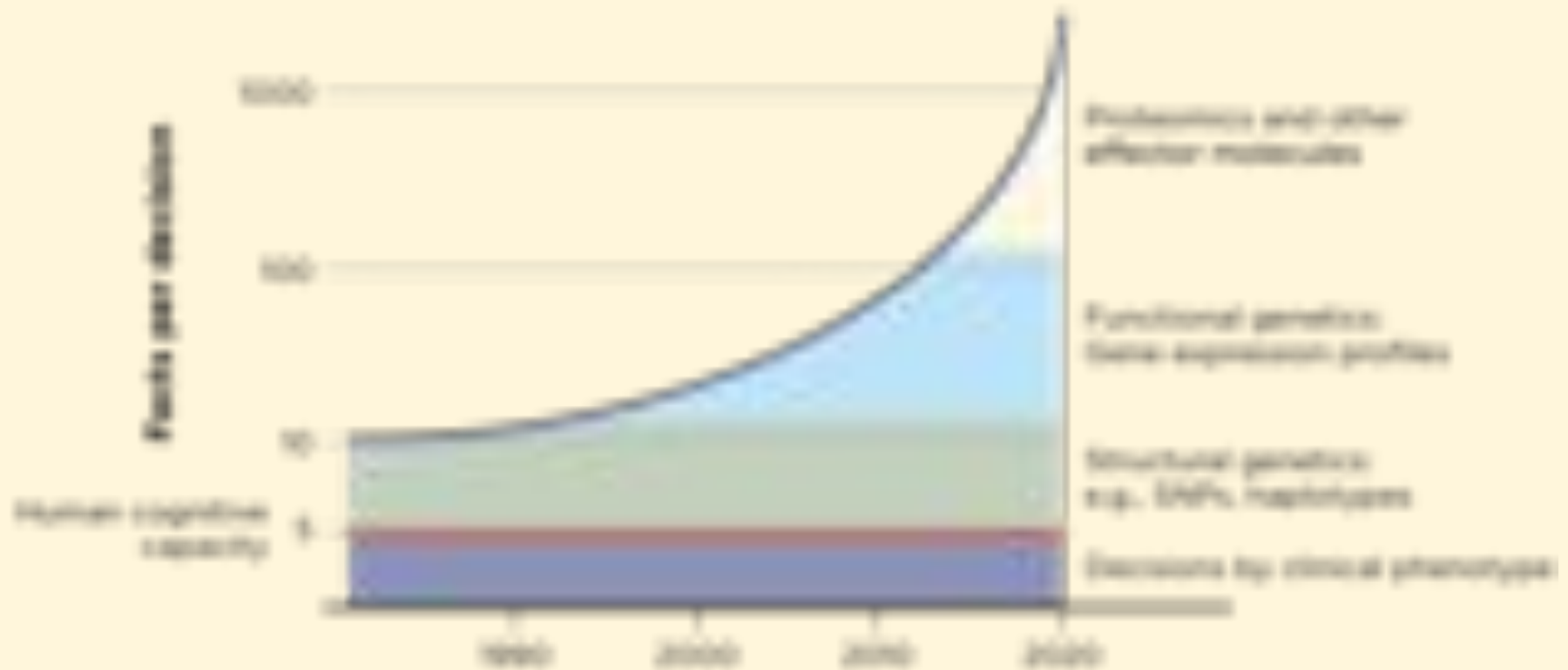
Biography: Brian Scassellati is a Professor of Computer Science, Cognitive Science, and Mechanical Engineering at Yale University and Director of the NSF Expedition on Socially Assistive Robotics. His research focuses on building embodied computational models of human social behavior, especially the developmental progression of early social skills. Using computational modeling and socially interactive robots, his research evaluates models of how infants acquire social skills and assists in the diagnosis and quantification of disorders of social development (such as autism).

Host: Maja Mataric



A Challenge: Healthcare and Complexity

Diagnostic factors in play per person



INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

Advising the nation / improving health



Overarching Challenge

Make data usable by people who aren't
computer scientists!

The Coming Decade: “Smart” Everything

- Proliferation of (mobile) sensors
- The creation of almost all information in digital form
- Dramatic cost reductions in storage
 - You can afford to keep all the data
- Dramatic increases in network bandwidth
 - You can move the data to where it’s needed



Drivers: Co-Existing and Collaborating



Smart Transportation (Google)



Smart Helpers (Rethink Robotics)



Smart Homes
(GE + Firstbuild)

A Challenge: Working in the Built Environment

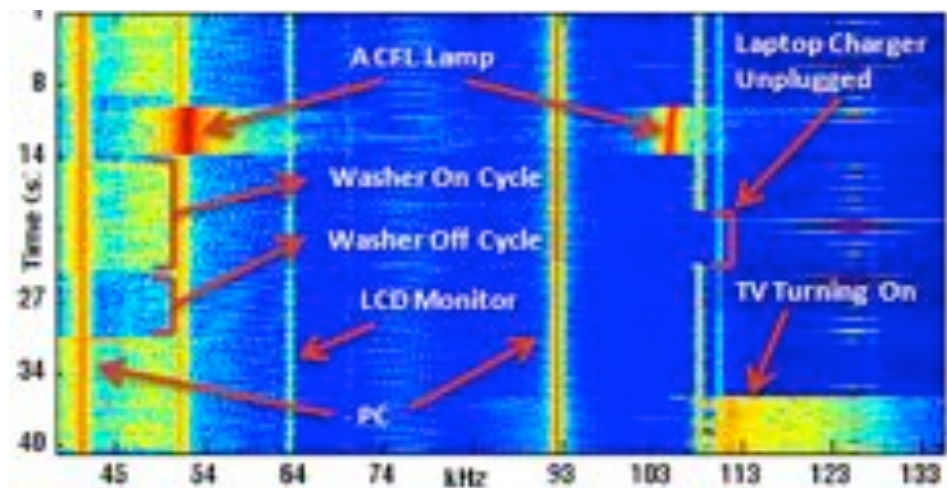


Figure 2: Frequency spectrogram showing device actuation in a

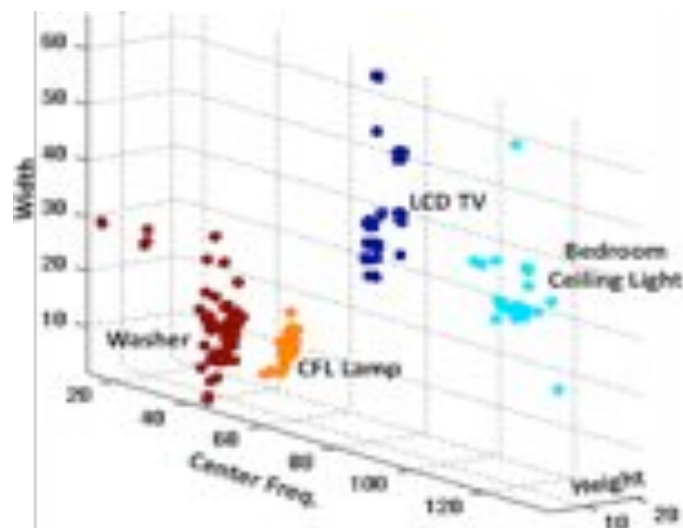


Figure 8: Variation of features over 6 months for four devices shown in the feature space. Note that no cluster overlaps.

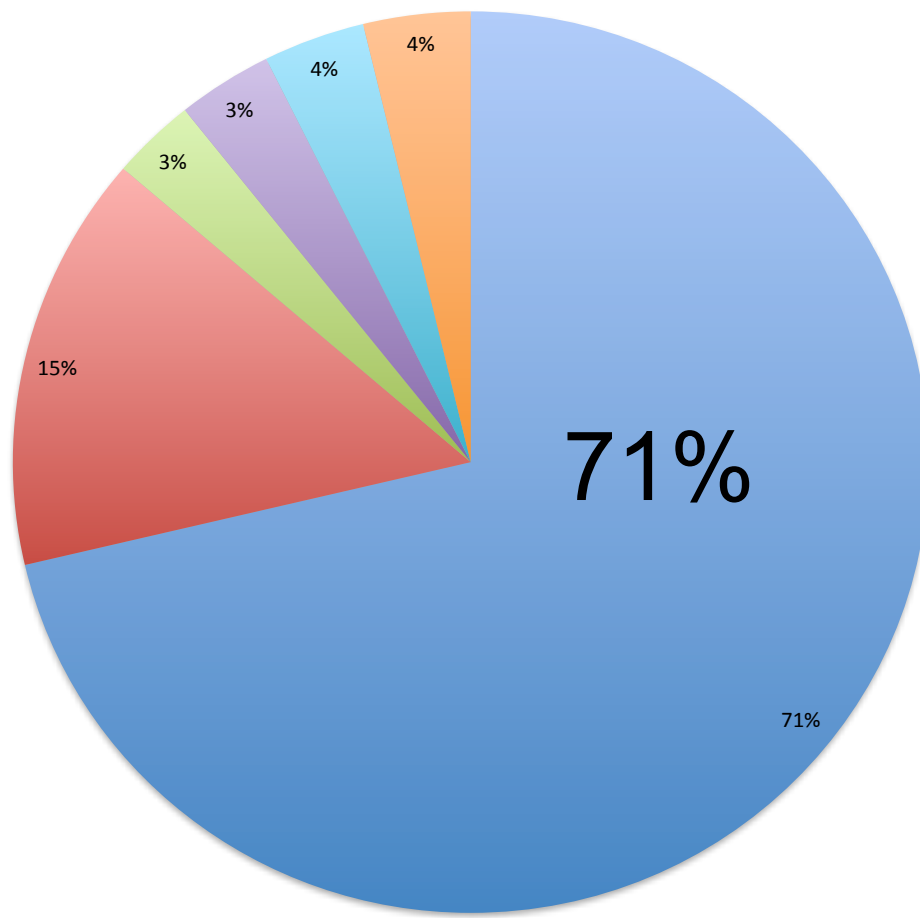
Gupta, S., Reynolds, M.S., Patel, S.N. ElectriSense: Single-Point Sensing Using EMI for Electrical Event Detection and Classification in the Home. In the *Proceedings of UbiComp 2010* (Sept. 26-29, Copenhagen, Denmark), ACM, New York, 2010, pp. 139-148.

An Overarching Challenge

Who's doing to do all of this?

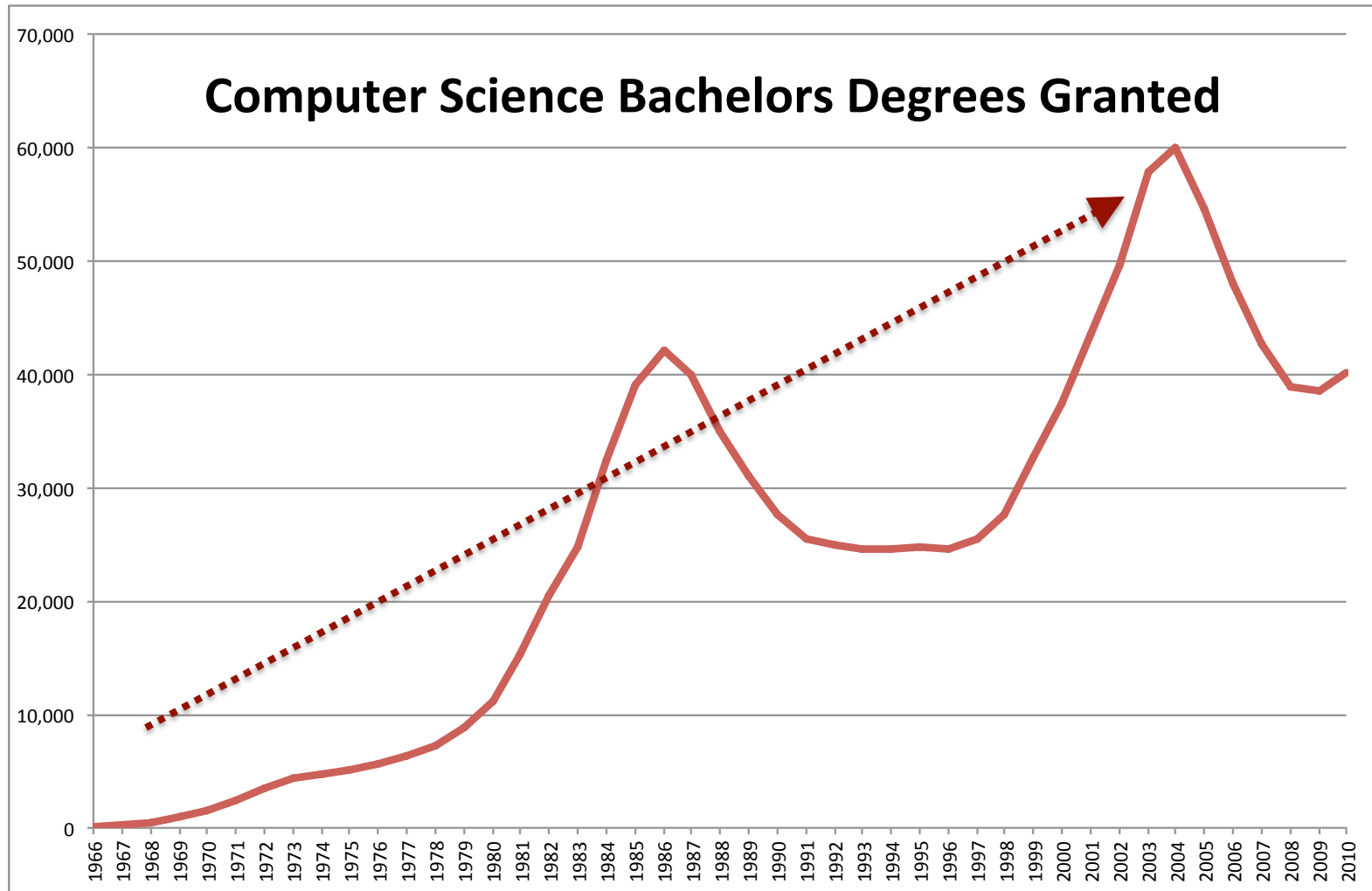
No wonder students (or their parents, more likely) are figuring out that all of the STEM jobs are in computer science

Job Growth, 2012-22 - U.S. Bureau of Labor Statistics
Computer Occupations = 71% of all STEM



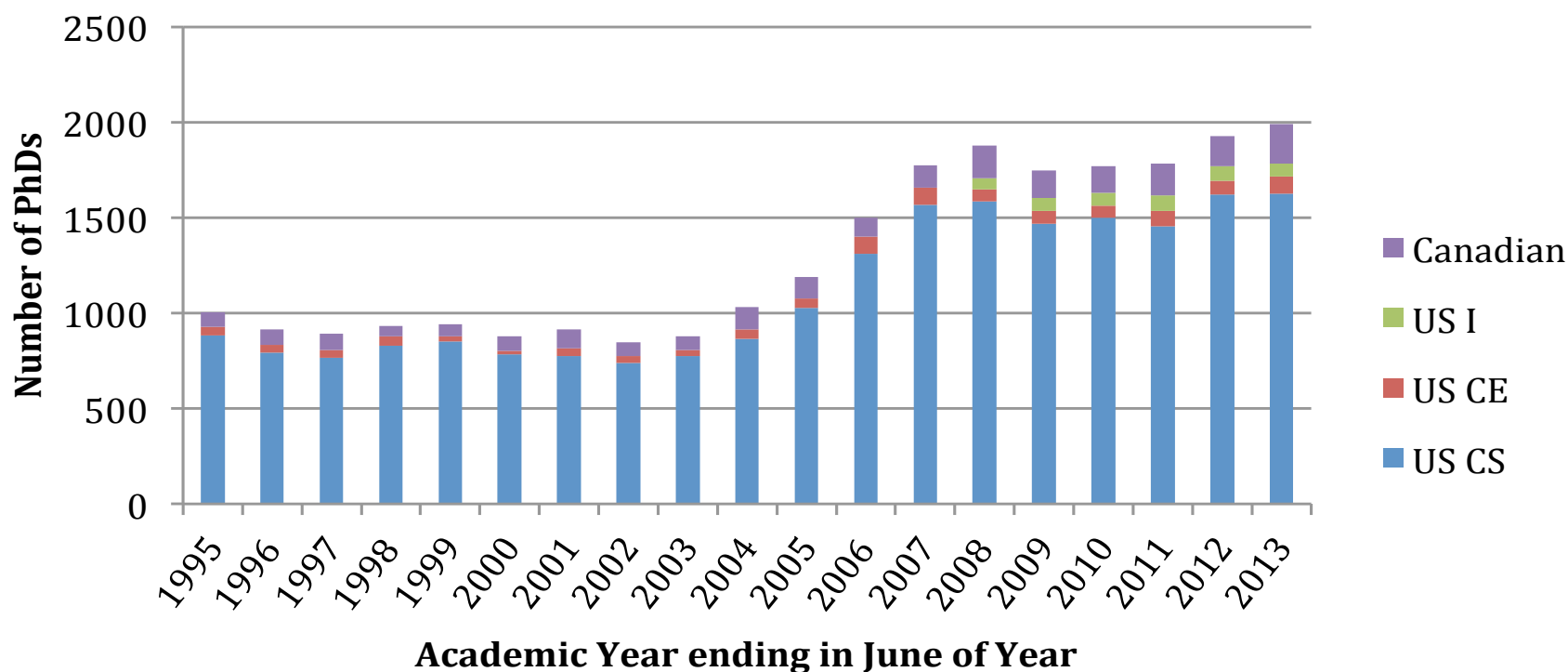
Data from the spreadsheet linked at http://www.bls.gov/emp/ep_table_102.htm
USC 2014, GD Hager

But, the kids are catching on ...



PhD Production is also at an all-time high!

Figure D1. PhD Production
CRA Taulbee Survey 2013

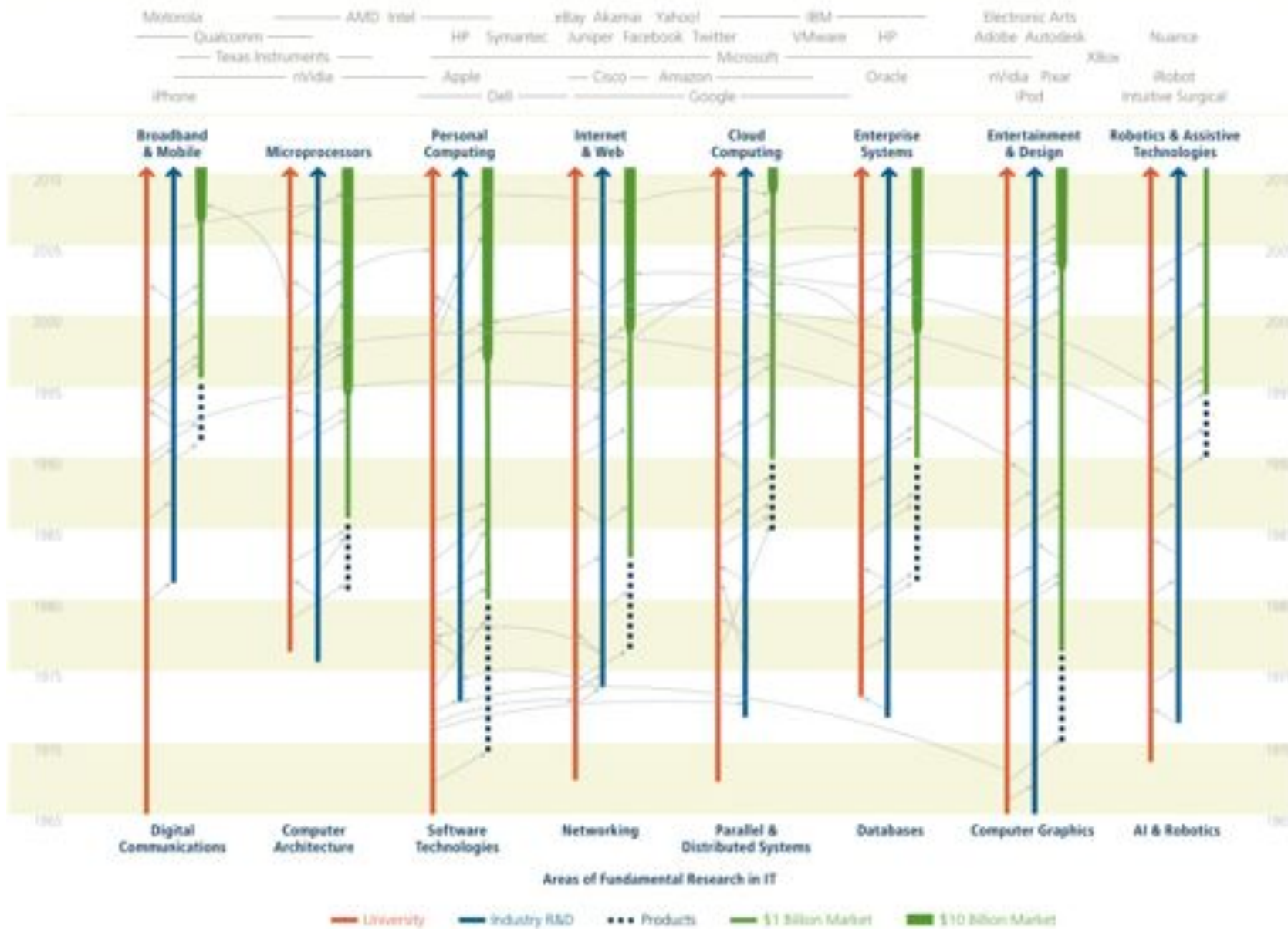


But What Ultimately Drives All of This?

Research and



IT Sectors With Large Economic Impact

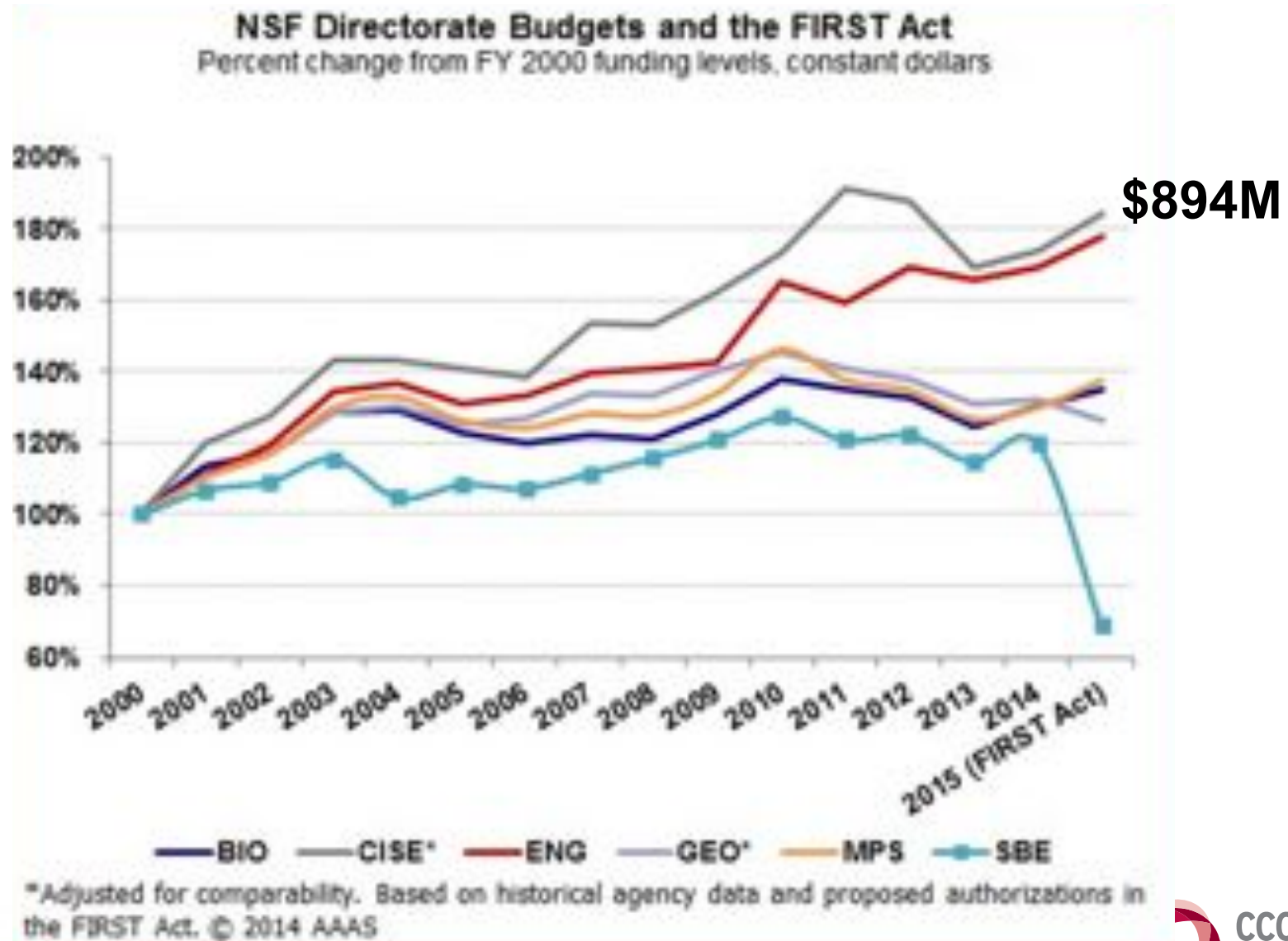


Drivers: Industry

- IT is around 1T\$* of US economy (itself 18T\$ GDP)
 - **Apple Inc. (Nasdaq: AAPL), (560B/30B)**
 - Exxon Mobil Corporation (NYSE: XOM),
 - **Google Inc (Nasdaq: GOOG), (358B /12B)**
 - **Microsoft Corporation (Nasdaq: MSFT), (344B/20B)**
 - Berkshire Hathaway Inc. (NYSE: BRK.B),
 - Wal-Mart Stores, Inc. (NYSE: WMT),
 - Johnson & Johnson (NYSE: JNJ),
 - General Electric Company (NYSE: GE),
 - Chevron Corporation (NYSE: CVX)
 - Wells Fargo & Co (NYSE: WFC)

*Atkinson, R. D., & Stewart, L. A. (2013). Just the FACTS:
The Economic Benefits of Information and Communications Technologies

Drivers: Government Investments

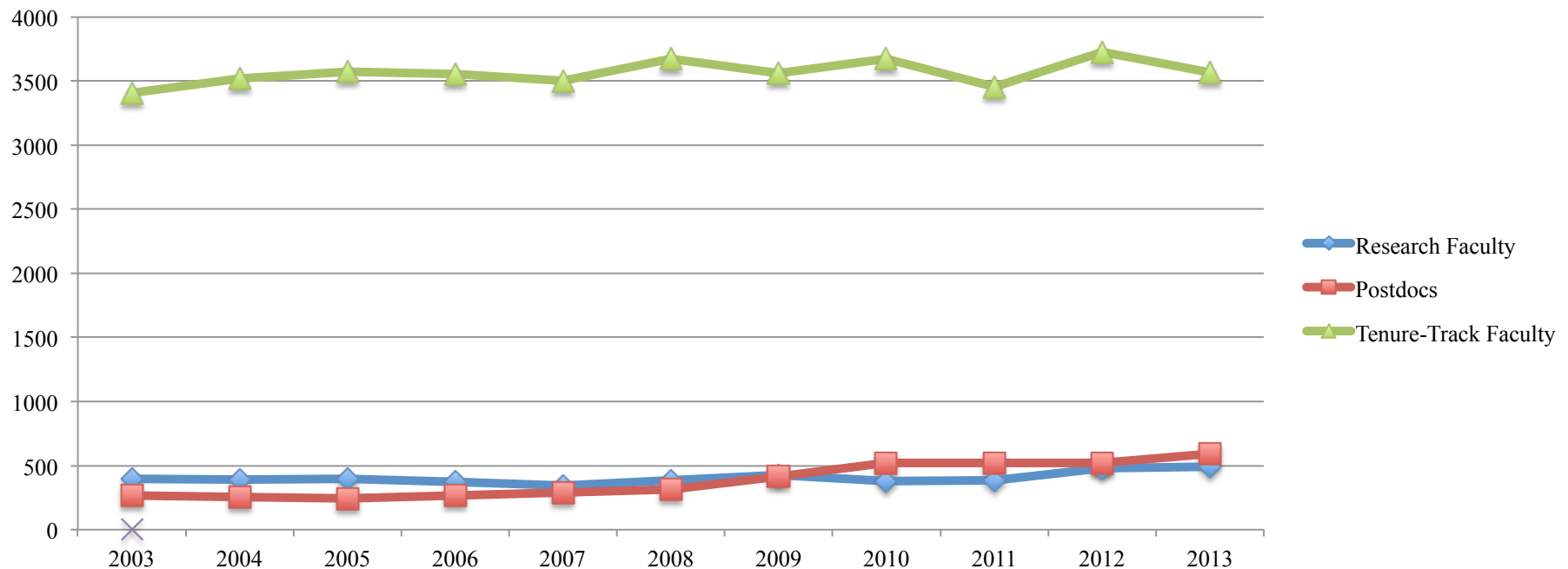


Payoff on Investment

- CISE core at 682M is 87% of CS funding nationally – effectively a payoff of 1200-1!

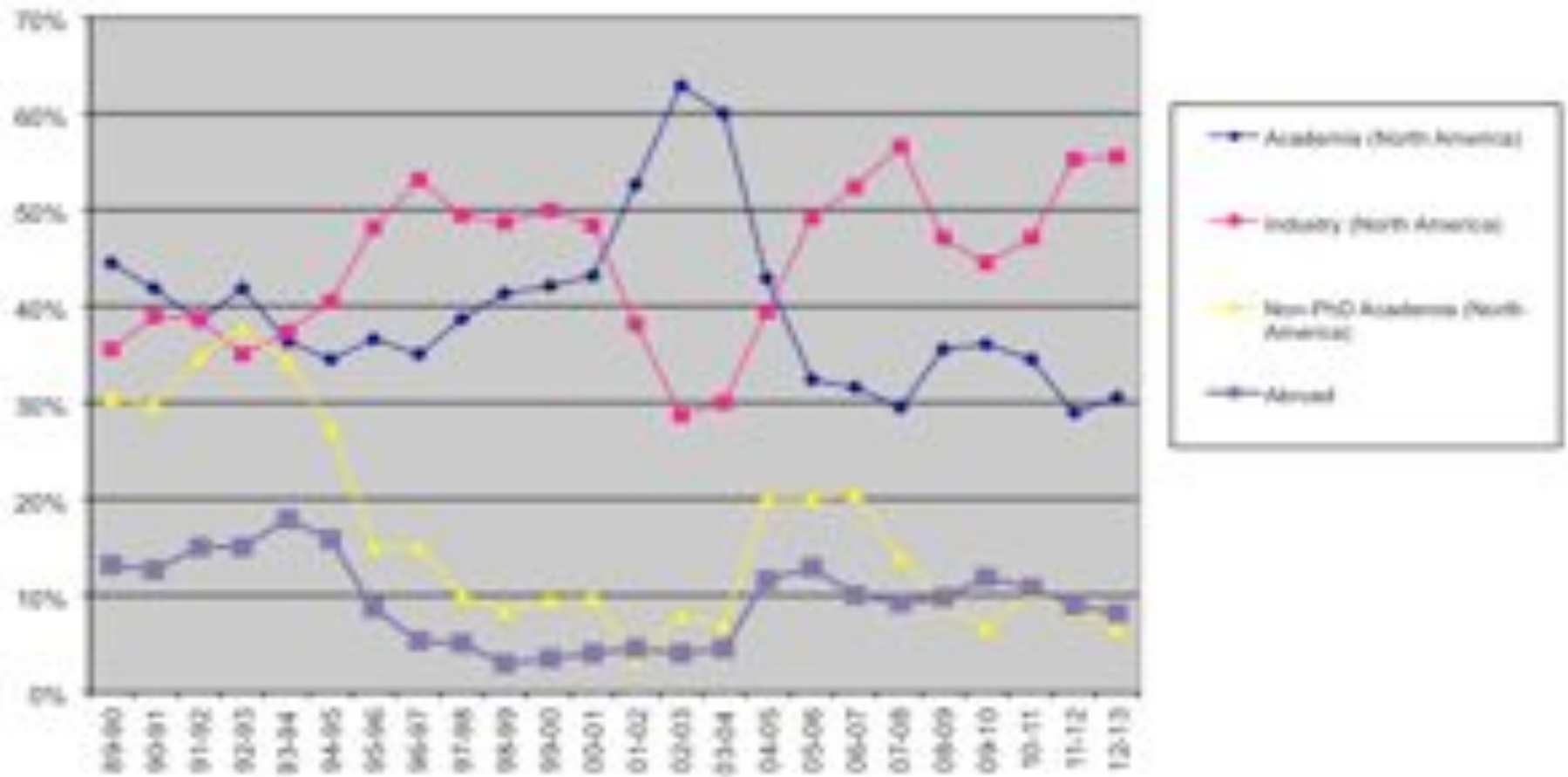
Payoff on Investment

- CISE core at 682M is 87% of CS funding nationally – effectively a payoff of 1200-1!
- But, we aren't growing academics!

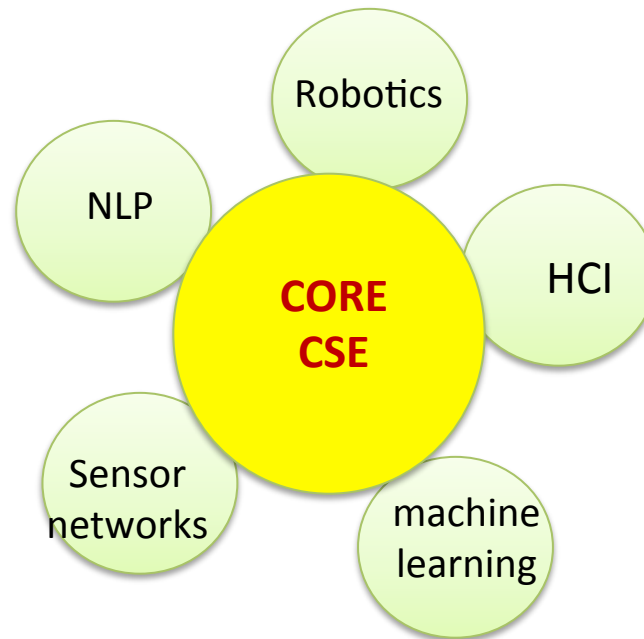


Most PhDs Go To Industry Too ...

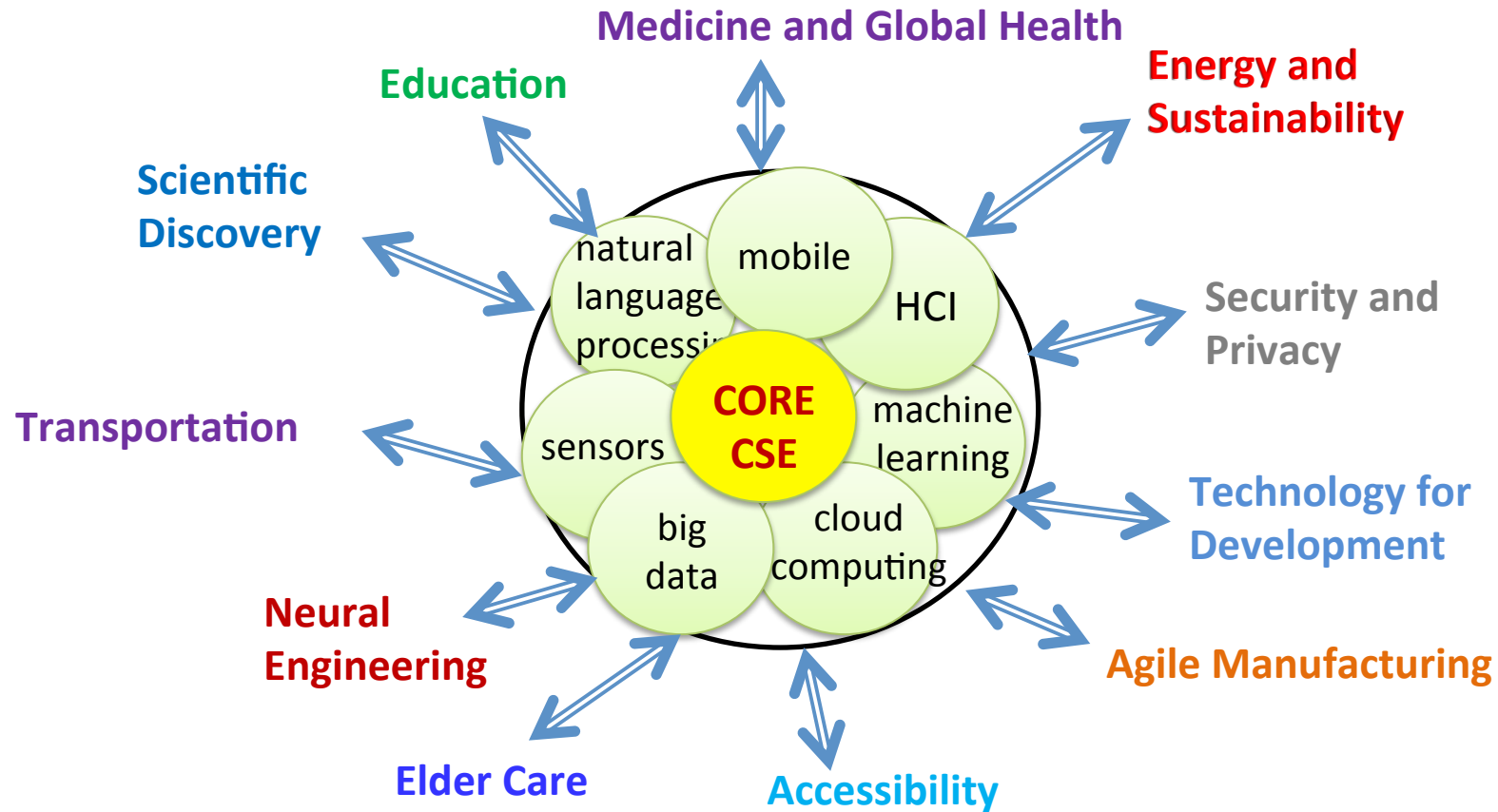
Figure D6. Employment of New Ph.D.s in U.S. and Canada
(RA Taubee Survey 2013)



The Way We Think of Ourselves



The Way It Really Is



Drivers: Industry, Society, Government, Science

What Is Our Future? How Do We Shape It?

Is Computing the
future of thought
and discourse?



Is Computing creating a new ways to combine
and create?



Is it the beginning of the
end of Computing as
we know it?

THE COMPUTING COMMUNITY CONSORTIUM: CATALYZING AND ENABLING COMPUTING RESEARCH

Gregory Hager
Chair
Johns Hopkins

Elizabeth Mynatt
Vice Chair
Georgia Tech

Ann Drobnis
Director



CCC

Computing Community Consortium
Catalyst

SOME MOTIVATING QUESTIONS

- How do we energize the community around “big ideas” that will create excitement and energy for computing and computational research?
- How do we shape and articulate our relevance to national priorities?
- How do we communicate these ideas, as a community, to science policy and funding leadership?

THE COMPUTING COMMUNITY CONSORTIUM

- Established in 2006 as a standing committee of the Computing Research Association
- Funded by NSF under a Cooperative Agreement
 - Second Award began in 2012, recently completed Reverse Site Visit

THE START

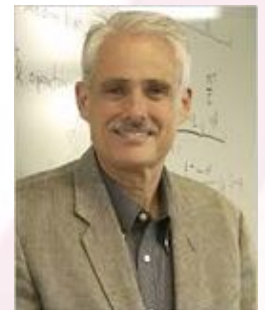
PIs

- Dan Reed, PI
- Andrew Bernat
- Susan Graham
- Anita Jones
- Edward Lazowska



Also in the Mix

- Randal Bryant
- Richard Karp
- Ken Kennedy
- Peter Lee
- Wim Sweldens
- Jeffrey Vitter



CCC

Computing Community Consortium
Catalyst

THE COMPUTING COMMUNITY CONSORTIUM

- Established in 2006 as a standing committee of the Computing Research Association
- Funded by NSF under a Cooperative Agreement
 - Second Award began in 2012, recently completed Reverse Site Visit
- Facilitates the development of a bold, multi-themed vision for computing research – and communicates this vision to stakeholders
- Led by a broad-based Council with 3 year terms
- Staffed by CRA

THE CCC COUNCIL – EXECUTIVE COMMITTEE



- Greg Hager, Johns Hopkins Univ. (Chair)
- Beth Mynatt, Georgia Tech (Vice Chair)
- Susan Graham, UC Berkeley (Past Chair)
- Bob Sproull, formerly Sun Labs, Oracle
- Liz Bradley, University of Colorado, Boulder
- Mark Hill, University of Wisconsin, Madison
- Ann Drobnis, Director
- Andy Bernat, CRA Executive Director



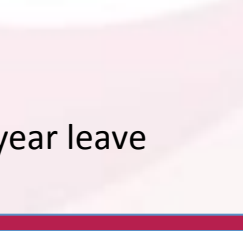
* Executive Committee
** 1 year leave



CCC

Computing Community Consortium
Catalyst

THE CCC COUNCIL



Terms ending June 2017

- Lorenzo Alvisi, UT Austin
- Vasant Honavar, Penn State
- Jennifer Rexford, Princeton
- Debra Richardson, UC Irvine
- Klara Nahrstedt, UIUC
- Ben Zorn, Microsoft Research

Terms ending June 2016

- Randy Bryant, CMU**
- Limor Fix, formerly Intel
- Tal Rabin, IBM
- Daniela Rus, MIT
- Ross Whitaker, Univ. Utah

Terms ending June 2015

- Sue Davidson, Univ. Pennsylvania
- Joe Evans, Univ. Kansas
- Ran Libeskind-Hadas, Harvey Mudd College
- Shashi Shekhar, Univ. Minnesota



** 1 year leave



CCC

Computing Community Consortium
Catalyst

OUR MISSION

- Catalyze and communicate the excitement of computing research
- Align and articulate our contributions to other fields and to national priorities
- Communicate to policymakers, industry, government, and community at large
- Groom future leadership to help shape science policy

HOW DO WE DO IT?

Community-initiated visioning:

- Workshops to discuss “out-of-the-box” ideas
- Blue Sky Ideas tracks at conferences

Outreach to White House, funding agencies:

- Outputs of visioning activities
- Short reports to inform policy makers
- Task Forces – Health IT, Sustainability IT, Data Analytics



Communicating CS Research:

- CCC Blog [<http://cccblog.org/>]
- Computing Research in Action Video Series
- Research “Highlight of the Week”
- “The Impact of NITRD” symposium

Nurturing the next generation of leaders:

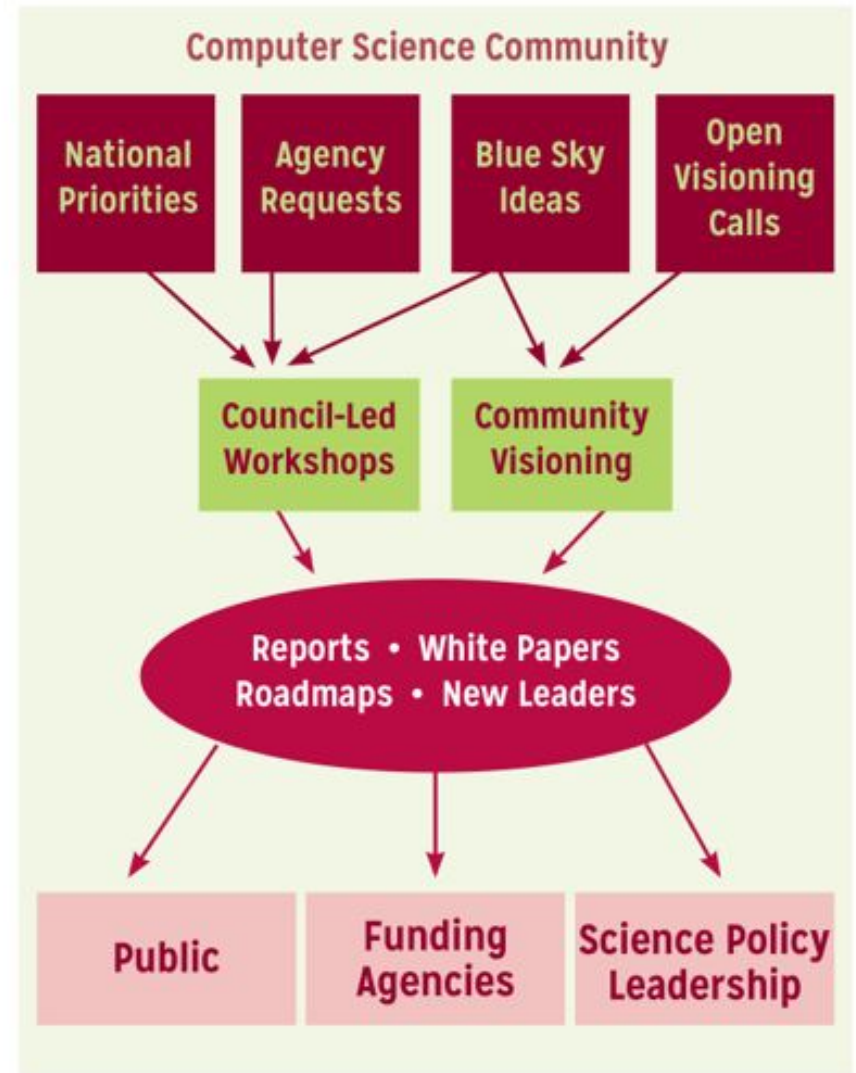
- Computing Innovation Fellows Project
- Leadership in Science Policy Institute



VISIONING GOALS

Communicate the role of CS research to stakeholders

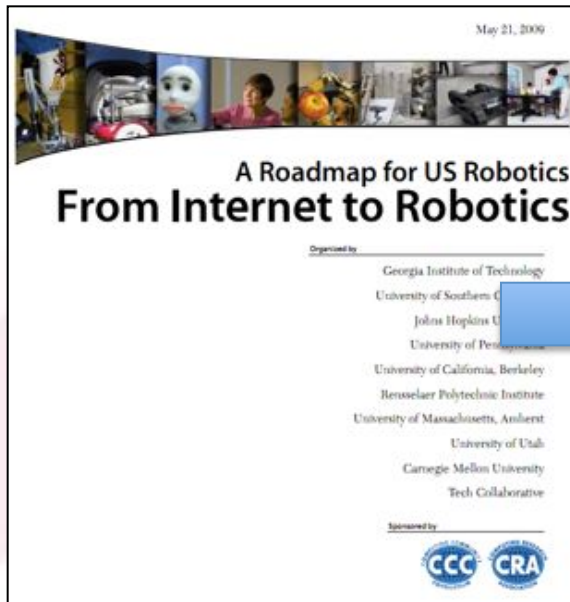
Develop leadership capacity to help shape science policy



CCC

Computing Community Consortium
Catalyst

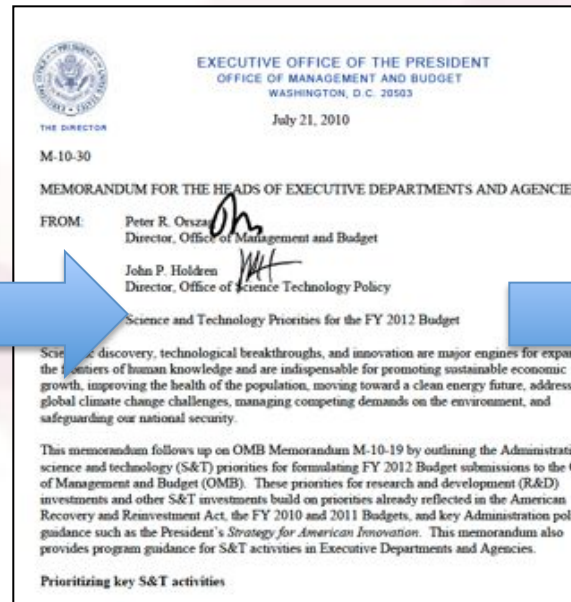
CATALYZING AND ENABLING: ROBOTICS



4 meetings during
summer 2008

Roadmap published
May 2009

*Extensive discussions
between visioning
leaders & agencies*



OSTP issues directive to all
agencies in summer 2010
to include robotics in
FY 12 budgets



National Robotics
Initiative announced
in summer 2011

Henrik Chistensen
Georgia Tech



CATALYZING AND ENABLING: BIG DATA

Big-Data Computing: Catalysts for Breakthroughs in Commerce and Science

Authors: Randall E. Bryant, Carnegie Mellon University; Randy H. Katz, University of California, San Diego

Motivation: Our Data-Driven World

Advances in digital sensors, communications, and collections of data, capturing information of our society. For example, search engine companies created an entirely new business by capturing all words from the web and providing it to people in useful ways. Bytes of data every day and continuously add new dimensions, and images, text, and video. The societal benefits have transformed how people find and make sense of information.

Just as search engines have transformed how we use data computing and will transform the world of medical practitioners, and our nation's defense is included:

- Walmart recently collected with its new capabilities of storing 4 petabytes (4096 billion bytes) of data every day – a data rate of 100 terabytes per day. By analyzing this data, Walmart can detect patterns indicating the effectiveness of their campaigns, and better manage their inventory.
- Many scientific disciplines have become data-intensive. The Large Hadron Collider (LHC) will scan the sky from a million miles away every day – a data rate of 100 terabytes per day. By analyzing this data, scientists will revolutionize our understanding of the universe. The LHC will generate 100 petabytes of data per day – 100 petabytes (100 billion bytes) of data per day. The LHC will generate 100 petabytes of data per day – 100 petabytes (100 billion bytes) of data per day. The LHC will generate 100 petabytes of data per day – 100 petabytes (100 billion bytes) of data per day.

A Series on Data Analytics: From Data to Knowledge to Action: A Global Enabler for the 21st Century

Eric Horvitz, Microsoft Research and Tom Mitchell, Carnegie Mellon University

Enabling Evidence-Based Healthcare [PDF | Word]
Eric Horvitz, Microsoft Research

Enabling an Initiative in "New Biology" [PDF | Word]
Chase Hensel, Computing Research Association and Erwin R. Gajander

Enabling 21st Century Discovery in Science and Engineering
Randall E. Bryant, Carnegie Mellon University and Ed Lazowsky

Enabling Advanced Intelligence and Decision-Making for Air and Space
Randall E. Bryant, Carnegie Mellon University, James G. Carboni, Tom Mitchell, Carnegie Mellon University

Enabling a Revolution in New Transportation [PDF | Word]
Sebastian Thrun, Stanford University, Chase Hensel, Computing Research Association

Enabling Personalized Education [PDF | Word]
Beverly Park Wood, University of Massachusetts-Amherst, Computing Research Association

Enabling the Smart Grid [PDF | Word]
Randall E. Bryant, Carnegie Mellon University, Randy H. Katz, University of California, San Diego, Erwin R. Gajander, Computing Research Association

Challenges and Opportunities with Big Data [PDF]
A community white paper developed by leading researchers

FOR IMMEDIATE RELEASE
March 29, 2012

Office of Science and Technology Policy
Executive Office of the President
New Executive Office Building
Washington, DC 20502

OSAMA ADMINISTRATION UNVEILS "BIG DATA" INITIATIVE: ANNOUNCES \$200 MILLION IN NEW R&D INVESTMENTS

Aiming to make the most of the fast-growing volume of digital data, the Obama Administration today announced a "Big Data Research and Development Initiative." By improving our ability to extract knowledge and insights from large and complex collections of digital data, the initiative promises to help solve some of the Nation's most pressing challenges.

To launch the initiative, six Federal departments and agencies today announced more than \$200 million in new commitments that, together, promise to greatly improve the tools and techniques needed to access, organize, and glean discoveries from huge volumes of digital data.

"In the same way that past Federal investments in information-technology R&D led to dramatic advances in supercomputing and the creation of the Internet, the initiative we are launching today promises to transform our ability to use Big Data for scientific discovery, environmental and biomedical research, education, and national security," said Dr. John P. Holdren, Assistant to the President and Director of the White House Office of Science and Technology Policy.

To make the most of this opportunity, the White House Office of Science and Technology Policy (OSTP)—in concert with several Federal departments and agencies—created the Big Data Research and Development Initiative to:

- Advance state-of-the-art core technologies needed to collect, store, preserve, manage, analyze, and share huge quantities of data.
- Harness these technologies to accelerate the pace of discovery in science and engineering, strengthen our national security, and transform teaching and learning, and
- Expand the workforce needed to develop and use Big Data technologies.

2008

2008

2010

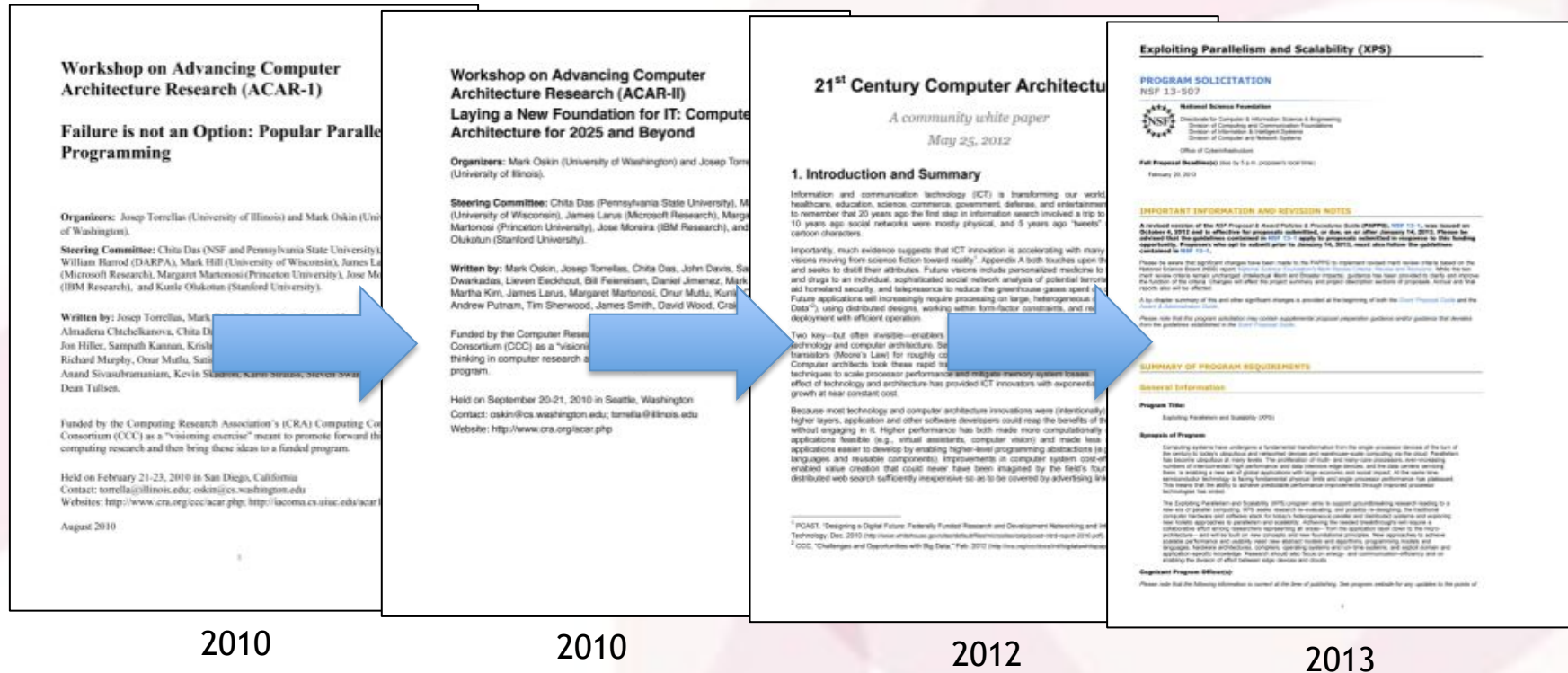
2012



CCC

Computing Community Consortium
Catalyst

CATALYZING AND ENABLING: ARCHITECTURE



Josep Torrellas
UIUC



Mark Oskin
Washington



Mark Hill
Wisconsin

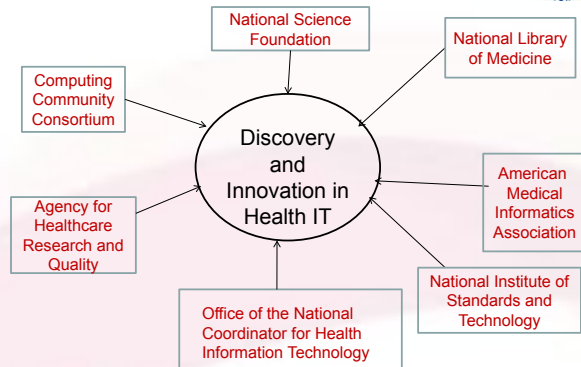


CCC

Computing Community Consortium
Catalyst

CATALYZING AND ENABLING: HEALTH IT

October 2009 Workshop



National Science Foundation
WHERE DISCOVERIES BEGIN

Directorate for Computer & Information Science & Engineering

SMART HEALTH AND WELLBEING (SHW)

CONTACTS

See program guidelines for contact information.

SYNOPSIS



Smart and Connected Health (SCH)

PROGRAM SOLICITATION NSF 13-543

REPLACES DOCUMENT(S): NSF 12-512



National Science Foundation

Directorate for Computer & Information Science & Engineering
Division of Computing and Communication Foundations
Division of Computer and Network Systems
Division of Information & Intelligent Systems

Directorate for Engineering

Directorate for Social, Behavioral & Economic Sciences



National Institutes of Health

October 2012 Workshop



CCC

Computing Community Consortium
Catalyst

SOME RECENT AND UPCOMING EVENTS

- Aging in Place (with NIH)
- Uncertainty in Computation (Community driven)
- BRAIN (with CISE) ←————→
- Privacy by Design (Community driven)
- CS Visions 2025 (with CISE AC)



Thanks Stefan!

YOUR
Workshop
HERE



CCC

Computing Community Consortium
Catalyst

BLUE SKY IDEAS CONFERENCE TRACKS

- Special “Blue Sky Ideas” tracks at leading conferences
 - Reach beyond usual papers
- CCC provides prize money for top 3 papers
 - Papers should be:
 - open-ended
 - “outrageous” or “wacky”
 - Present new problems, new application domains or new methodologies
 - Relatively short (4-6 pages)
 - Published after the conference



CCC

Computing Community Consortium
Catalyst

BLUE SKY IDEAS CONFERENCE TRACKS

- BuildSys 2012
- Computational Sustainability Track @ AAI 2013
- Computational Sustainability Award @ CHI 2013
- Robotics: Science and Systems 2013
- Conference on Innovation Data Systems Research (CIDR-2013)
- Autonomous Agents and MultiAgent Systems (AAMAS-2014)
- Upcoming:
 - Foundations of Software Engineering 2014
 - Association for the Advancement of Artificial Intelligence 2015
 - SIGSPATIAL 2015

COMMUNICATING: LEADERSHIP IN SCIENCE POLICY INSTITUTE



CCC Computing Community Consortium
We support the computing research community in creating compelling research visions and the mechanisms to realize these visions.

HOME ABOUT YOUR VISION **ACTIVITIES** RESOURCES CONTACT GO

CCC Leadership in Science Policy Institute

Agenda

8:30 am - 9:00 am
Welcome [180 KB PDF] [Referenced videos - Lazewski | Bartlett | Brooks]
{Fred Schneider, Cornell, Workshop Chair}

Lay out the goals of the workshop: to provide a crash-course in relevant science policy issues and the mechanics of policymaking, including a sense of how federal science policy is crafted, how it's implemented, and where are the opportunities for members of the community to participate in the policy-making process.

9:00 am - 10:30 am
Interacting with Agencies/Creating New Initiatives
{Jeanette Wing, CMU [434 KB PDF]; Milt Corn, NIH [242 KB PDF]; Henry Kelly, DOE}

The agencies are where the science-policy rubber hits the road, where decisions made in both the Administrative and Legislative branches get implemented, and the most common avenue for individuals in the science community to interact with the federal government. Influencing policy decisions at the agency level can require a somewhat different skill set and somewhat different approach than influencing your faculty peers, the Congress, or the White House. Agencies also provide opportunities for individuals in the community to directly shape federal policy in their field, by serving on an agency advisory committee, or by taking a rotation as a program manager, division director, or office director. This session will cover the agency budget process and will discuss opportunities for scientists to advise and engage federal science agencies like NSF, DOE, and NIH. The speakers will discuss the mechanics of how agency new initiatives get started, focusing on the culture and traditions that constitute the lens through which agencies view themselves and are viewed by others. In practical terms, how is success measured? To what extent is outside advice sought and in support of what kinds of activities? What kinds of advice and modes of engagement are unlikely to be effective?

[Back to Main Page](#)

Content is still being added to this site. Please check back periodically. The last change was made on: **December 13, 2011.**

Logistics

Date: November 7, 2011
Location: Hyatt Regency Capitol Hill, Washington, DC

Participation in the workshop will include breakfast and lunch at the workshop, as well as a reception with workshop speakers and other interested guests at the conclusion of the meeting. Hotel accommodations for two nights (before and after the workshop) as well as reimbursement for airfare and other travel expenses will be provided by the workshop (through funding from CCC).

Agenda

[List of Sessions and Speakers and Slides](#)



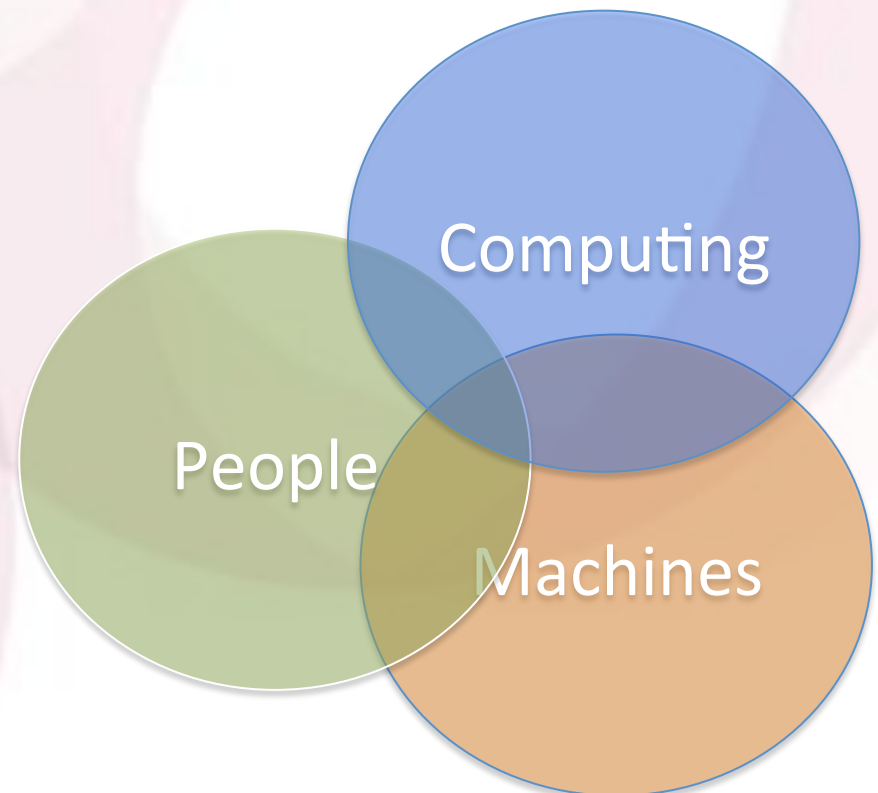
#3 coming 4/15!



Computing Community Consortium
Catalyst

SOME CURRENT THEMES

- Computing and the Physical World
- What are the underlying CS research questions that will enable new generations of smart systems that move, manipulate, and control our environment?



CCC

Computing Community Consortium
Catalyst

SOME CURRENT THEMES

- Industry
 - What are interaction modes with industry?
 - How do they benefit both sides?
 - What are the growth barriers/opportunities?

Drivers: Industry

- IT is around 1T\$* of US economy (itself 18T\$ GDP)
 - **Apple Inc. (Nasdaq: AAPL), (560B/30B)**
 - Exxon Mobil Corporation (NYSE: XOM),
 - **Google Inc (Nasdaq: GOOG), (358B /12B)**
 - **Microsoft Corporation (Nasdaq: MSFT), (344B/20B)**
 - Berkshire Hathaway Inc. (NYSE: BRK.B),
 - Wal-Mart Stores, Inc. (NYSE: WMT),
 - Johnson & Johnson (NYSE: JNJ),
 - General Electric Company (NYSE: GE),
 - Chevron Corporation (NYSE: CVX)
 - Wells Fargo & Co (NYSE: WFC)



CCC

Computing Community Consortium
Catalyst

SOME CURRENT THEMES

- Cyber-infrastructure
 - Next generation HPC and relationship to data intensive computing
 - Production, transport, analysis, and visualization
- Manufacturing
 - Agile manufacturing = smart devices, networks, and software
 - 3D printing = smart devices, networks, and software
 - How do we engage the CS community

SOME CURRENT THEMES

- Education
 - What are ways that CS can help create a highly trained workforce?
 - What are the CS research questions that will enable that future?
- Healthcare
 - How do we continue to bring CS into the conversations around major healthcare initiatives?

WRAP-UP

- It is a great time to be in CS!
- We have to keep our eyes to the forefront of research
- We have to frame our ideas in a way that communicates the excitement and impact of computing research
- Subscribe to the Blog!
- Participate in LiSPI (April 2015)
- Propose a workshop or conference track
- We need your ideas!



CCC

Computing Community Consortium
Catalyst

SOME CCC VISIONING ACTIVITIES

Extreme Scale Design Automation

Sustainability & IT

Financial Cyberinfrastructure

Computing and Healthcare

Privacy R&D

Online Education

Spatial Computing

Big Data Computing

ROBOTICS

Cyber-physical systems

Disaster Management

Free & Open Source Software

Human Computation

Learning Technologies

Global Development

Uncertainty in Computation



CCC

Computing Community Consortium
Catalyst

CCC: CATALYZING AND ENABLING COMPUTING RESEARCH

*Gregory Hager
CCC Chair
Johns Hopkins University*



CCC

Computing Community Consortium
Catalyst