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UNIVERSITY

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

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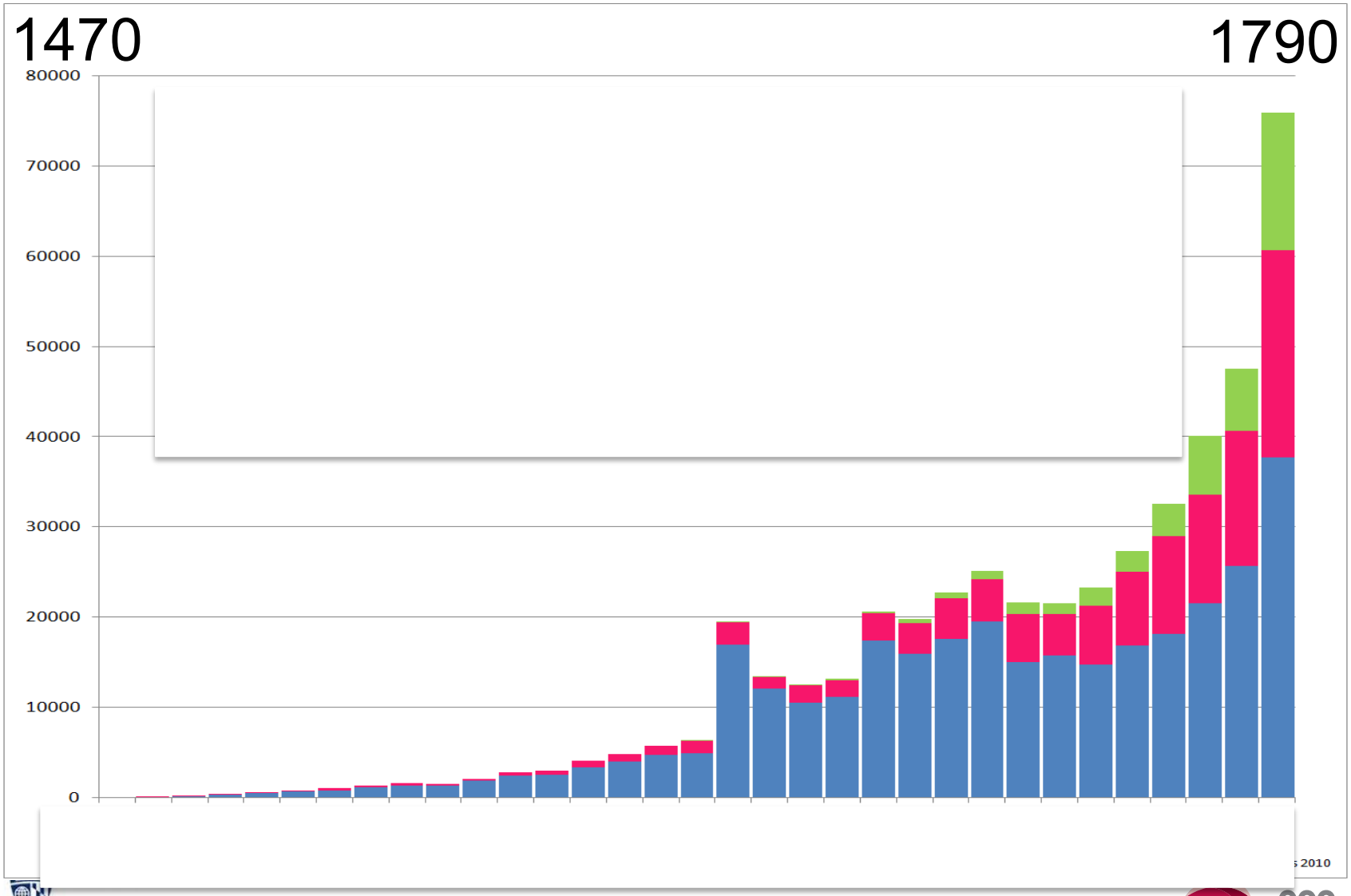
The Plan

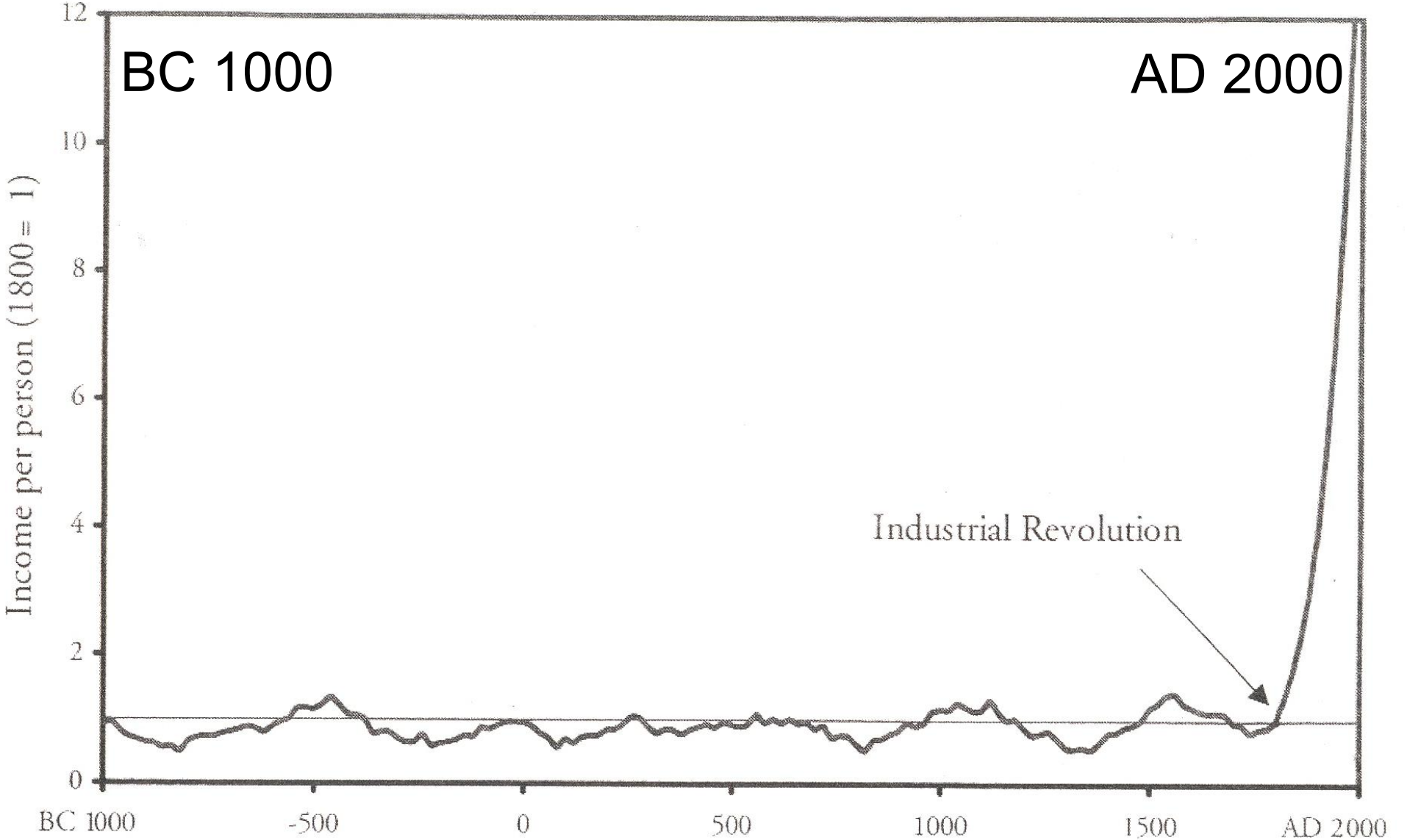
- Some observations on the past and current evolution on computing
- Some ideas about some of the forces driving computing today and how they are unique
- Some thoughts on the possible directions for the future
- The CCC and its role in shaping the future

We Aren’t The First Exponential!



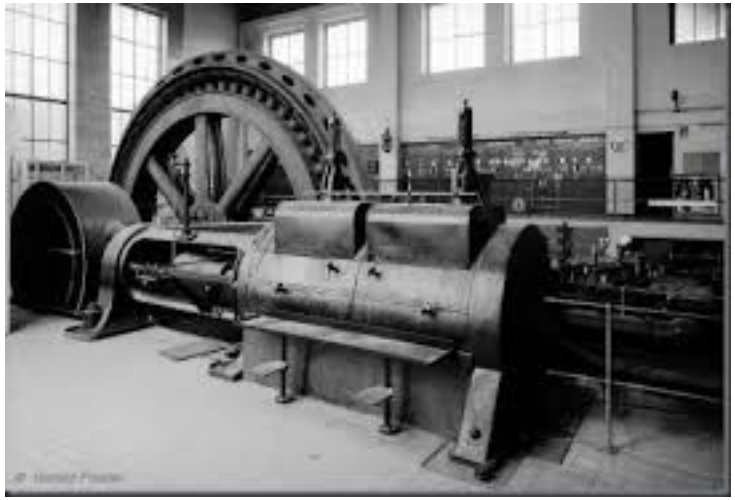
Credit: Olaf Simons

Another Exponential

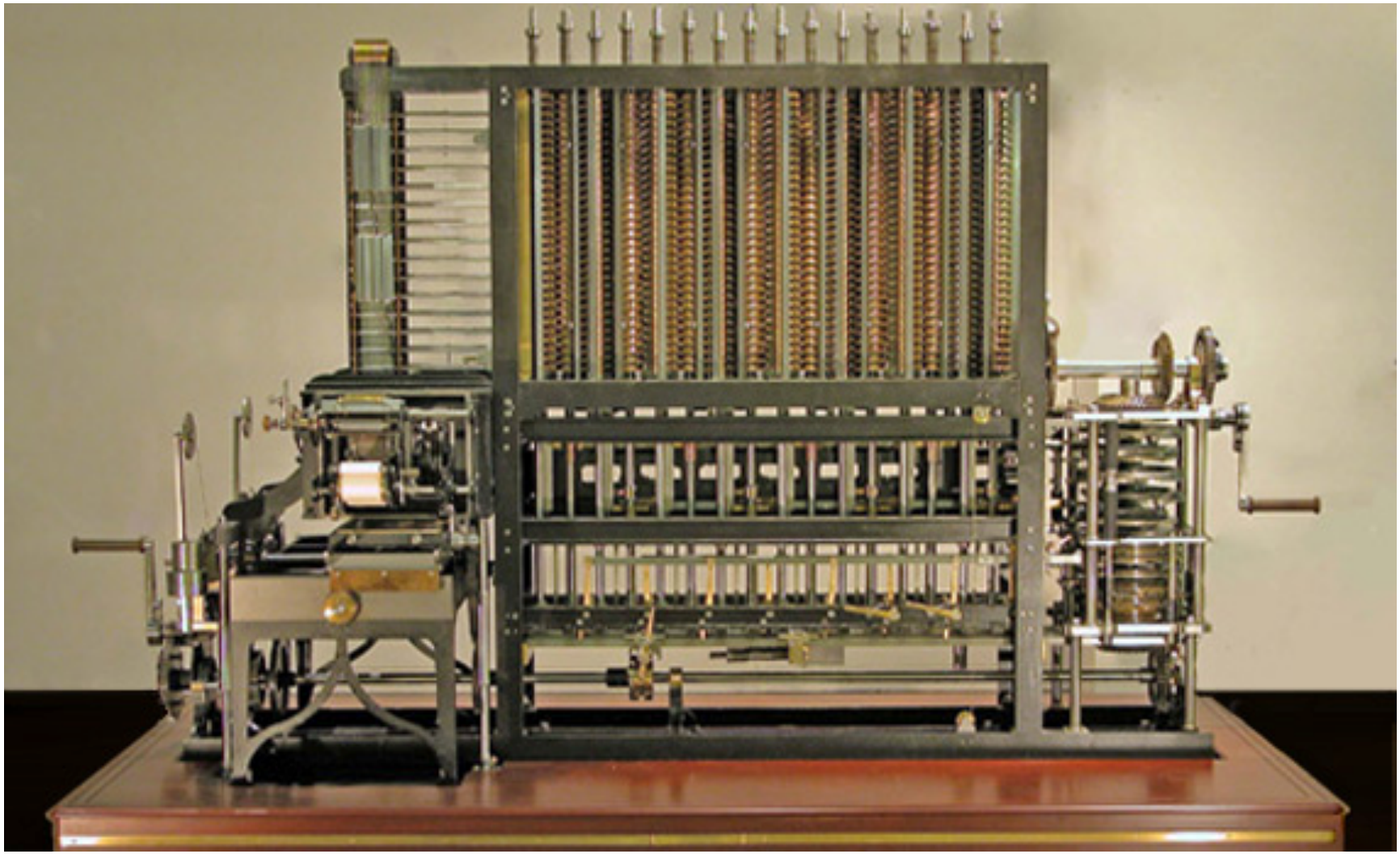


Source: Gregory Clark (2007) *A Farewell to Alms: A Brief Economic History of the World*, Princeton University Press

The Age of Steam



Physical Machines, Virtual Work!



http://www.computerhistory.org/babbage/history/

From Concept to Commodity

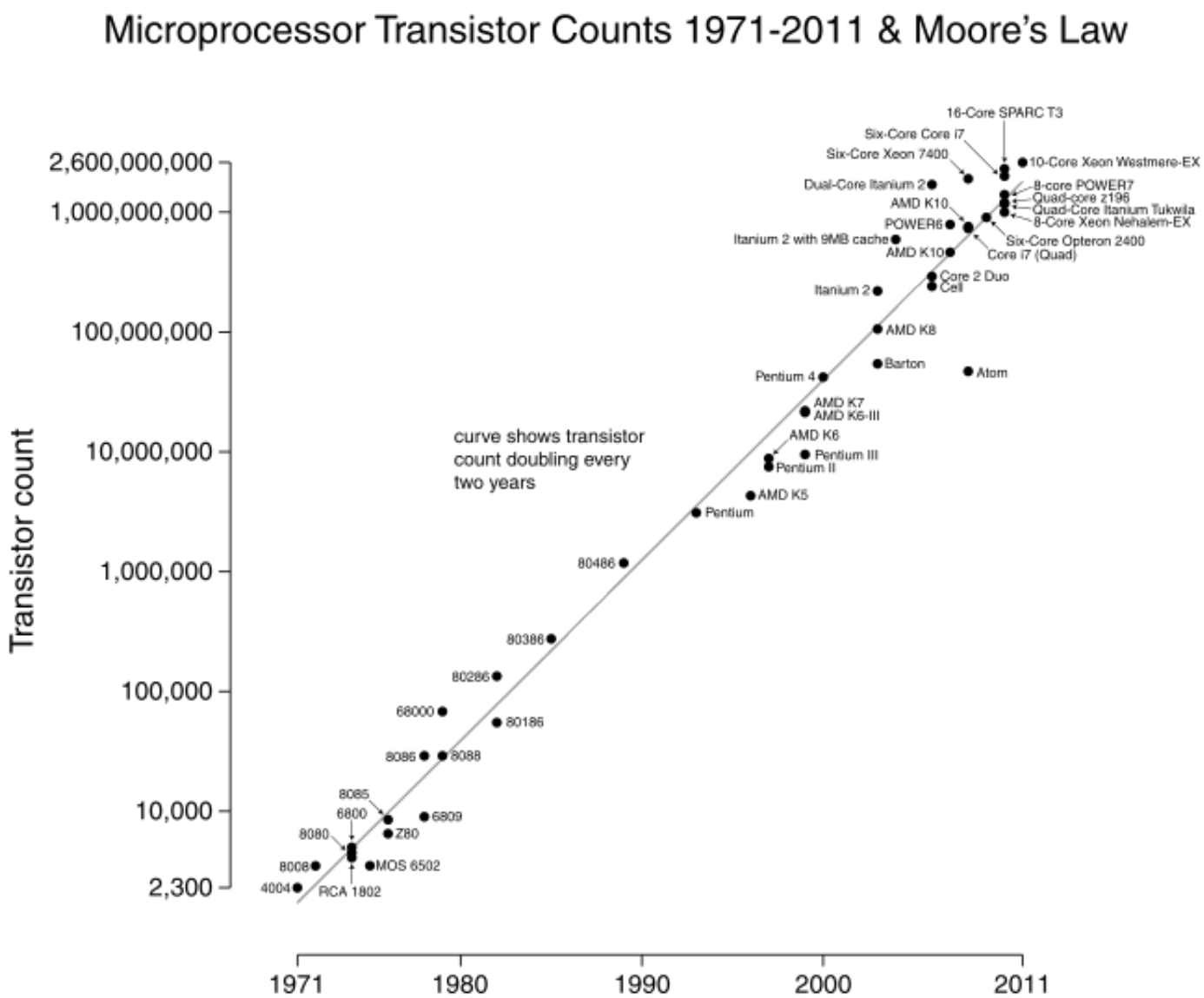
The WOMEN who first programmed them!

Ada Lovelace

Grace Hopper

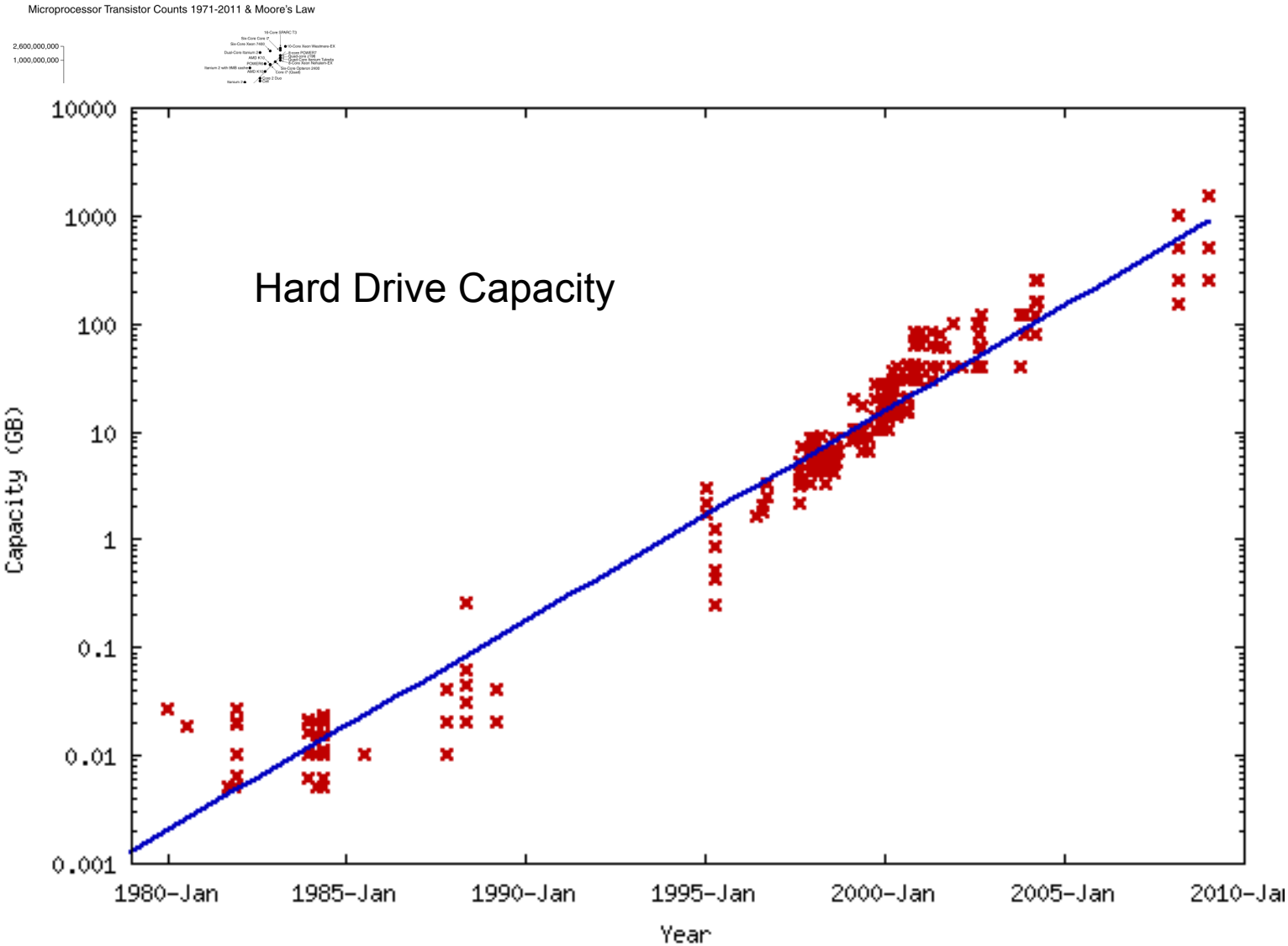
Kathy Kleiman,
Jean Bartik,
Marlyn Meltzer,
Kay Mauchly Antonelli
Betty Holberton

Surfing Exponential (Economic) Waves

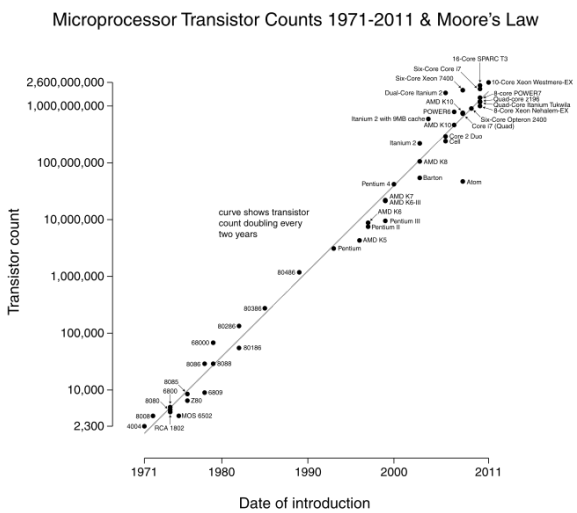


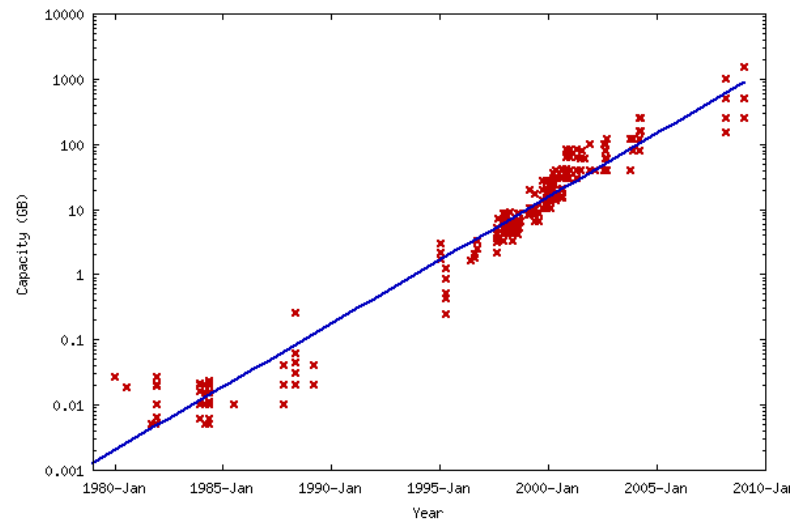
Gordon Moore

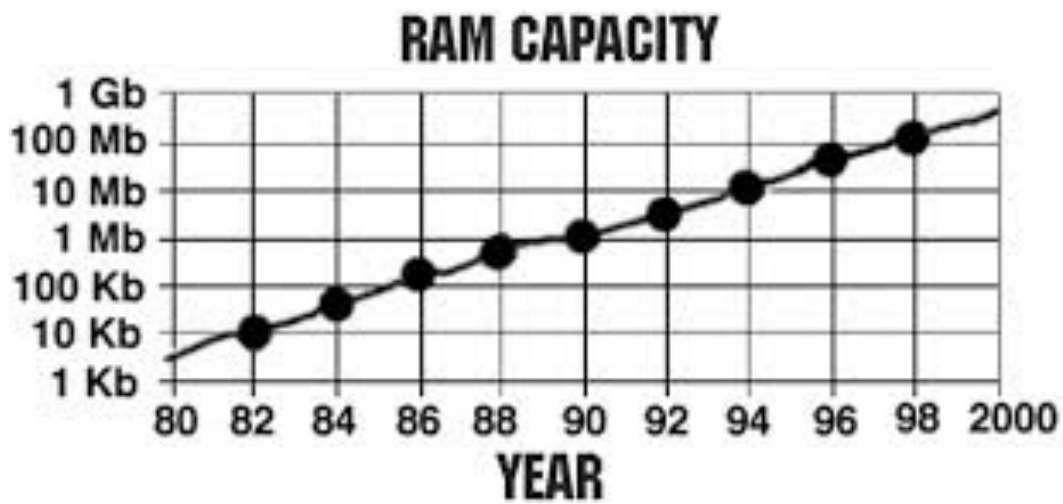
Surfing Exponential (Economic) Waves



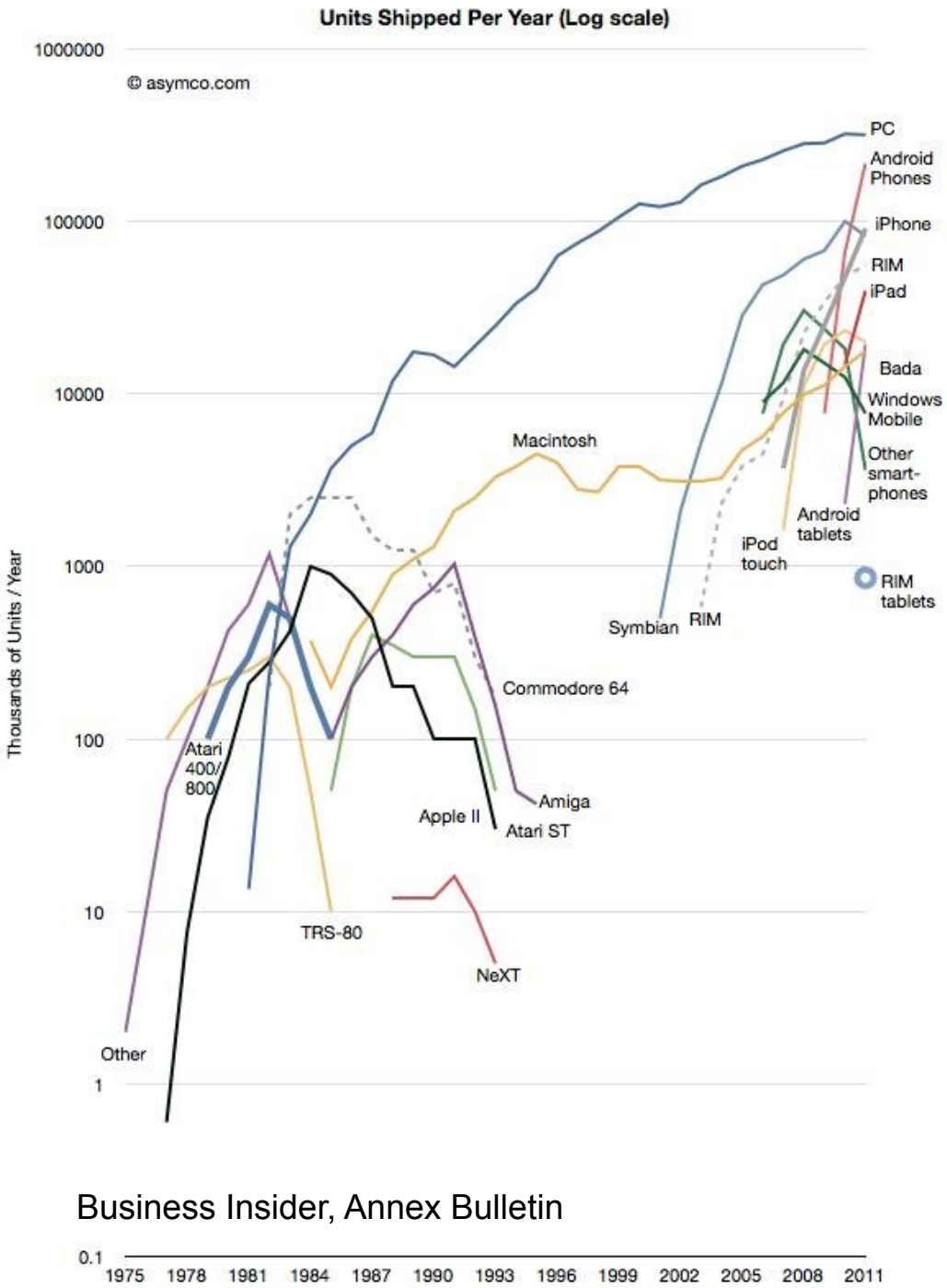
Surfing Exponential (Economic) Waves







The PC Revolution



BPwiz.com

Business Insider, Annex Bulletin

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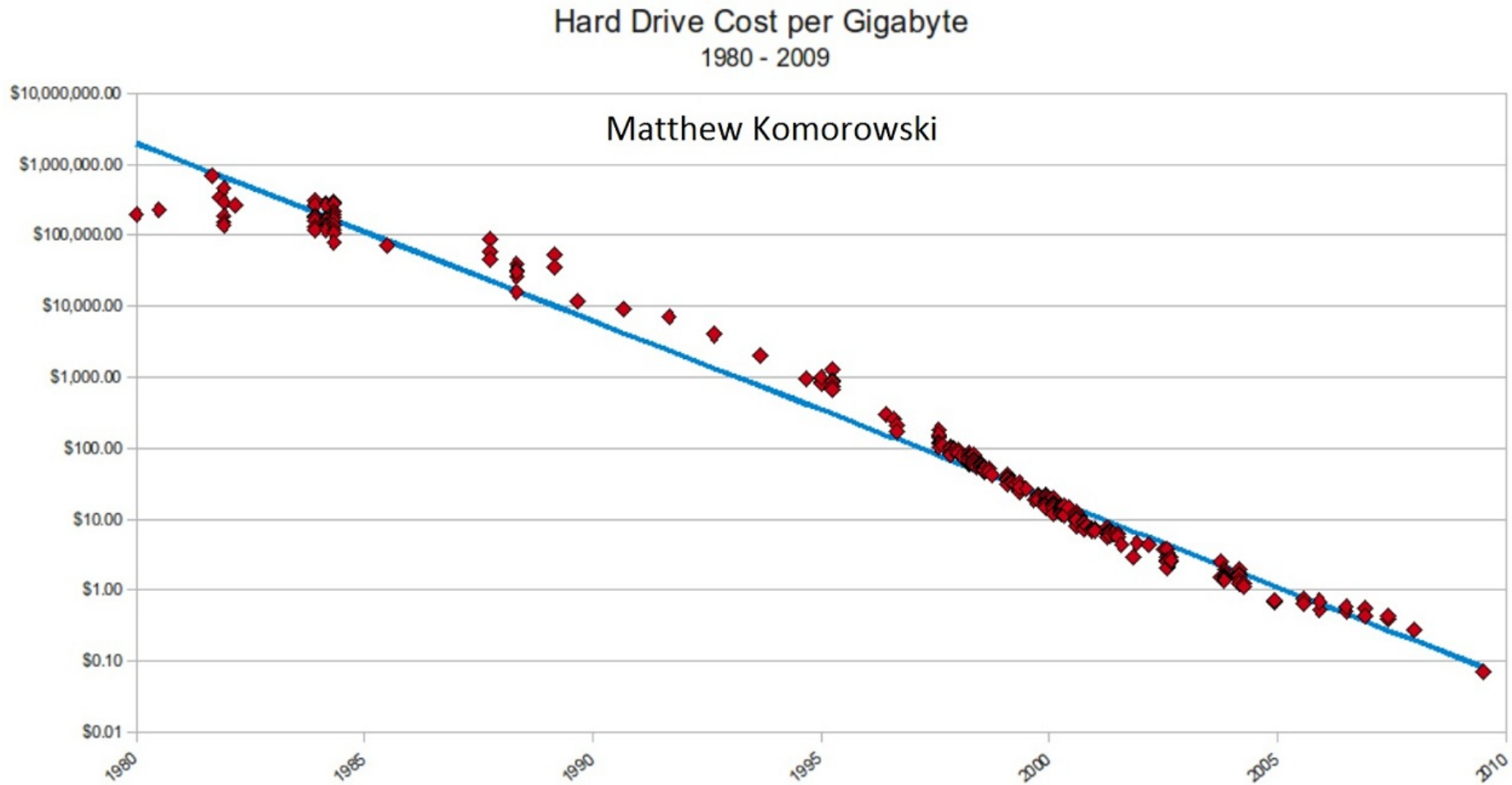
The Corresponding Economics

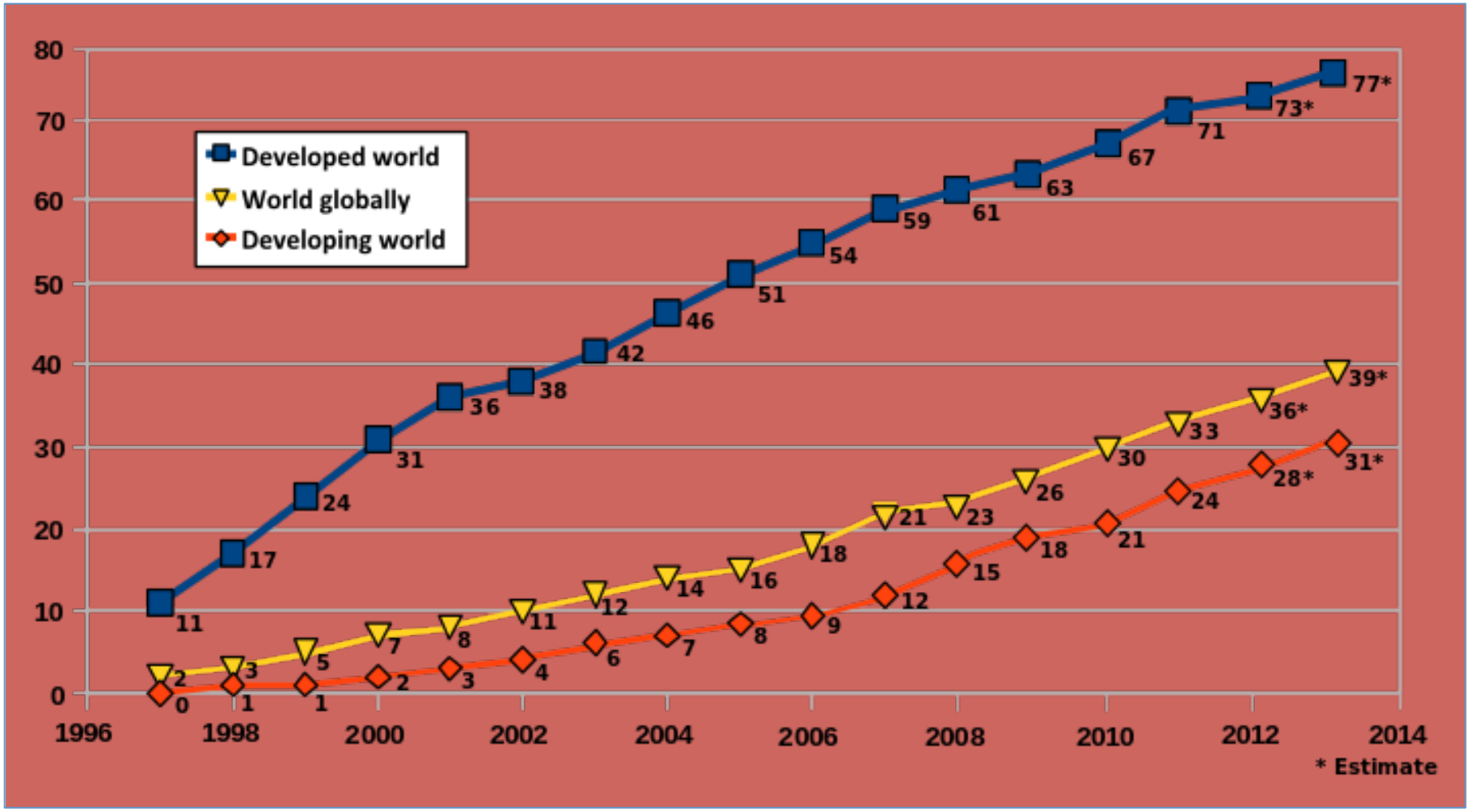


Oracle 2012

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



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Internet Connectivity

USC 2014, GD Hager

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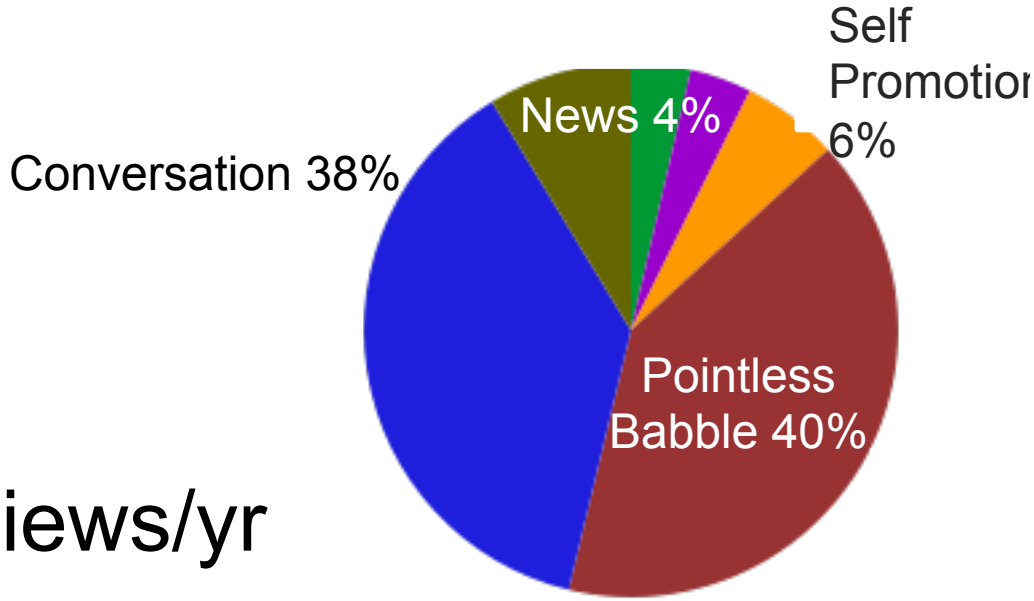
The Current Decade: Online Everything

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

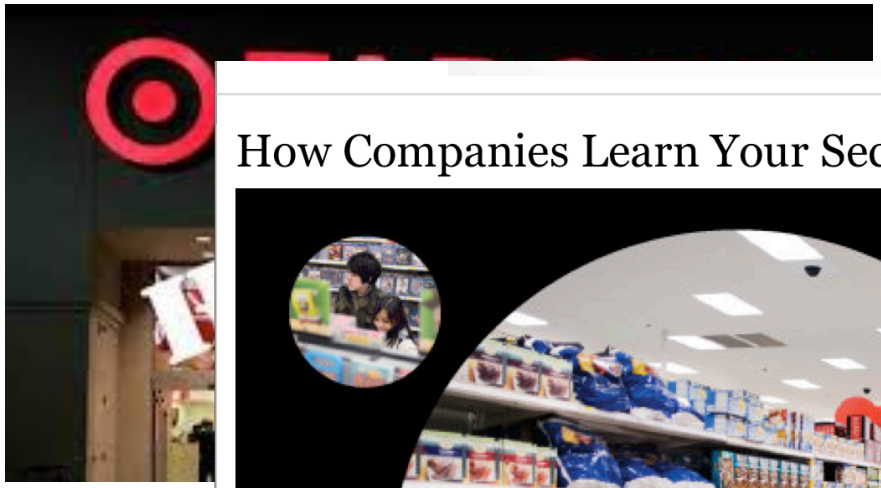


Twitter Stats

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

A Big Driver: Us!

Challenge: Security and Privacy



How Companies Learn Your Secrets

Antonio Bolfo/Reportage for The New York Times

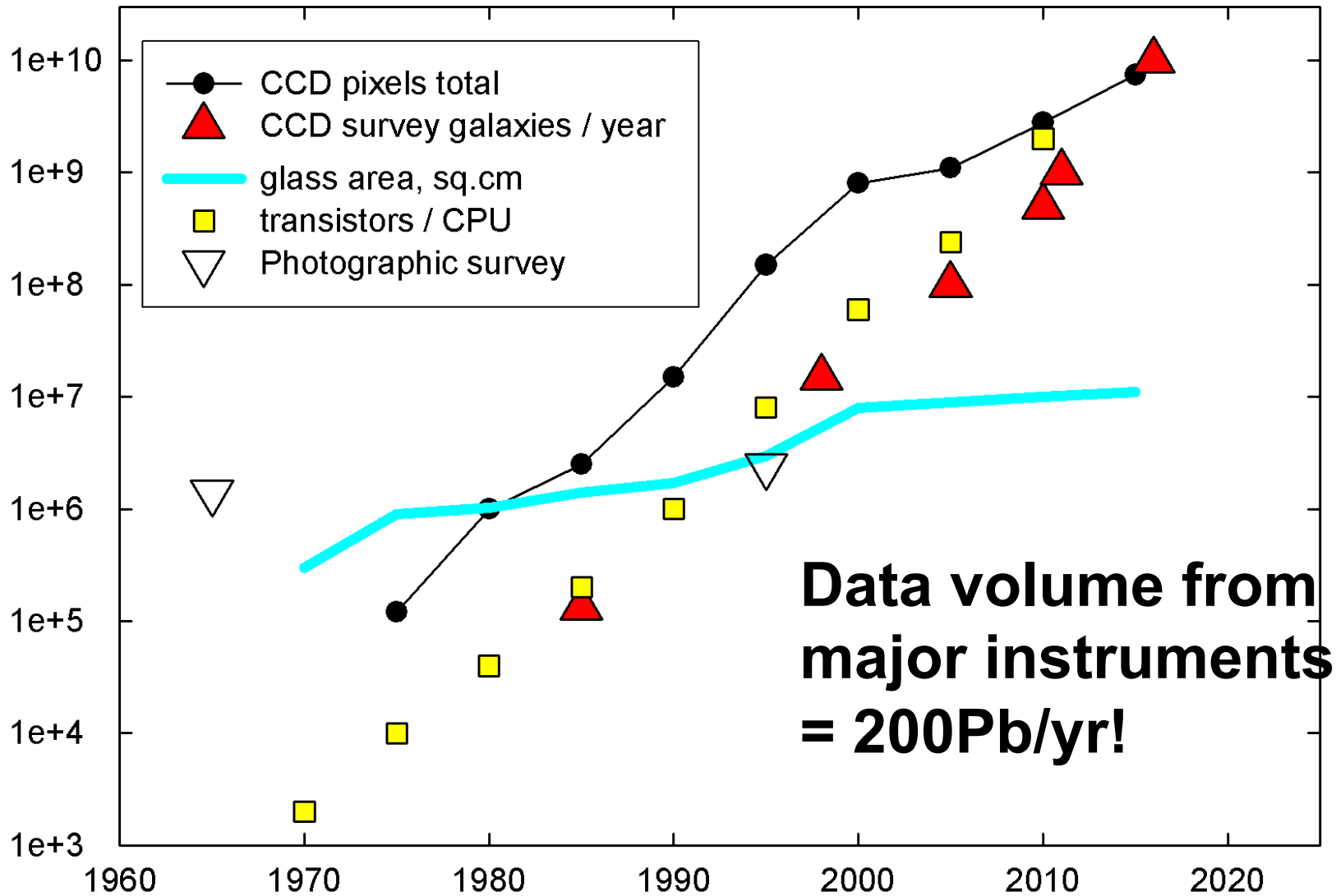
By CHARLES DUHIGG
Published: February 16, 2012 | 570 Comments

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

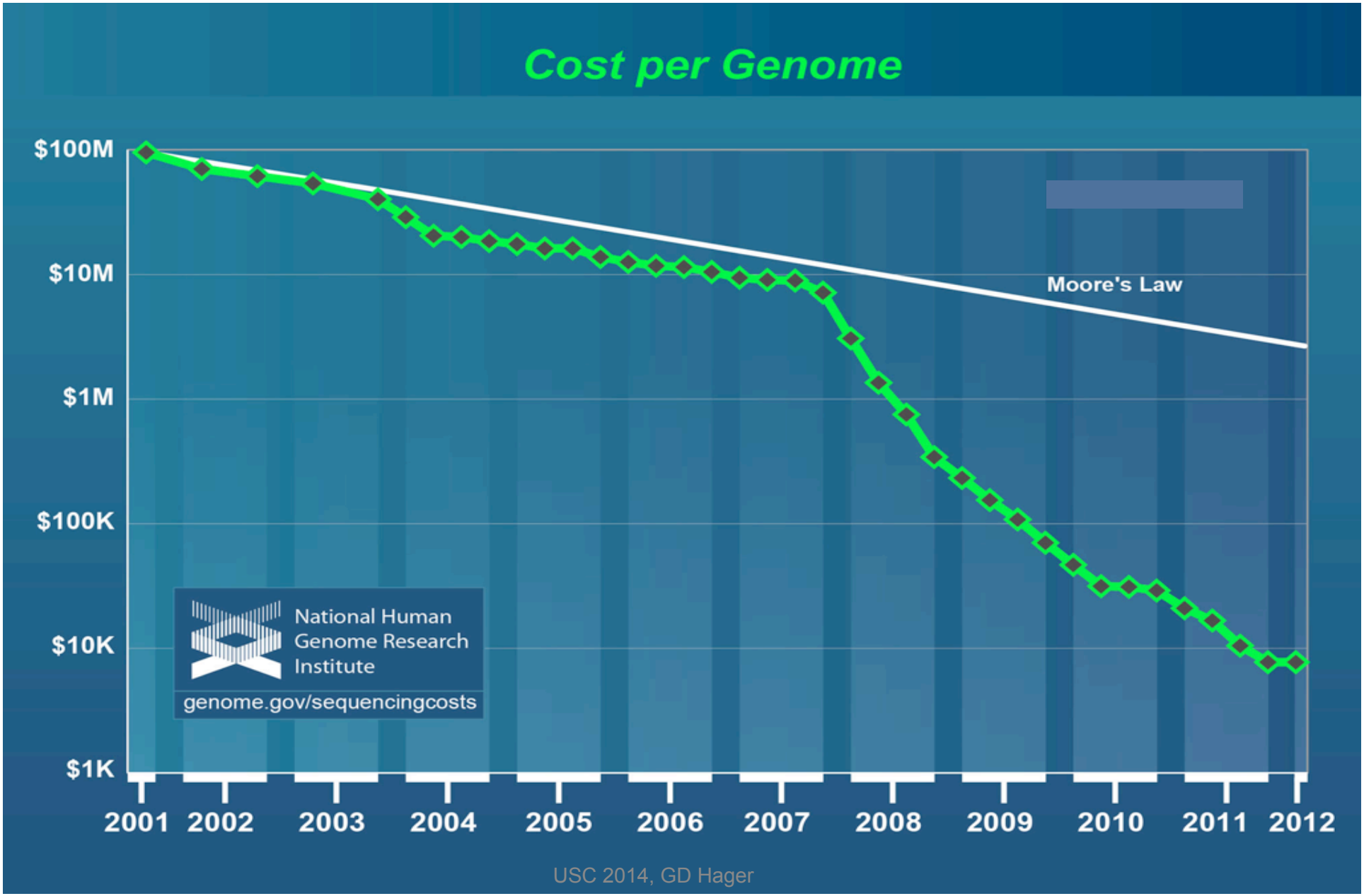
Drivers: Science

Trends in Optical Astronomy Survey Data

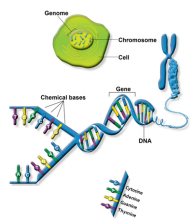


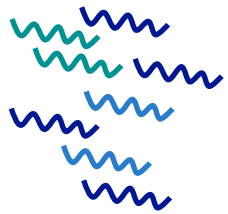
Courtesy Alex Szalay and Tony Tyson

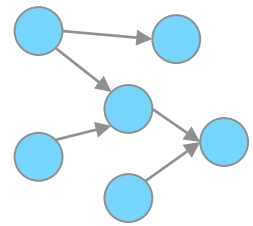
Drivers: Science

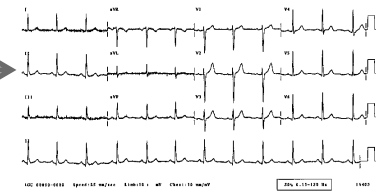


A Challenge: Making Sense of Data







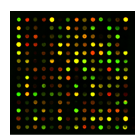


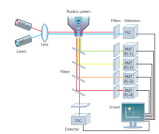
DNA
Inherited
Unchanging (mostly)

RNA
Gene expression
Constantly changing

Protein
Actual machinery of cell
Enzymes, receptors, etc

Disease





Genotype and genome-wide sequence data:
Up to 3B bases/person

Genome-wide profiles
RNA-sequencing
30K genes/person

Mass spectrometry
10K genes/person

Electronic records
Model organisms

Courtesy Alexis Battle

USC Viterbi School of Engineering

The Social Realm Too!

Events Calendar

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 on-going 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

Johns Hopkins Whiting School of Engineering

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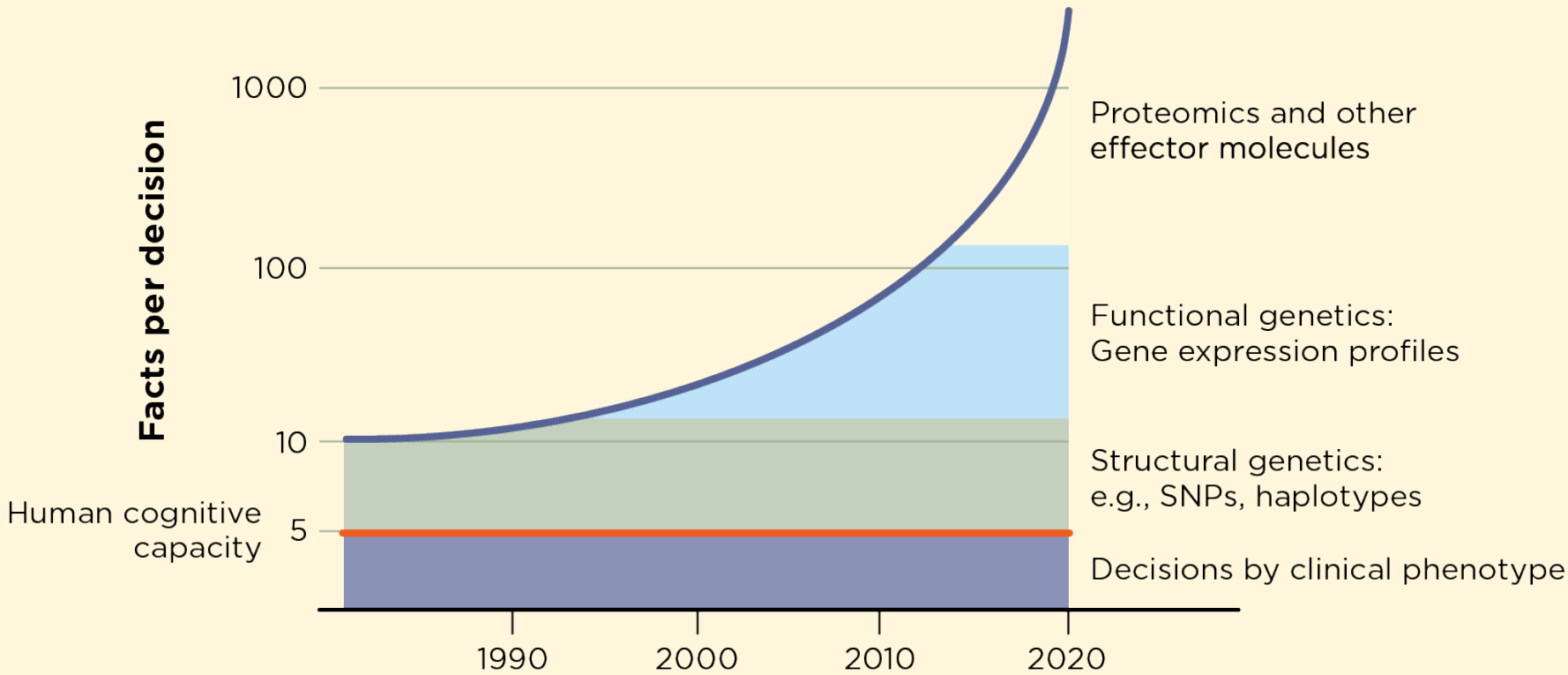
A Challenge: Healthcare and Complexity

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!

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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

Inspiration: Ed Lazowska

Drivers: Co-Existing and Collaborating

Smart Transportation (Google)

Smart Helpers (Rethink Robotics)

Smart Homes
(GE + Firstbuild)

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A Challenge: Working in the Built Environment

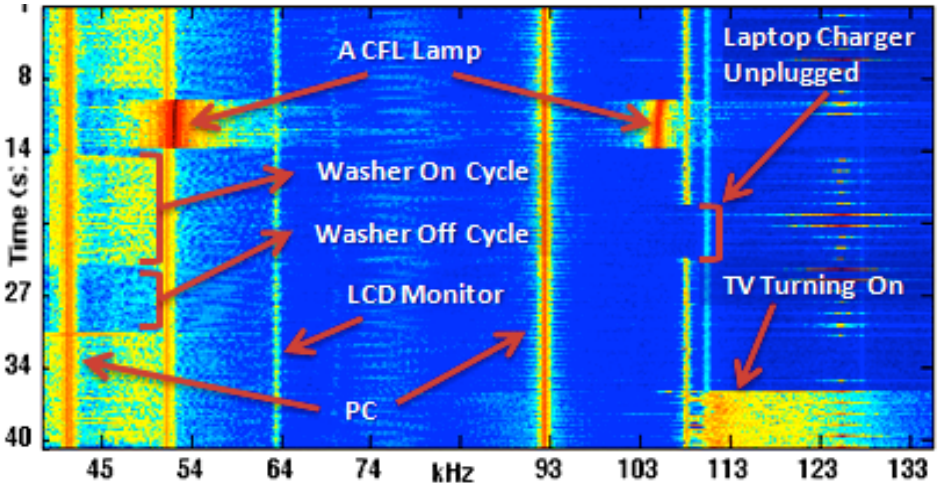

Figure 2: Frequency spectrogram showing device actuation in a

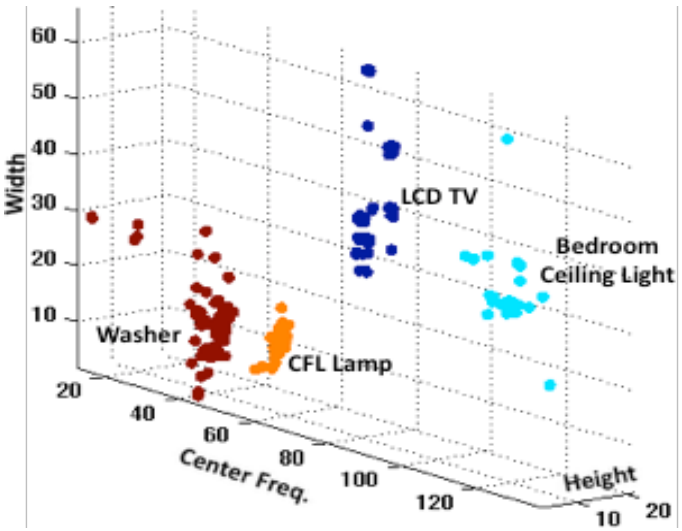

Figure 8: Variation of features over 6 months for four devices shown in the feature space. Note that no cluster overlaps.

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.

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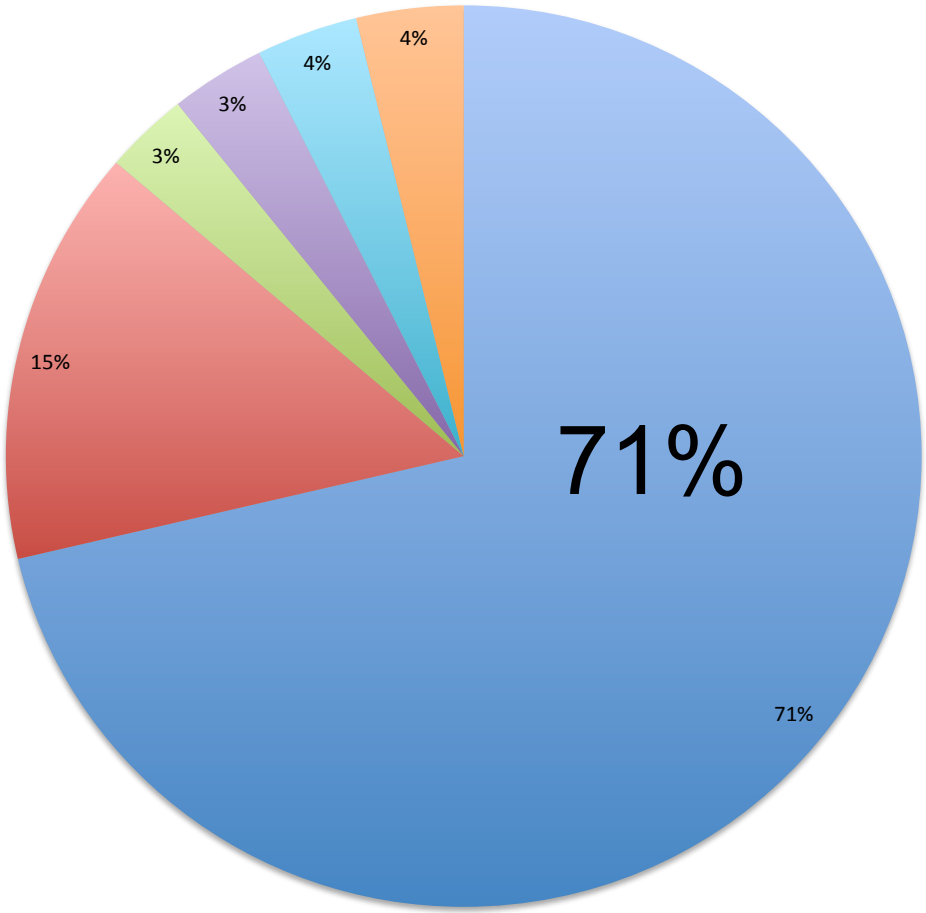
An Overarching Challenge

Who’s doing to do all of this?

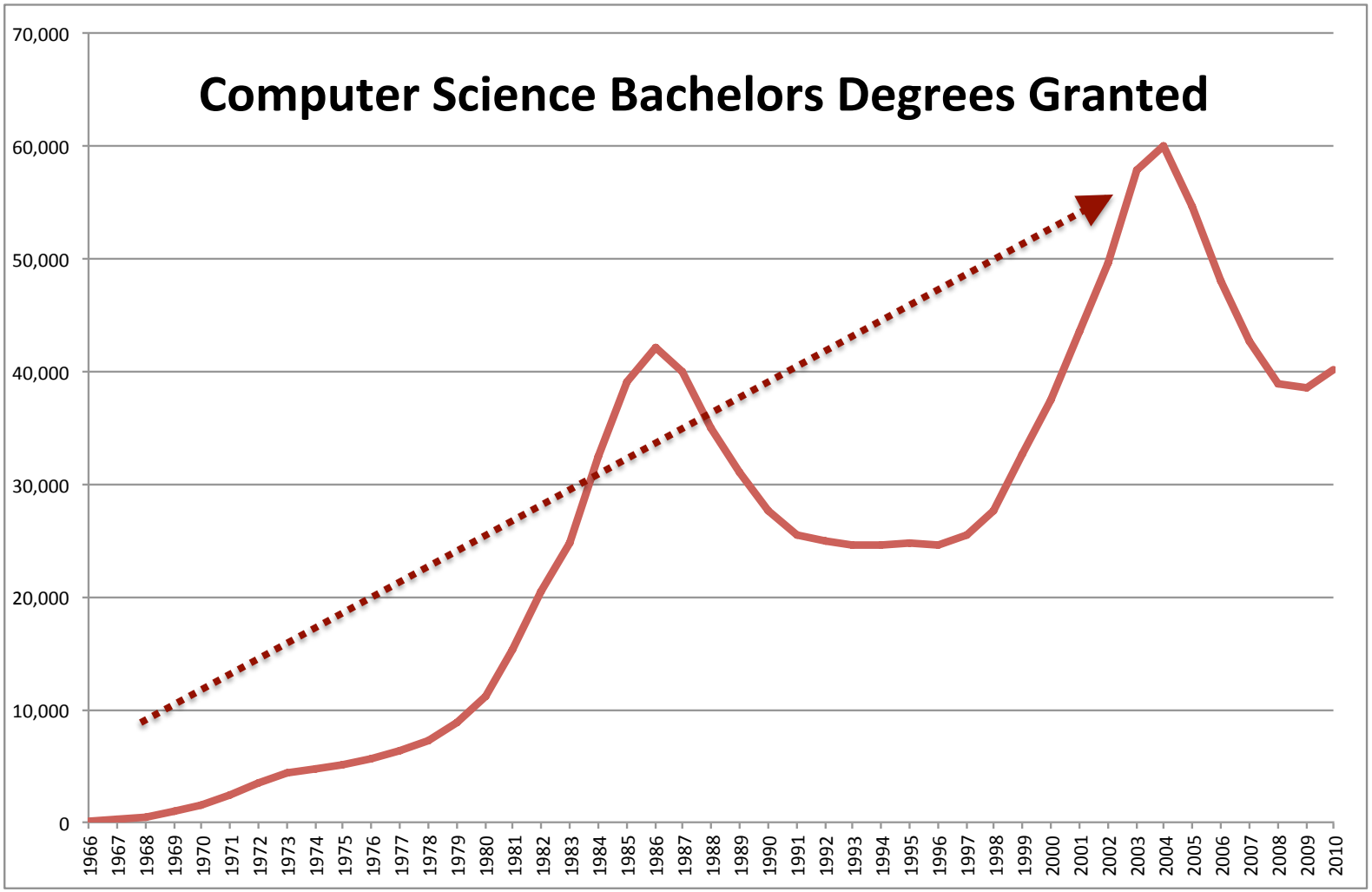
No wonder students (or their parents, more likely) are figuring out that all of the STEM jobs are in computer science

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



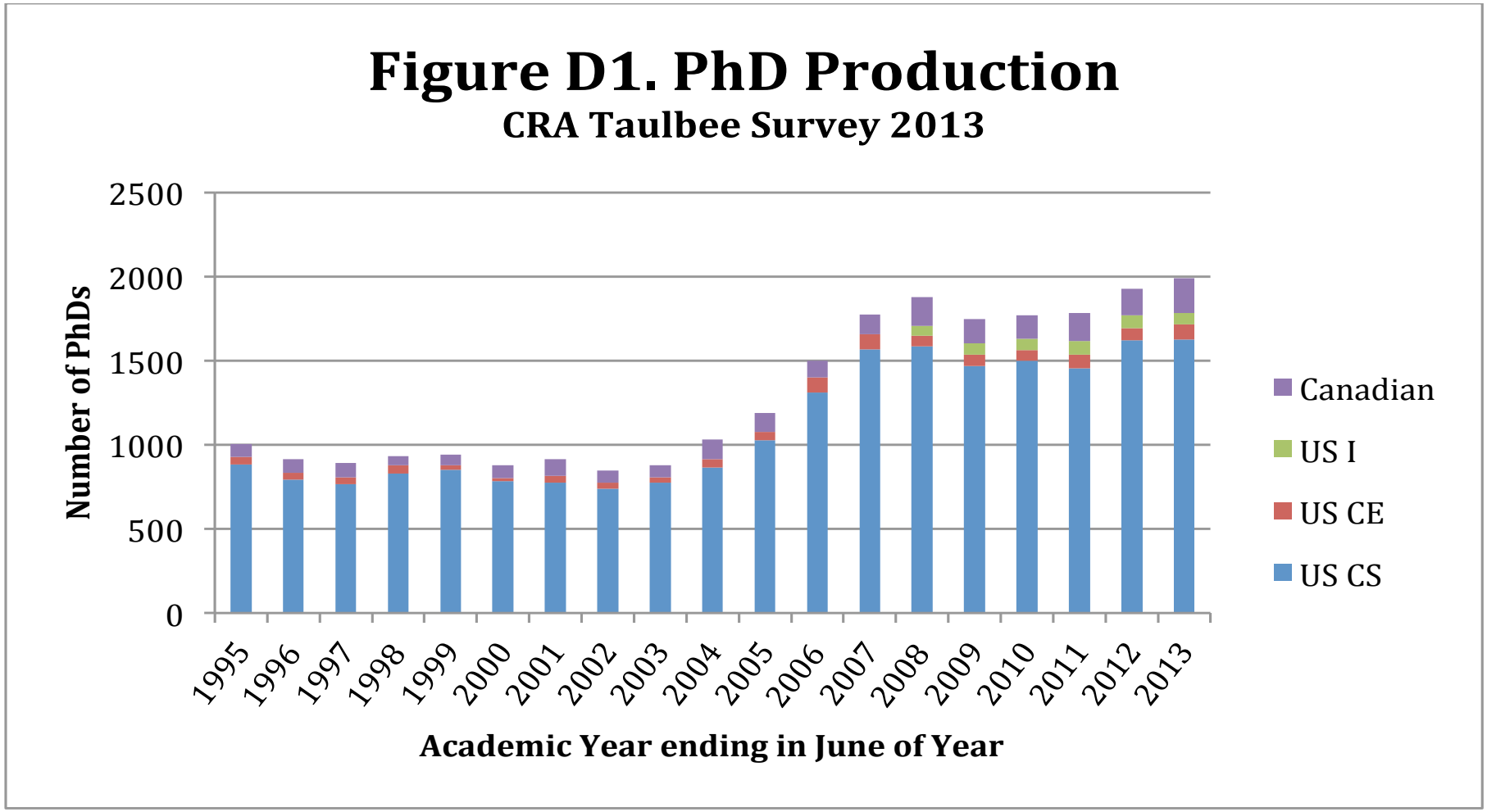
Data from the spreadsheet linked at http://www.bls.gov/emp/ep_table_102.htm

But, the kids are catching on …



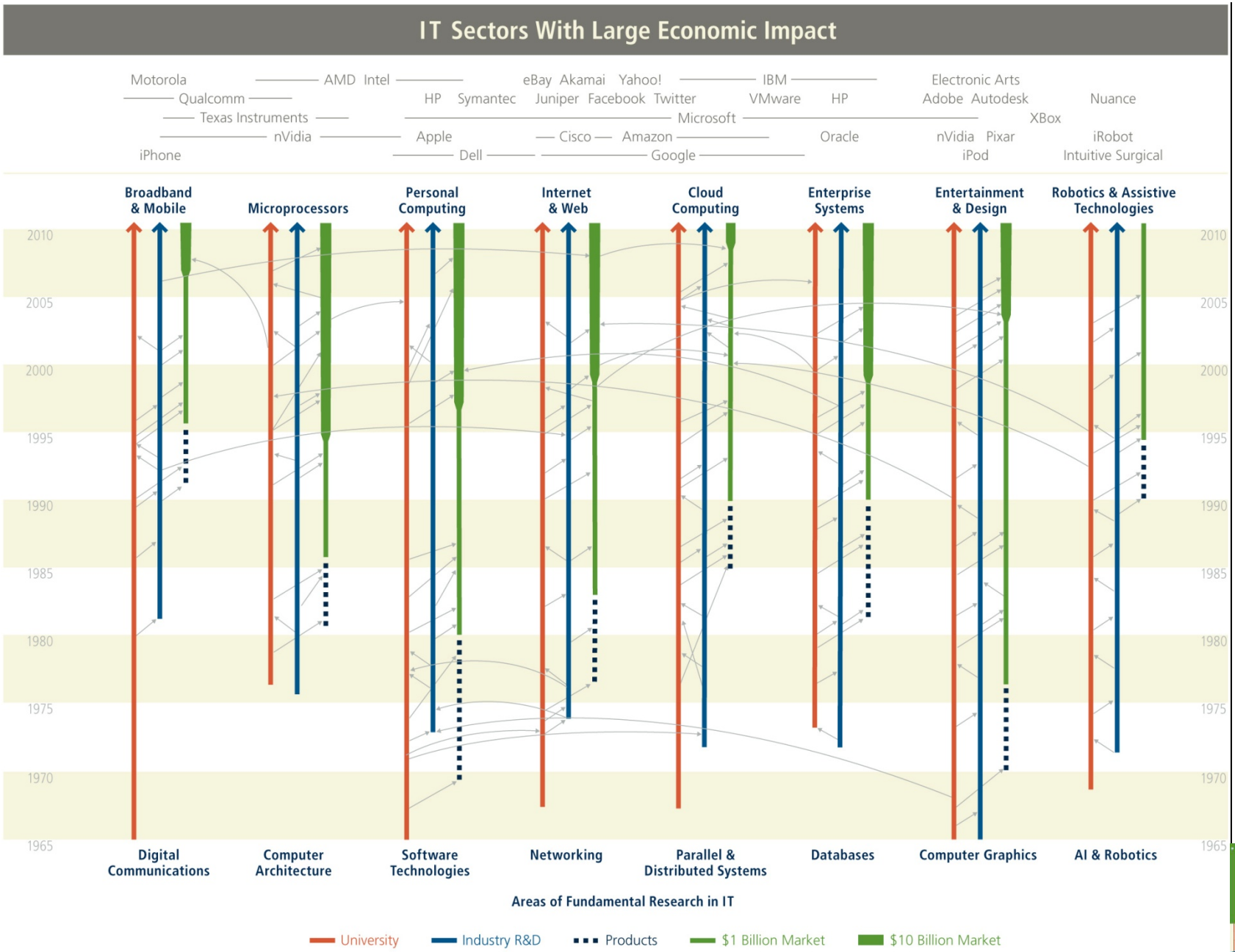
Credit: Ed Lazowska

PhD Production is also at an all-time high!



But What Ultimately Drives All of This?

Research and


IT Sectors With Large Economic Impact
Motorola
Qualcomm
Texas Instruments
nVidia
iPhone
AMD
Intel
HP
Symantec
Apple
Dell
eBay
Akamai
Yahoo!
Juniper
Facebook
Twitter
Microsoft
Cisco
Amazon
Google
IBM
VMware
HP
Oracle
Electronic Arts
Adobe
Autodesk
XBox
nVidia
Pixar
iPod
Nuance
iRobot
Intuitive Surgical
Broadband & Mobile
Microprocessors
Personal Computing
Internet & Web
Cloud Computing
Enterprise Systems
Entertainment & Design
Robotics & Assistive Technologies
2010
2005
2000
1995
1990
1985
1980
1975
1970
1965
Digital Communications
Computer Architecture
Software Technologies
Networking
Parallel & Distributed Systems
Databases
Computer Graphics
AI & Robotics
Areas of Fundamental Research in IT
University
Industry R&D
Products
$1 Billion Market
$10 Billion Market

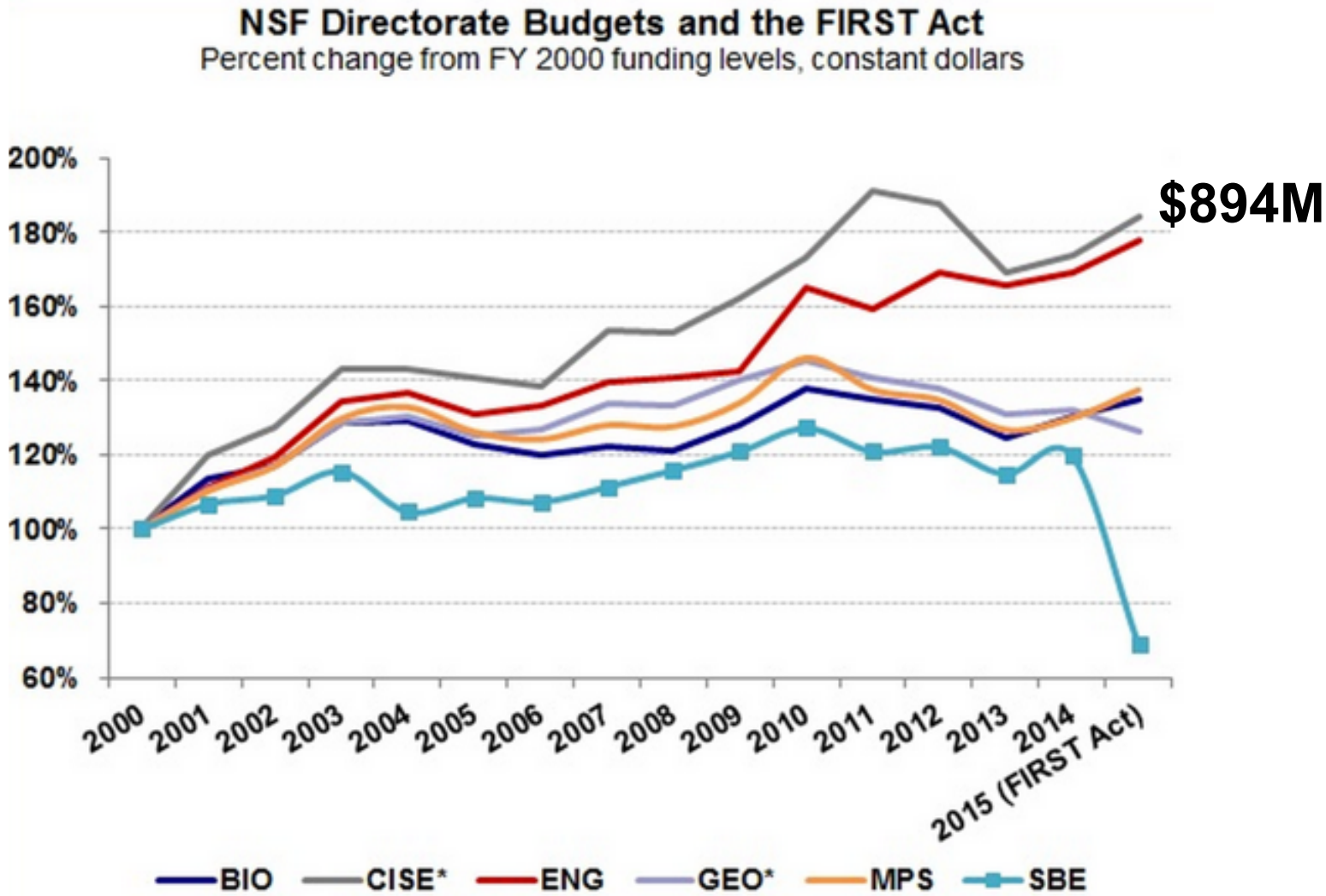

Continuing
Innovation
IN INFORMATION TECHNOLOGY

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



*Adjusted for comparability. Based on historical agency data and proposed authorizations in the FIRST Act. © 2014 AAAS

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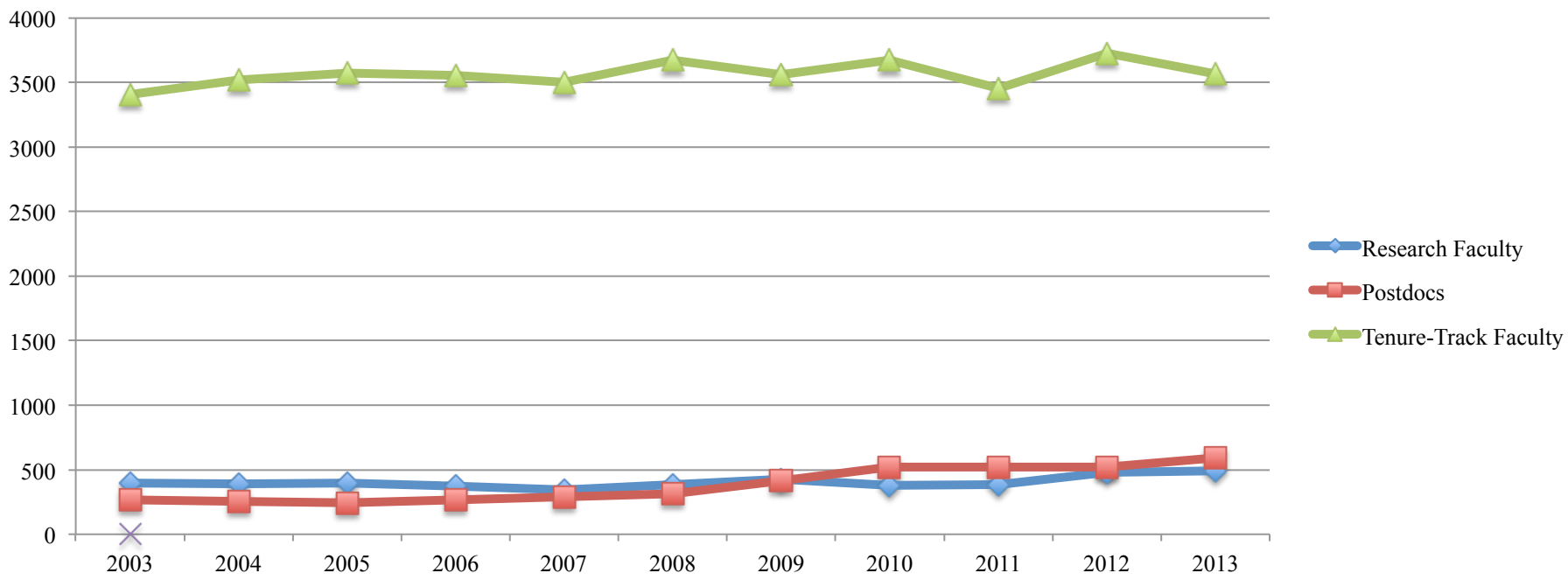
Payoff on Investment

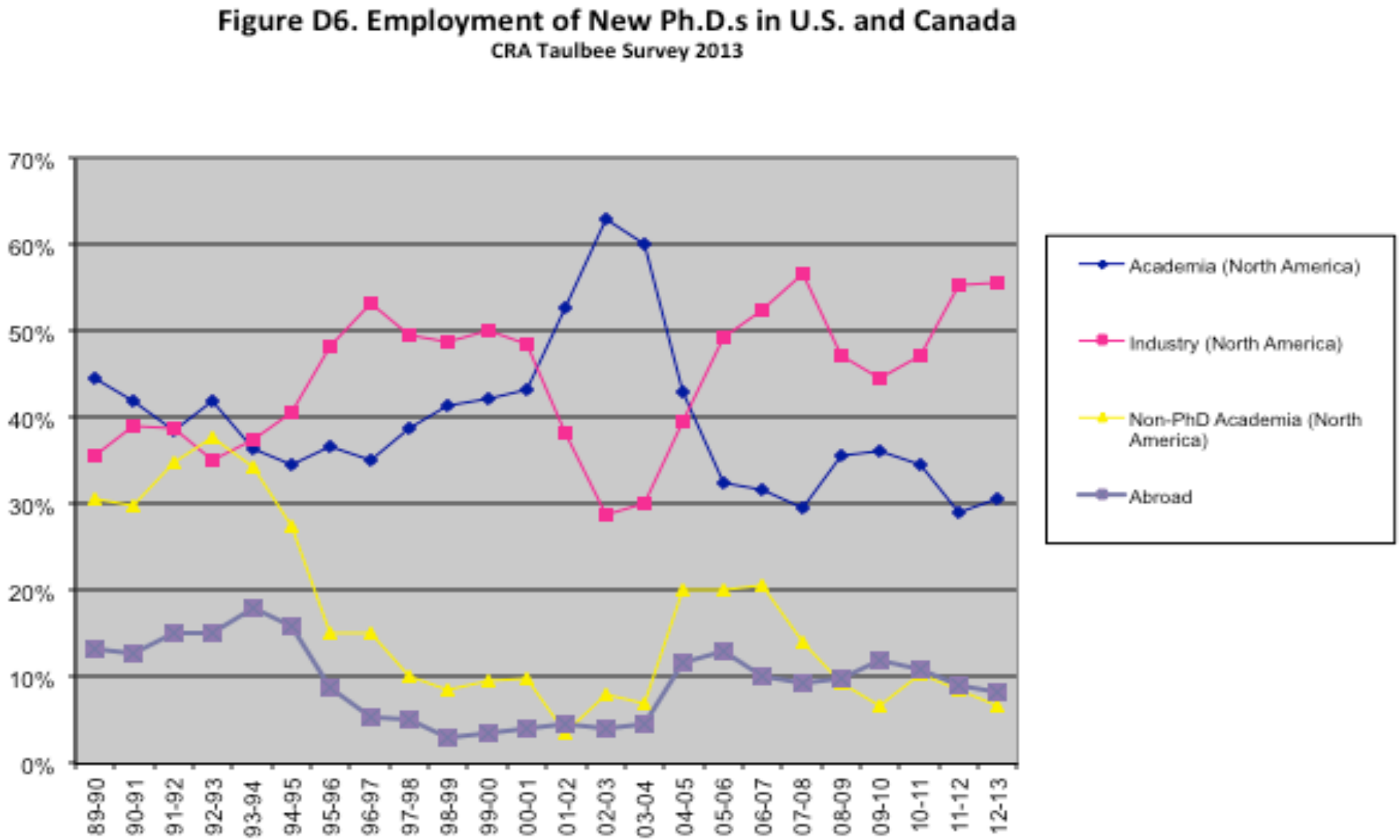
- CISE core at 682M is 87% of CS funding nationally – effectively a payoff of 1200-1!

Payoff on Investment

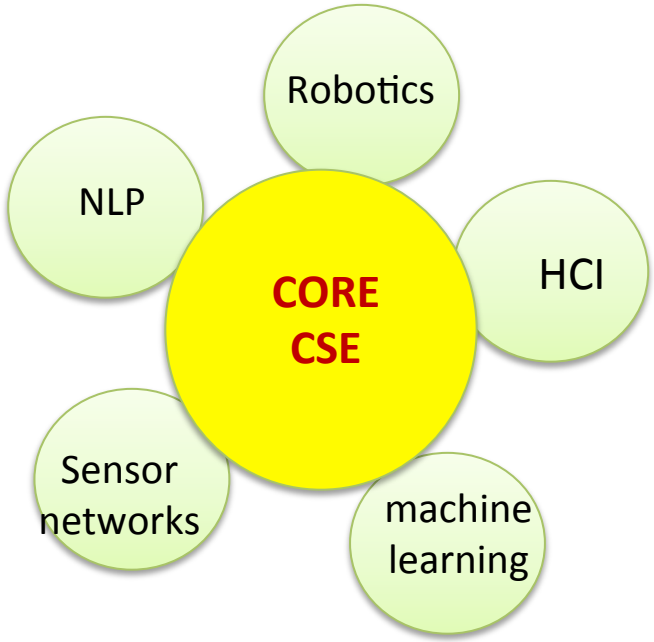
- CISE core at 682M is 87% of CS funding nationally – effectively a payoff of 1200-1!
- But, we aren't growing academics!



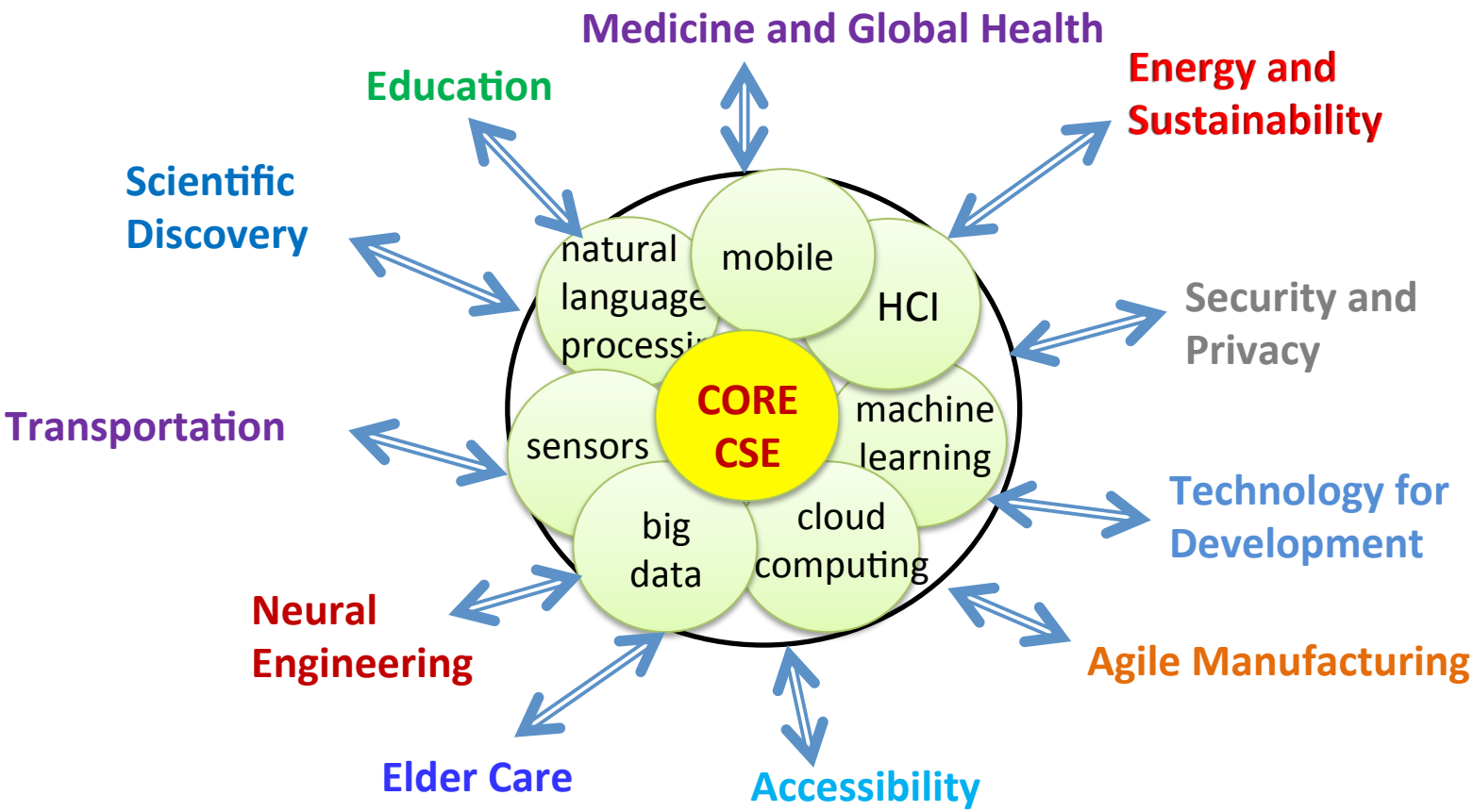
Most PhDs Go To Industry Too …



The Way We Think of Ourselves



The Way It Really Is

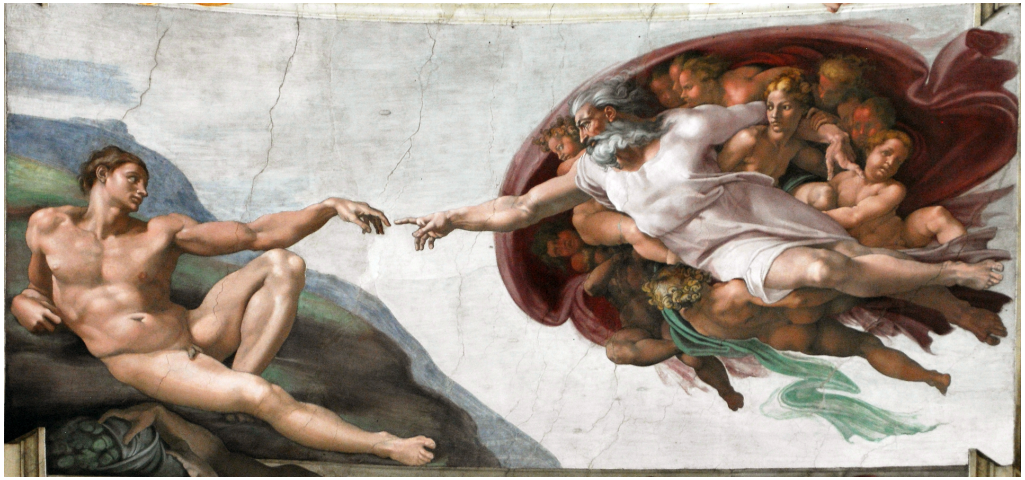


Drivers: Industry, Society, Government, Science

What Is Our Future?
How Do We Shape It?

Is Computing the future of thought and discourse?

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



Is Computing creating a new ways to combine and create?

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THE COMPUTING COMMUNITY CONSORTIUM: CATALYZING AND ENABLING COMPUTING RESEARCH

Gregory Hager
Chair
Johns Hopkins

Elizabeth Mynatt
Vice Chair
Georgia Tech

Ann Drobnis
Director

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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?

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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

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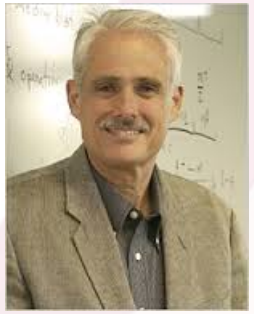
THE START

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



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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

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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

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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







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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

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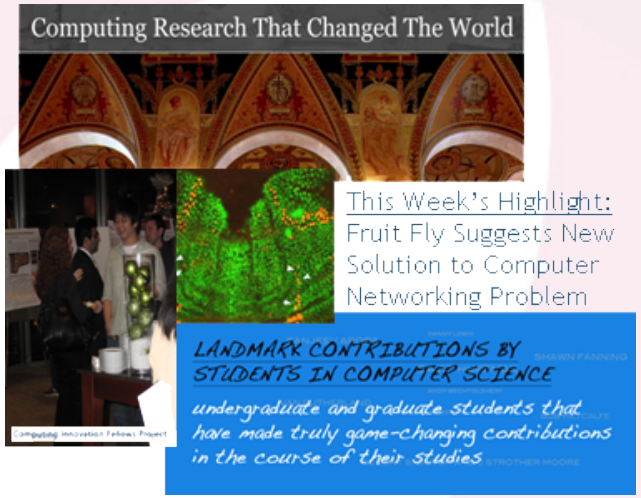
HOW DO WE DO IT?

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

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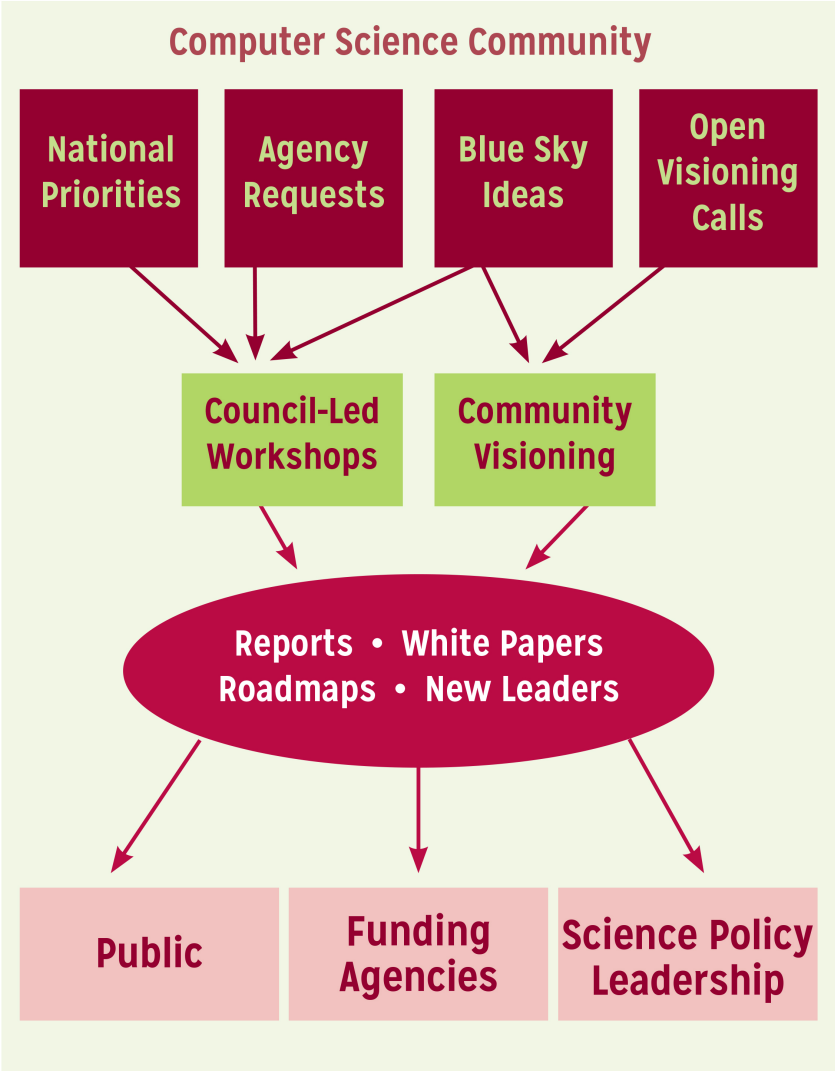
Computing Community Consortium
Catalyst

VISIONING GOALS

Communicate the role of CS research to stakeholders

Develop leadership capacity to help shape science policy



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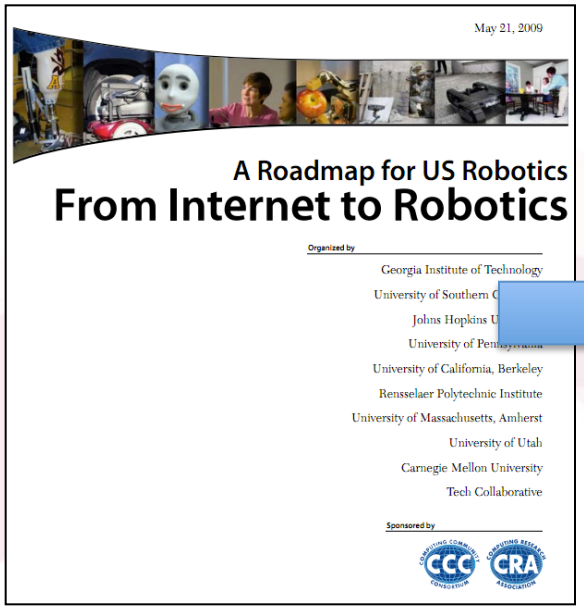
CATALYZING AND ENABLING: ROBOTICS



May 21, 2009

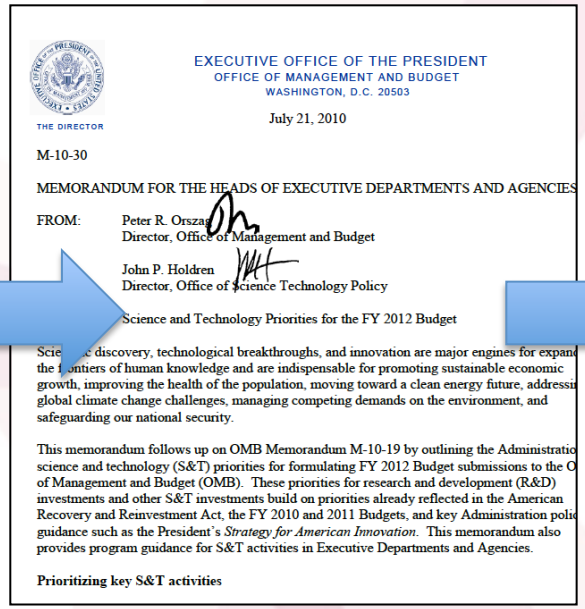
A Roadmap for US Robotics

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 c discovery, technological breakthroughs, and innovation are major engines for expand the f ontiers 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 poli 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

E- 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 I 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 to (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 or 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 as

4 meetings during summer 2008

Roadmap published May 2009

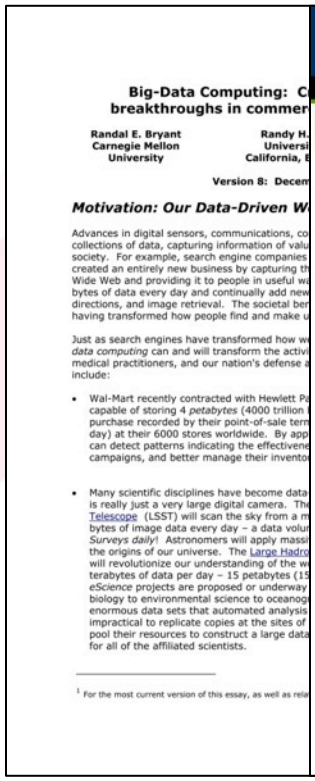
Extensive discussions between visioning leaders & agencies

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: C
breakthroughs in commer

Randal E. Bryant
Carnegie Mellon
University

Randy H.
Universi
California,

Version 8: Decem

Motivation: Our Data-Driven W

Advances in digital sensors, communications, co
collections of data, capturing information of valu
society. For example, search engine companies
created an entirely new business by capturing th
Wide Web and providing it to people in useful wa
bytes of data every day and continually add new
directions, and image retrieval. The societal ben
having transformed how people find and make u

Just as search engines have transformed how w
data computing can and will transform the activi
medical practitioners, and our nation's defense a
include:

- Wal-Mart recently contracted with Hewlett Pa
capable of storing 4 *petabytes* (4000 trillion
purchase recorded by their point-of-sale term
day) at their 6000 stores worldwide. By app
can detect patterns indicating the effectivene
campaigns, and better manage their inventor

- Many scientific disciplines have become data-
is really just a very large digital camera. Th
Telescope (LSST) will scan the sky from a m
bytes of image data every day – a data volu
Surveys daily! Astronomers will apply massi
the origins of our universe. The Large Hadro
will revolutionize our understanding of the w
terabytes of data per day – 15 petabytes (15
eScience projects are proposed or underway
biology to environmental science to oceanog
enormous data sets that automated analysis
impractical to replicate copies at the sites of
pool their resources to construct a large data
for all of the affiliated scientists.

[1] For the most current version of this essay, as well as rela

Computing Community
We support the computing research community in crea

HOME | ABOUT | YOUR VISION | ACTIVITIES | RE

Spatial Computing | Disaster Management | SEES IT
Learning Tech | Open Source | Cyber Physical Systems

You are here: CCC Home | Activities | Funded Visioning Activities | Big-Data

Big-Data Computing Study Group

Under sponsorship by the CCC, the Big-Data Study Group will explore
for research and applications of high-performance, data-intensive com
benefiting application areas ranging from astronomy to machine transl
two events were held in March, 2008.

One Pager
Establishing a Big-Data Computing Study Group - [72 KB PDF]

Leads for this workshop and Lead for effort
Randy Bryant (CMU) and Thomas Kwan (Yahoo!)

CCC council liaison for this workshop and effort
Ed Lazowska (University of Washington)

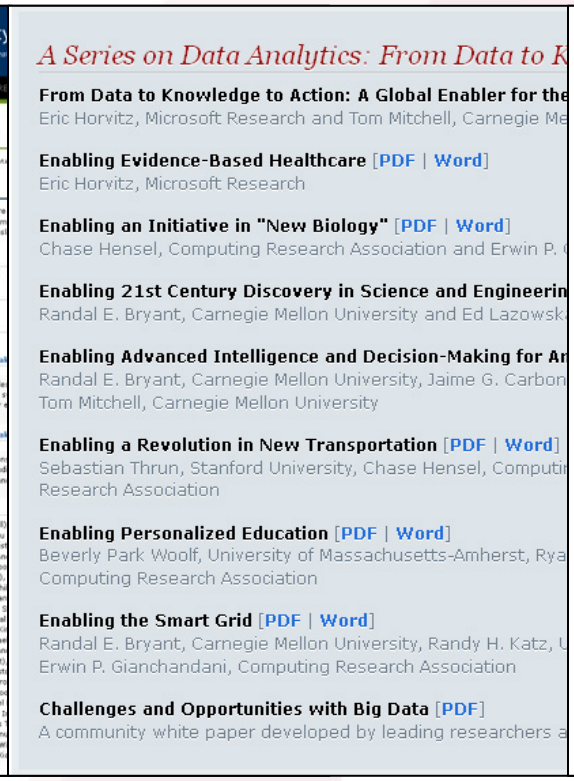
Hadoop Summit [3/25/08, Sunnyvale, CA] | Speak

Hadoop is an open source project developing software that enable
computing on cluster-based systems. It includes a distributed file s
programming support for Map/Reduce, a data-parallel notation for e
element-wise and aggregating operations on collections of data.

Data-Intensive Computing Symposium [3/25/08, Sunnyvale, CA] | Speak

This symposium covered a broad range of topics, with presentation
academic leaders on all aspects of data-intensive computing, includ
programming, algorithms, data management, and both scientific an
applications.

Participants
Bernie Ack (NCSA), Eugene Agichtein (Emory), William Arms (Cornell)
(Yahoo!), Roger Barga (Microsoft), Chaitin Baru (SDSC), Sugato Basu
(SLAC), Emery Berger (UMass-Amherst), Fran Berman (SDSC), Christ
Andrei Broder (Yahoo!), Randy Bryant (CMU), Jamie Callan (CMU), An
Charlie Clarke (Waterloo), Andrew Connolly (UWashington), Gene Coo
Jeff Dean (Google), Tina Eliassi-Rad (LLNL), Christos Faloutsos (CMU),
Ian Foster (Argonne), Jim French (NSF), Dennis Gannon (Indiana), Phi
Gibson (CMU), Ian Gorton (Pacific NW National Lab), Robert Grossman
Halem (UM-BC), Jeff Hammerbacher (Facebook), Jiawei Han (UIUC), S
Hellerstein (Berkeley), Haym Hirsh (NSF/Rutgers), Chenyi Hu (Central
(Virginia), Richard Karp (Berkeley), Randy Katz (Berkeley), Yoo-Ah Ki
(Yahoo!), Jon Kleinberg (Cornell), Ed Lazowska (UWashington), Michae
Xiaozhou Li (HP Labs), Xavier Llora (NCSA), Qi Lu (Yahoo!), Chris Man
Meacham (NSF), Jill Mesirov (Broad Institute), Marc Najork (Microsoft),
(Pittsburgh Supercomputing), Dave O'Hallaron (Intel/CMU), Chris Olst
Olukotun (Stanford), Patrick Pantel (Yahoo!), Savas Parastatidis (Micro
(Indiana), Prabhakar Raghavan (Yahoo!), Raghu Ramakrishnan (Yahoo
(SUNY Buffalo), Dan Reed (Microsoft), Anne Rogers (Chicago), Mikael
Arie Shoshani (Lawrence Berkeley Laboratory), Padhraic Smyth (UC I
(Yahoo!), Ravi Sundaram (Northeastern), Alex Szalay (JHU), Douglas
Thompson (Dartmouth), Andrew Tomkins (Yahoo!), Cristian Ungurean
Vogel (CMU), Dan Weld (UWashington), John Wilkes (HP), Jeannette W
Labs), Ke-This Yao (ISI/USC), Hongyuan Zha (GeorgiaTech), ChengXi
Zhang (UC Santa Cruz)



A Series on Data Analytics: From Data to K

From Data to Knowledge to Action: A Global Enabler for the
Eric Horvitz, Microsoft Research and Tom Mitchell, Carnegie Me

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 P.

Enabling 21st Century Discovery in Science and Engineerin
Randal E. Bryant, Carnegie Mellon University and Ed Lazowsk

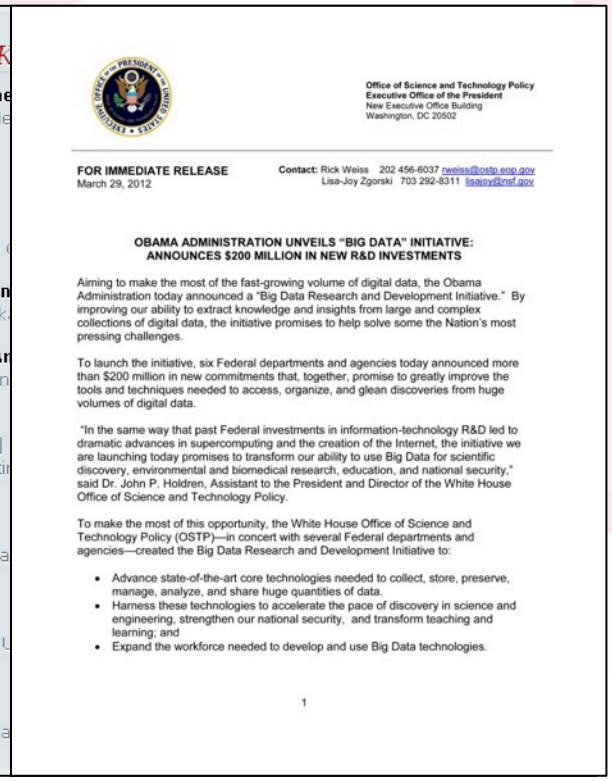
Enabling Advanced Intelligence and Decision-Making for Ar
Randal E. Bryant, Carnegie Mellon University, Jaime G. Carbon
Tom Mitchell, Carnegie Mellon University

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

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

Enabling the Smart Grid [PDF | Word]
Randal E. Bryant, Carnegie Mellon University, Randy H. Katz,
Erwin P. Gianchandani, Computing Research Association

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



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

FOR IMMEDIATE RELEASE
March 29, 2012

Contact: Rick Weiss 202 456-6037 rweiss@ostp.eop.gov
Lisa-Joy Zgorski 703 292-8311 lisajoy@nsf.gov

OBAMA 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 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.

1

2008 2008 2010 2012

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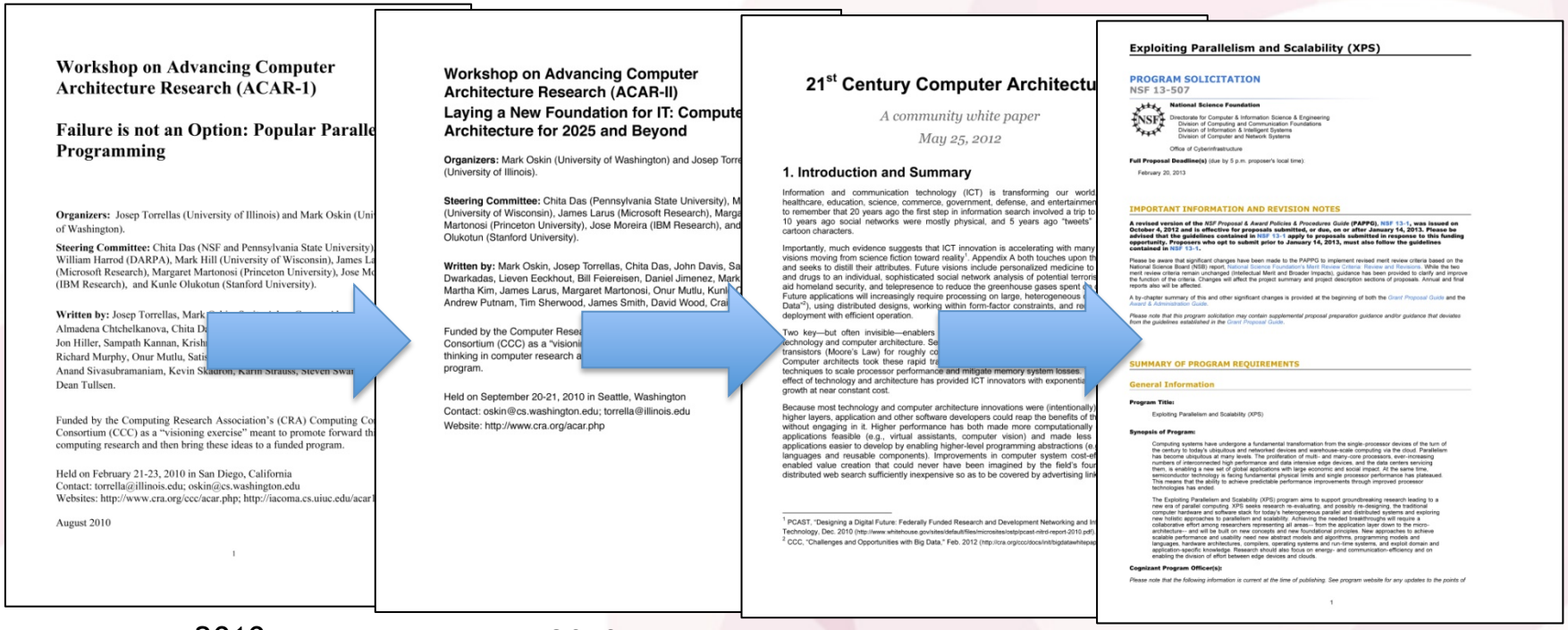
CATALYZING AND ENABLING: ARCHITECTURE



Workshop on Advancing Computer Architecture Research (ACAR-1)

Failure is not an Option: Popular Paralle Programming

Organizers: Josep Torrellas (University of Illinois) and Mark Oskin (Uni of Washington).

Steering Committee: Chita Das (NSF and Pennsylvania State University), William Harrod (DARPA), Mark Hill (University of Wisconsin), James La (Microsoft Research), Margaret Martonosi (Princeton University), Jose Mo (IBM Research), and Kunle Olukotun (Stanford University).

Written by: Josep Torrellas, Mark Almadena Chtchelkanova, Chita Da Jon Hiller, Sampath Kannan, Krish Richard Murphy, Onur Mutlu, Satis Anand Sivasubramaniam, Kevin Skadron, Karin Strauss, Steven Swar Dean Tullsen.

Funded by the Computing Research Association's (CRA) Computing Co Consortium (CCC) as a "visioning exercise" meant to promote forward th computing research and then bring these ideas to a funded program.

Held on February 21-23, 2010 in San Diego, California
Contact: torrella@illinois.edu; oskin@cs.washington.edu
Websites: http://www.cra.org/ccc/acar.php; http://iacoma.cs.uiuc.edu/acar

August 2010

1

Workshop on Advancing Computer Architecture Research (ACAR-II)
Laying a New Foundation for IT: Compute Architecture for 2025 and Beyond

Organizers: Mark Oskin (University of Washington) and Josep Torre (University of Illinois).

Steering Committee: Chita Das (Pennsylvania State University), M (University of Wisconsin), James Larus (Microsoft Research), Marga Martonosi (Princeton University), Jose Moreira (IBM Research), and Olukotun (Stanford University).

Written by: Mark Oskin, Josep Torrellas, Chita Das, John Davis, Sa Dwarkadas, Lieven Eeckhout, Bill Feiereisen, Daniel Jimenez, Mark Martha Kim, James Larus, Margaret Martonosi, Onur Mutlu, Kunl Andrew Putnam, Tim Sherwood, James Smith, David Wood, Crai

Funded by the Computer Resea Consortium (CCC) as a "visioni thinking in computer research a program.

Held on September 20-21, 2010 in Seattle, Washington
Contact: oskin@cs.washington.edu; torrella@illinois.edu
Website: http://www.cra.org/acar.php

21st Century Computer Architectu

A community white paper

May 25, 2012

1. Introduction and Summary

Information and communication technology (ICT) is transforming our world healthcare, education, science, commerce, government, defense, and entertainmen to remember that 20 years ago the first step in information search involved a trip to 10 years ago social networks were mostly physical, and 5 years ago "tweets" cartoon characters.

Importantly, much evidence suggests that ICT innovation is accelerating with many visions moving from science fiction toward reality[1]. Appendix A both touches upon th and seeks to distill their attributes. Future visions include personalized medicine to and drugs to an individual, sophisticated social network analysis of potential terroris aid homeland security, and telepresence to reduce the greenhouse gases spent Future applications will increasingly require processing on large, heterogeneous Data[2]), using distributed designs, working within form-factor constraints, and re deployment with efficient operation.

Two key—but often invisible—enablers technology and computer architecture. Se transistors (Moore's Law) for roughly co Computer architects took these rapid tra techniques to scale processor performance and mitigate memory system losses. effect of technology and architecture has provided ICT innovators with exponenti growth at near constant cost.

Because most technology and computer architecture innovations were (intentionally) higher layers, application and other software developers could reap the benefits of th without engaging in it. Higher performance has both made more computationally applications feasible (e.g., virtual assistants, computer vision) and made less applications easier to develop by enabling higher-level programming abstractions (e languages and reusable components). Improvements in computer system cost-ef enabled value creation that could never have been imagined by the field's four distributed web search sufficiently inexpensive so as to be covered by advertising lin

[1] PCAST, "Designing a Digital Future: Federally Funded Research and Development Networking and In Technology. Dec. 2010 (http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-nitrd-report-2010.pdf).
[2] CCC, "Challenges and Opportunities with Big Data," Feb. 2012 (http://cra.org/ccc/docs/init/bigdatawhitepap

Exploiting Parallelism and Scalability (XPS)

PROGRAM SOLICITATION
NSF 13-507

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

Office of Cyberinfrastructure

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

February 20, 2013

IMPORTANT INFORMATION AND REVISION NOTES

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

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

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

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

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Exploiting Parallelism and Scalability (XPS)

Synopsis of Program:

Computing systems have undergone a fundamental transformation from the single-processor devices of the turn of the century to today's ubiquitous and networked devices and warehouse-scale computing via the cloud. Parallelism has become ubiquitous at many levels. The proliferation of multi- and many-core processors, ever-increasing numbers of interconnected high performance and data intensive edge devices, and the data centers servicing them, is enabling a new set of global applications with large economic and social impact. At the same time, semiconductor technology is facing fundamental physical limits and single processor performance has plateaued. This means that the ability to achieve predictable performance improvements through improved processor technologies has ended.

The Exploiting Parallelism and Scalability (XPS) program aims to support groundbreaking research leading to a new era of parallel computing. XPS seeks research re-evaluating, and possibly re-designing, the traditional computer hardware and software stack for today's heterogeneous parallel and distributed systems and exploring new holistic approaches to parallelism and scalability. Achieving the needed breakthroughs will require a collaborative effort among researchers representing all areas – from the application layer down to the micro-architecture– and will be built on new concepts and new foundational principles. New approaches to achieve scalable performance and usability need new abstract models and algorithms, programming models and languages, hardware architectures, compilers, operating systems and run-time systems, and exploit domain and application-specific knowledge. Research should also focus on energy- and communication-efficiency and on enabling the division of effort between edge devices and clouds.

Cognizant Program Officer(s):

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

1

2010 2010 2012 2013

Josep Torrellas
UIUC

Mark Oskin
Washington

Mark Hill
Wisconsin

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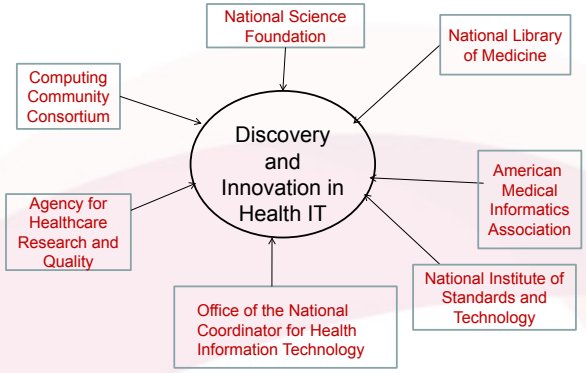
CATALYZING AND ENABLING: HEALTH IT

October 2009 Workshop



National Science Foundation
WHERE DISCOVERIES BEGIN

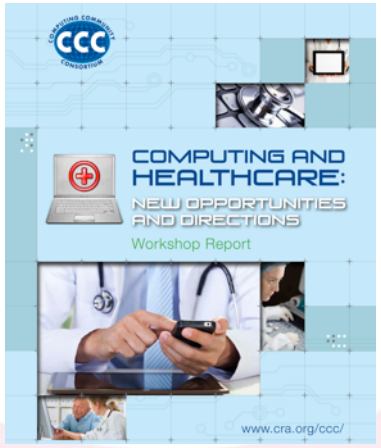
Directorate for Computer & Information Science & Engineering

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

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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!

CCC
Computing Community Consortium
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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

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BLUE SKY IDEAS CONFERENCE TRACKS

- BuildSys 2012
- Computational Sustainability Track @ AAAI 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

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COMMUNICATING: LEADERSHIP IN SCIENCE POLICY INSTITUTE

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 - Lazowska | 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
(Jeannette 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, Washinton, 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


Milt Corn, NIH


Henry Kelly, DoE

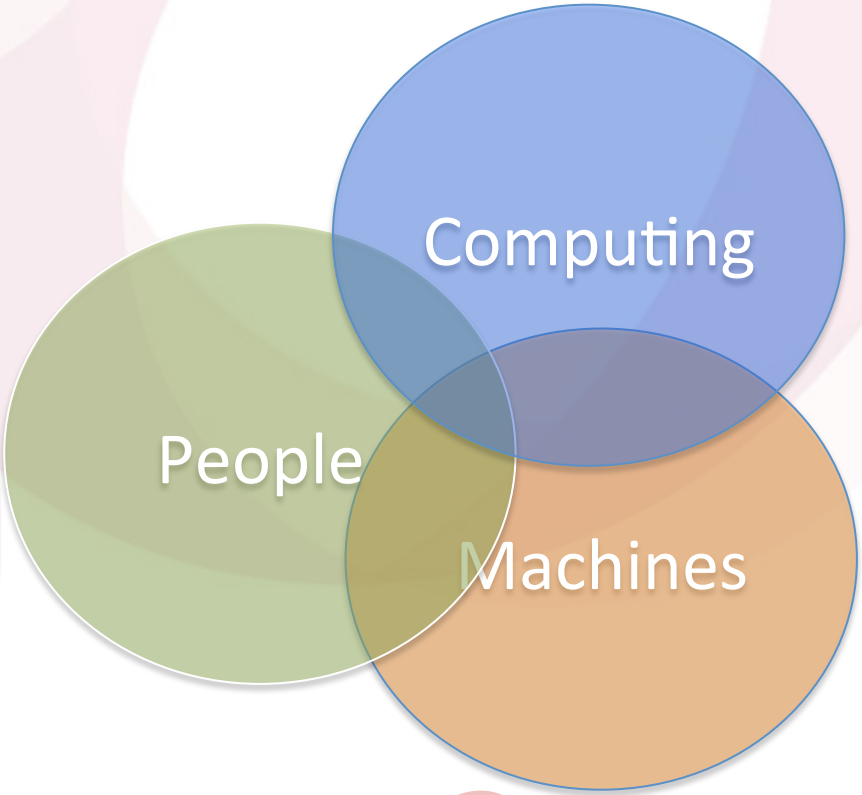

Attendees

#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?



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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)

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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

CCC
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Catalyst

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?

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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!

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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

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CCC: CATALYZING AND ENABLING COMPUTING RESEARCH

Gregory Hager
CCC Chair
Johns Hopkins University

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