Computer Science: Past, Present, and Future

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Computer Science & Engineering
University of Washington

Chair, Computing Community Consortium

University of Waterloo

October 2011

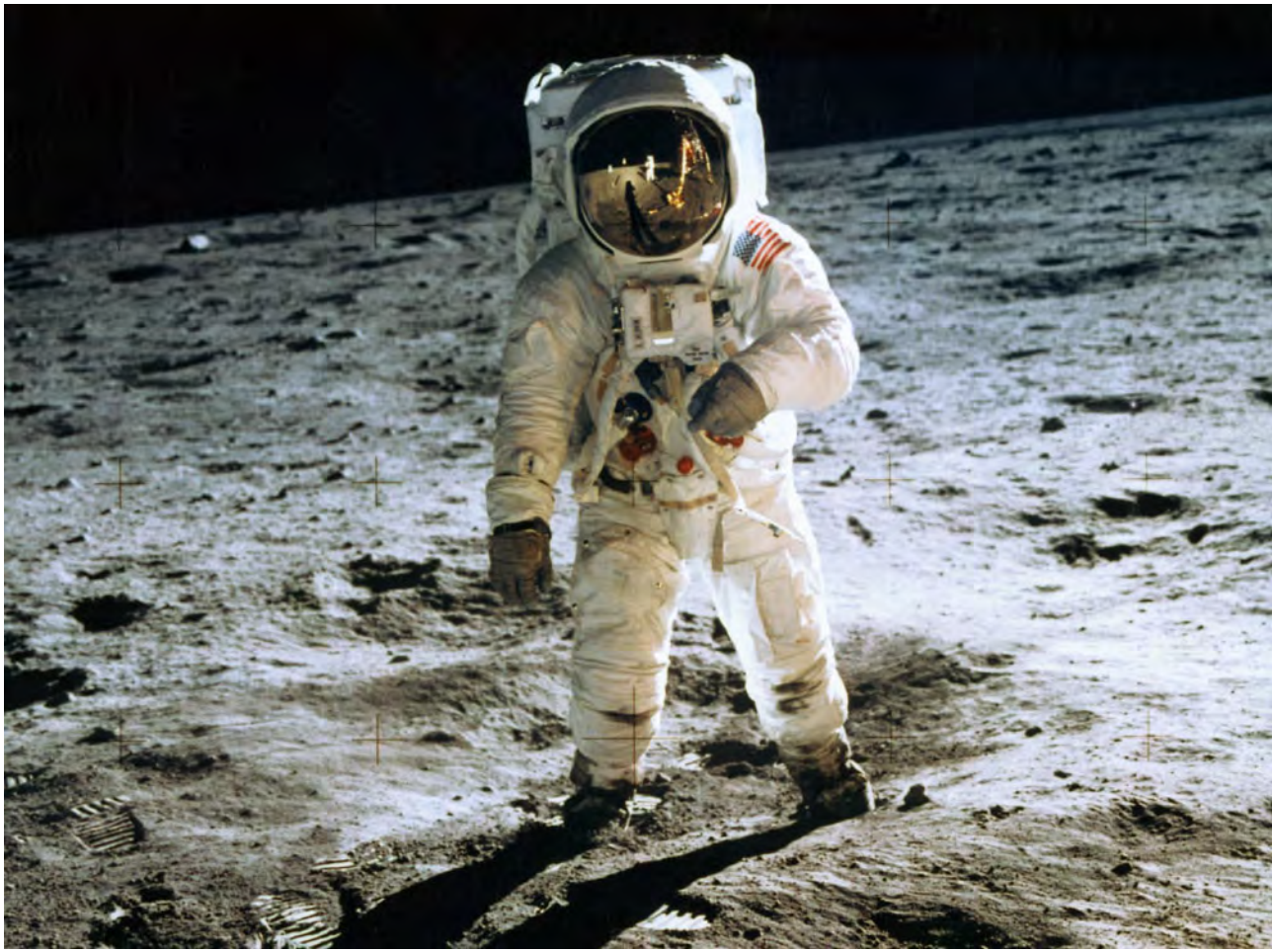
http://lazowska.cs.washington.edu/waterloo.pdf

Today …

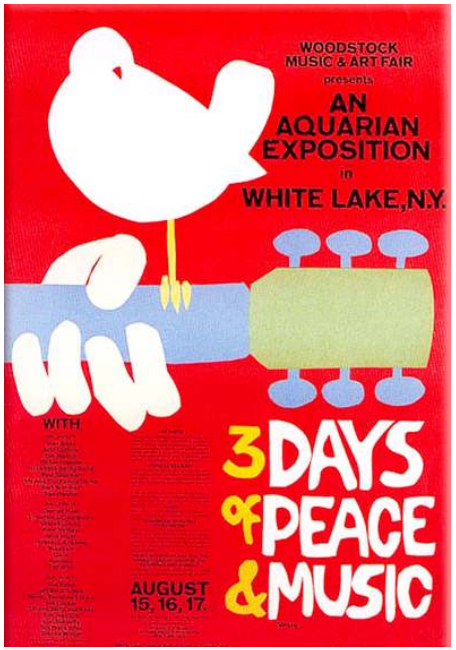
- A quick reminder of what we've accomplished as a field
- The Computing Community Consortium: origins, goals, recent activities
- Some research challenges for our field
- Three exhortations

Forty years ago …

Credit: Peter Lee, Microsoft Research




1969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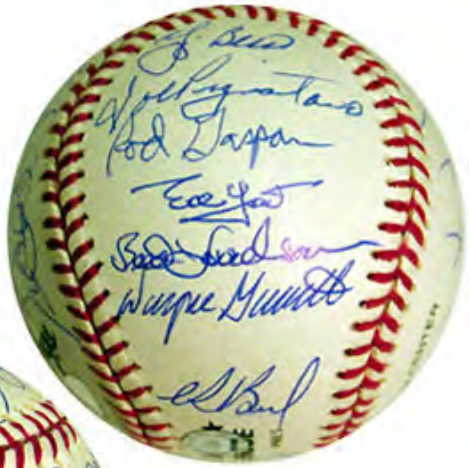
1969


1969 WORLD SERIES
NEW YORK METS




WORLD
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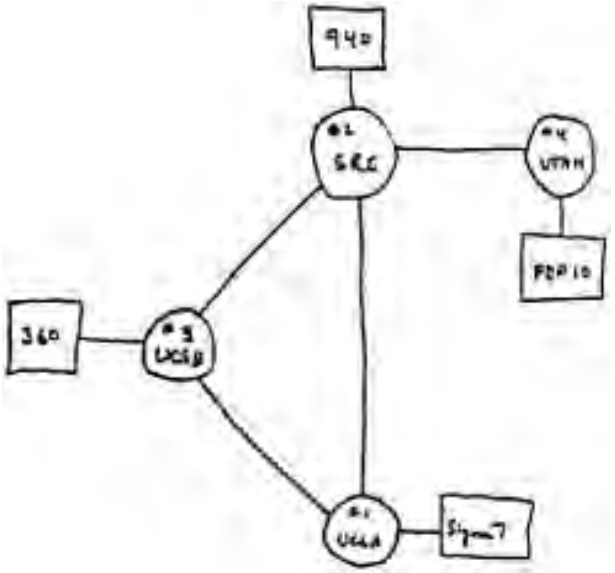
1969


Mets



THE ARPA NETWORK
DEC 1969
4 NODES

29OCT69	2100	LOADED OP. PROGRAM FOR BEN BARKER BBN	CSK
	22:30	Talked to SRI Host to Host	CSK
		Left op. imp. program running after sending a host dead message to imp.	CSK

With forty years hindsight, which had the greatest impact?

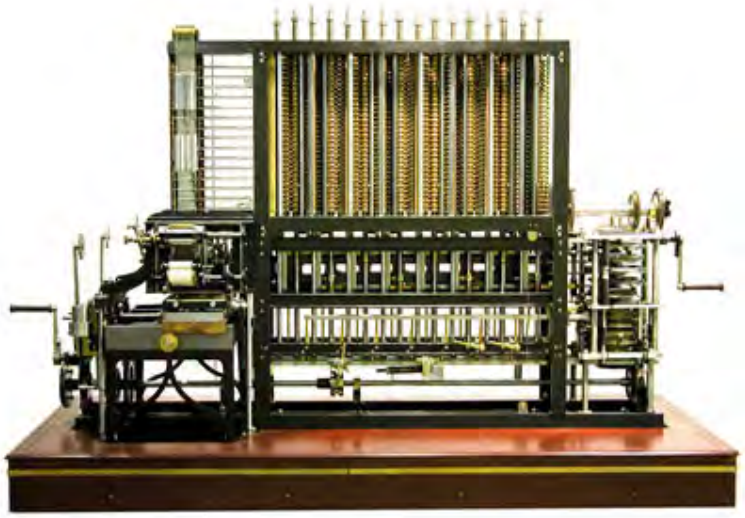
- Unless you're big into Tang and Velcro (or sex and drugs), the answer is clear …

- And so is the reason …

EXPONENTIALS 'R' US

EXPONENTIALS R US

- Mechanical



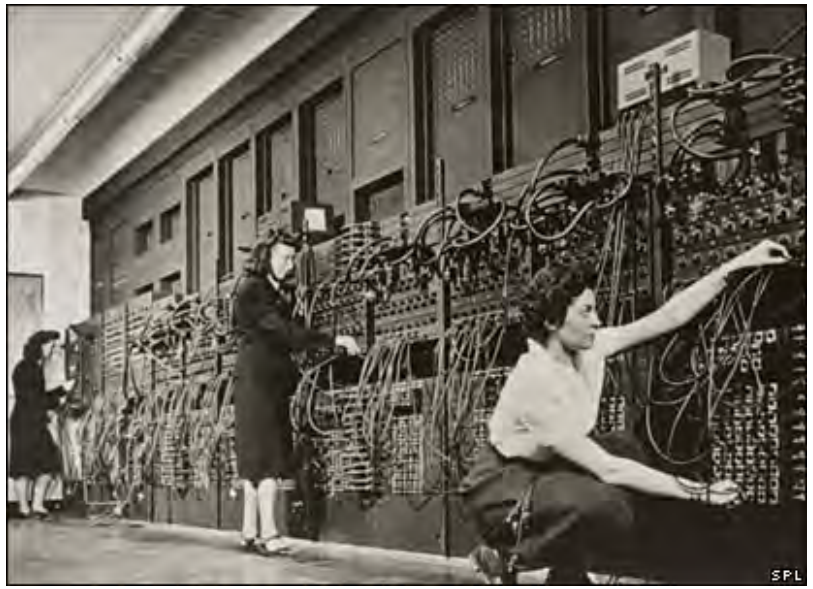
Babbage's Difference Engine No. 2
(designed 1847-1849,
constructed 1989-2000)
[11'x7', 8000 parts, 5 tons]

Vannevar Bush's Differential Analyzer (1931)

Vacuum tube electronic

ENIAC (constructed 1943-1946)

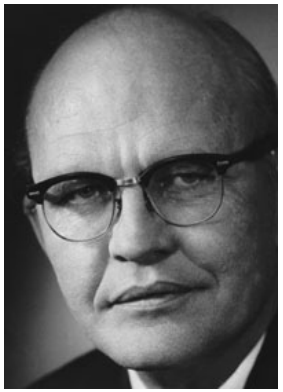
[8.5′ (h) x 3′ (d) x 80′ (linear),
30 tons, 17,468 vacuum tubes,
150 kW of power, 5,000 additions/second]

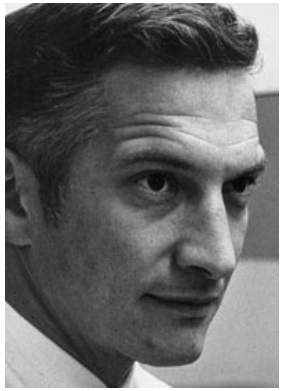


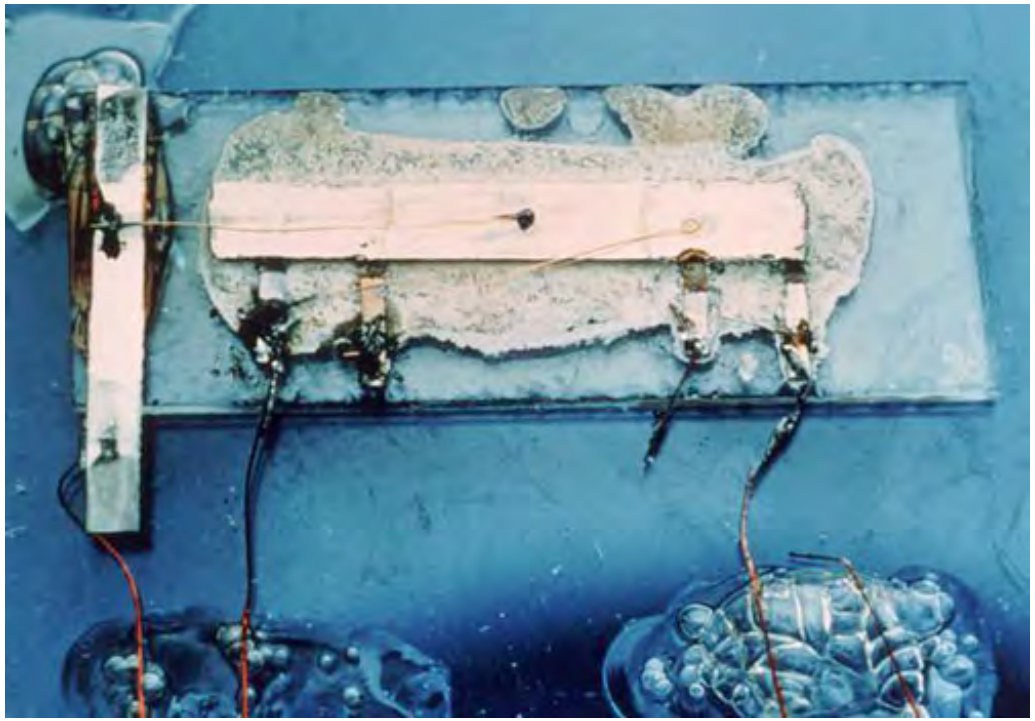
- The transistor (1947)
  - William Shockley, Walter Brattain and John Bardeen, Bell Labs

The integrated circuit (1958)

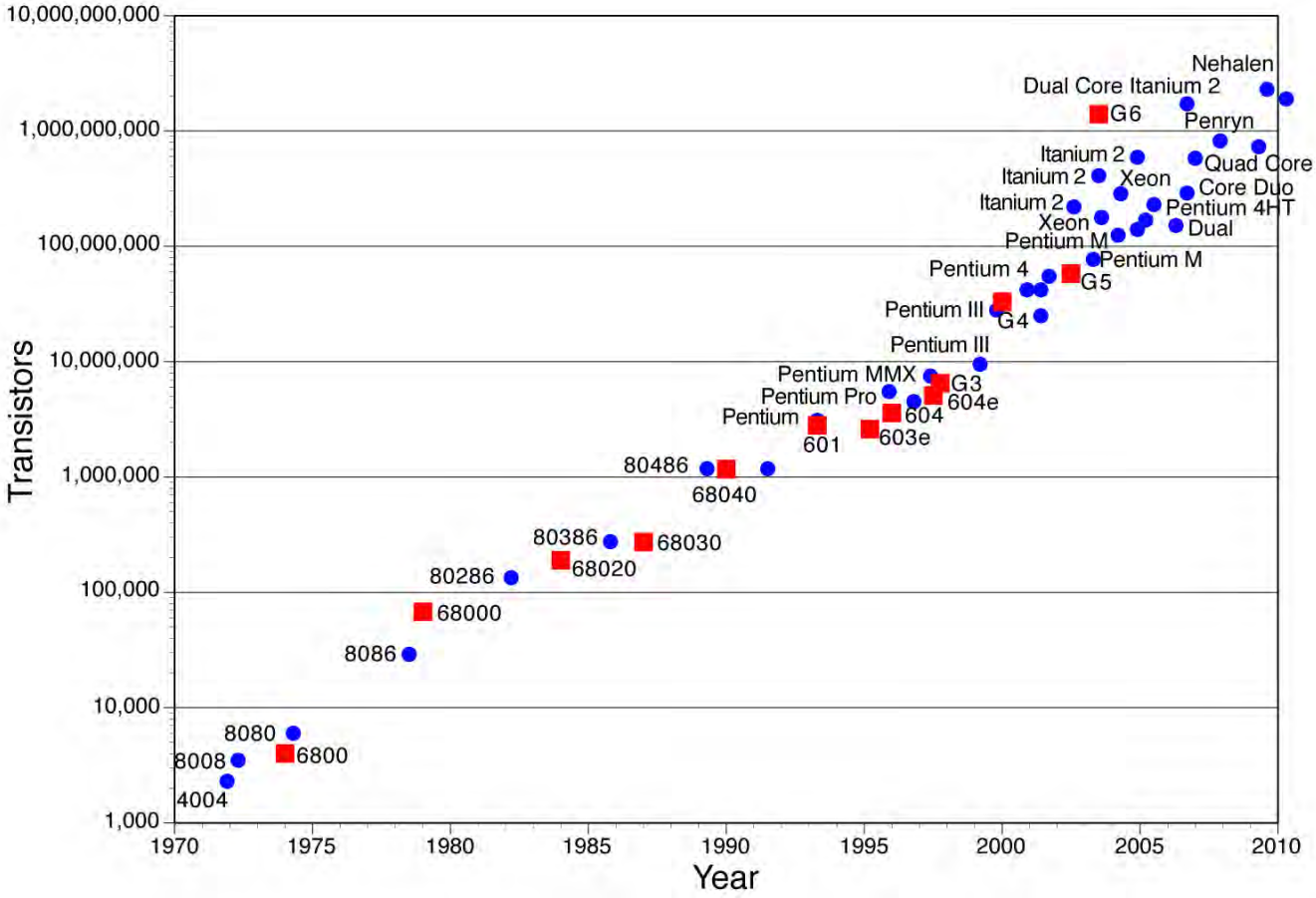
- Jack Kilby, Texas Instruments, and Bob Noyce, Fairchild Semiconductor Corporation



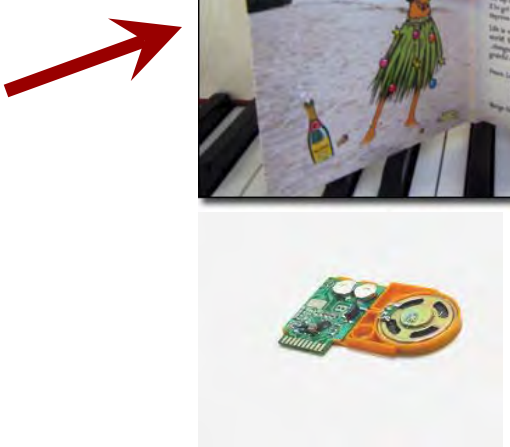




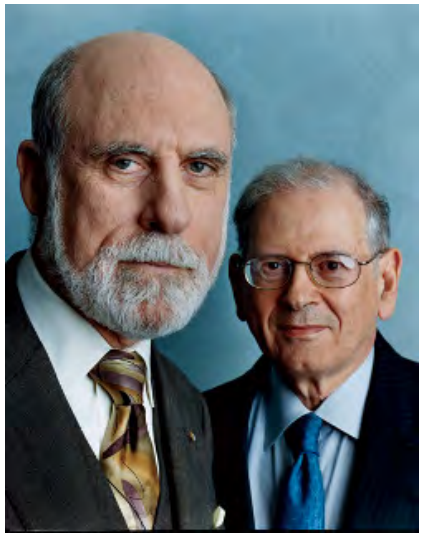
Moore's Law and exponential progress (1965-today)

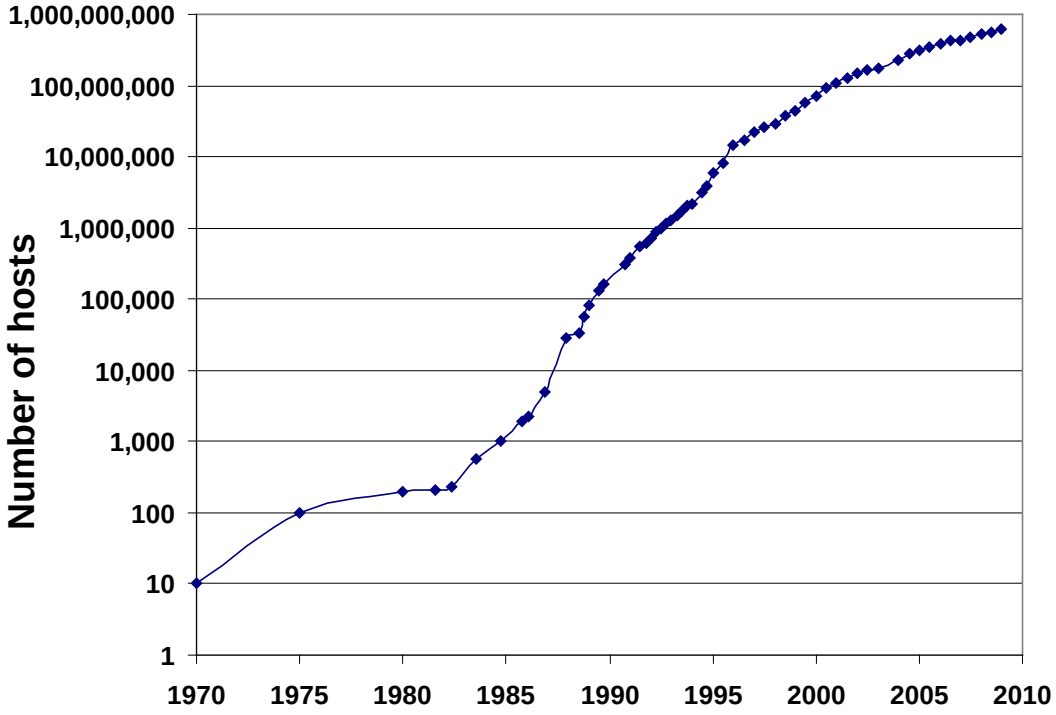



UNIVAC



Ditto the Internet





In just the past 20 years (1991-2011), the number of Internet hosts and the number of transistors on a die each have increased 2000x!

A connected region – then

A connected region – now

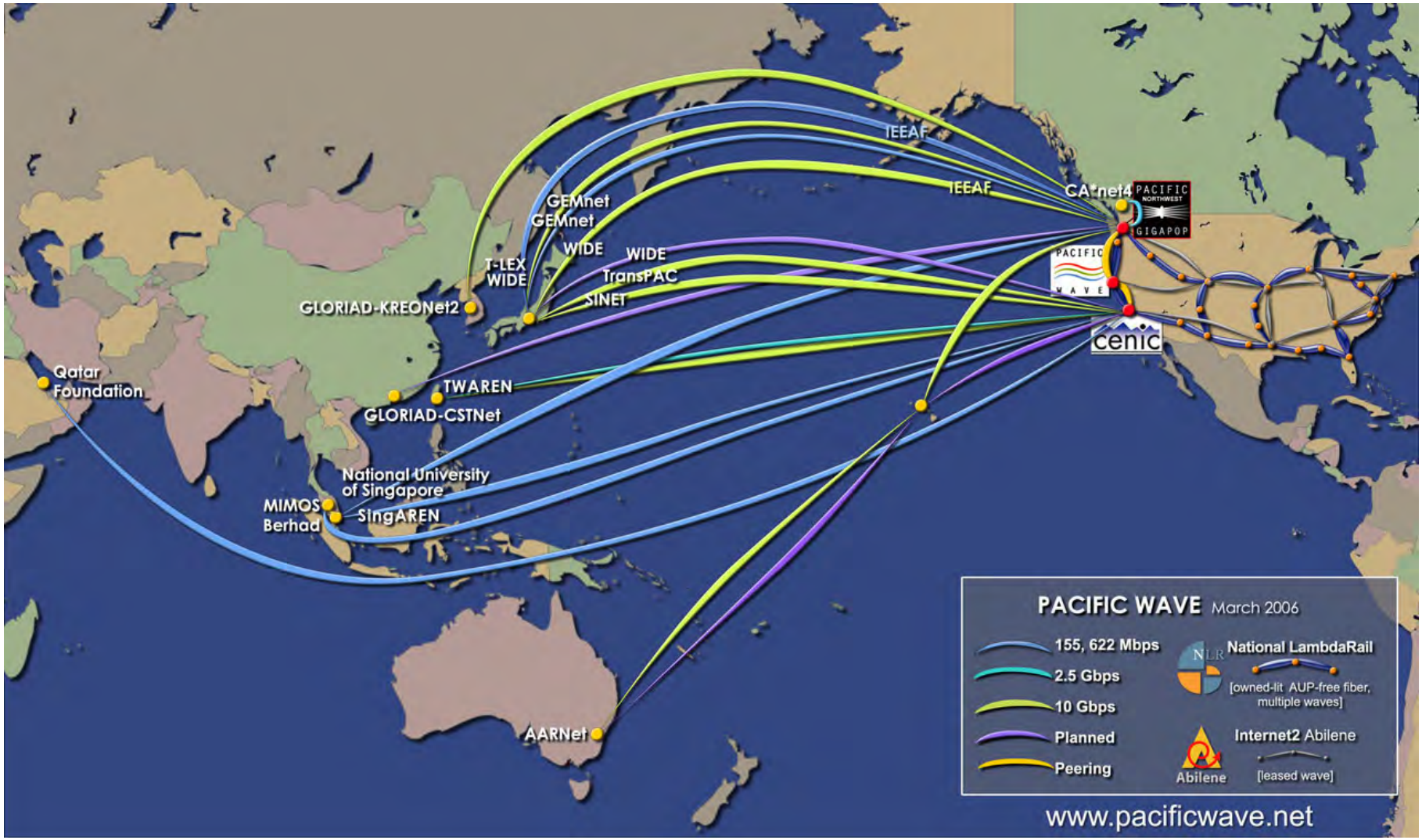


Table 1

BRIEF DESCRIPTIONS OF POTENTIAL HOME INFORMATION SERVICES

1. CASHLESS-SOCIETY TRANSACTIONS. Recording of any financial transactions with a hard copy output to buyer and seller, a permanent record and updating of balance in computer memory.

2. DEDICATED NEWSPAPER. A set of pages with printed and graphic information, possibly including photographs, the organization of which has been predetermined by the user to suit his preferences.

3. COMPUTER-AIDED SCHOOL INSTRUCTION. At the very minimum, the computer determines the day's assignment for each pupil and, at the end of the day, receives the day's progress report. At its most complex, such a service would use a real-time, interactive video color display with voice input and output and an appropriate program suited to each pupil's progress and temperament.

4. SHOPPING TRANSACTIONS (STORE CATALOGS). Interactive programs, perhaps video-assisted, which describe or show goods at request of the buyer, advise him of the price, location, delivery time, etc.

5. PERSON-TO-PERSON (PAID WORK AT HOME). Switched video and facsimile service substituting for normal day's contacts of a middle-class managerial personnel where daily contacts are of mostly routine nature. May also apply to contacts with the public of the receptionist, doctor, or his assistant.

6. PLAYS AND MOVIES FROM A VIDEO LIBRARY. Selection of all plays and movies. Color and good sound are required.

7. COMPUTER TUTOR. From a library of self-help programs available, a computer, in an interactive mode, will coach the pupil (typically adult) in the chosen subject.

8. MESSAGE RECORDING. Probably of currently available type but may include video memory (a patient showing doctor the rash he has developed).

9. SECRETARIAL ASSISTANCE. Written or dictated letters can be typed by a remotely situated secretary.

10. HOUSEHOLD MAIL AND MESSAGES. Letters and notes transmitted directly to or from the house by means of home facsimile machines.

11. MASS MAIL AND DIRECT ADVERTISING MAIL. Higher output, larger-sized pages, color output may be necessary to attract the attention of the recipient--otherwise similar to item 10 above.

12. ANSWERING SERVICES. Stored incoming messages or notes whom to call--possibly computer logic recognizing emergency situation and diverting the call.

13. GROCERY PRICE LIST, INFORMATION, AND ORDERING. Grocery price list is used as an example of up-to-the-minute, updated information about perishable foodstuffs. Video color display may be needed to examine selected merchandise. Ordering follows.

14. ACCESS TO COMPANY FILES. Information in files is coded for security; regularly updated files are available with cross-references indicating the code where more detailed information is stored. Synthesis also may be available.

15. FARES AND TICKET RESERVATION. As provided by travel more comprehensive and faster. Cheapest rates, info the differences between carriers with respect to se may be available.

16. PAST AND FORTHCOMING EVENTS. Events, dates of even description; short previews of future theater plays past events.

17. CORRESPONDENCE SCHOOL. Taped or live high school, tional courses available on request with an option graduate. Course on TV, paper support on facsimile.

18. DAILY CALENDAR AND REMINDER ABOUT APPOINTMENTS. Pr pointments and regularly occurring appointments sto reminder.

19. COMPUTER-ASSISTED MEETINGS. The computer particip meeting, answering questions of fact, deriving corre olating trends.

20. NEWSPAPER, ELECTRONIC, GENERAL. Daily newspaper, possibly printed during the night, available in time for breakfast. Special editions following major news breaks.

21. ADULT EVENING COURSES ON TV. Noninteractive, broadcast mode, live courses on TV--wider choice of subjects than at present.

22. BANKING SERVICES. Money orders, transfers, advice.

23. LEGAL INFORMATION. Directory of lawyers, computerized legal counseling giving precedents, rulings in similar cases, describing jurisdiction of various courts and changes of successful suits in a particular area of litigation.

24. SPECIAL SALES INFORMATION. Any sales within the distance specified by the user and for items specified by him will be "flashed" onto the home display unit.

25. CONSUMERS' ADVISORY SERVICE. Equivalent of *Consumer Reports*, giving best buy, products rated "acceptable", etc.

26. WEATHER BUREAU. Country-wide, regional forecasts or special forecasts (farmers, fishermen), hurricane and tornado warnings similar to current special forecast services.

27. BUS, TRAIN, AND AIR SCHEDULING. Centrally available information with one number to call.

28. RESTAURANTS. Following a query for a type of restaurant (Japanese, for instance), reservations, menu, prices are shown. Displays of dishes, location of tables, may be included.

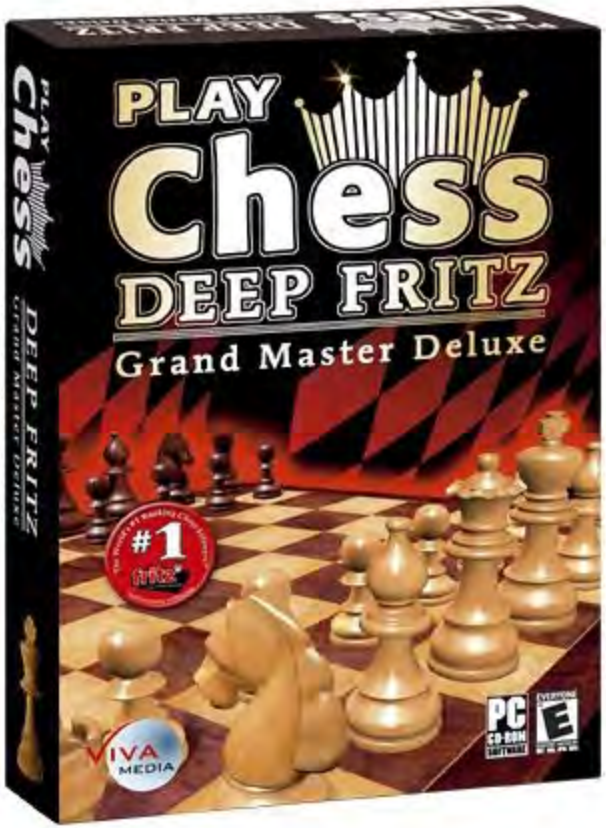
29. LIBRARY ACCESS. After an interactive "browsing" with a "librarian computer" and a quotation for the cost of hard copy facsimile or a slow-scan video transmission, a book or a magazine is transmitted to the home.

30. INDEX, ALL SERVICES SERVED BY THE HOME TERMINAL. Includes prices or charges of the above, or available communications services.

1926-2011

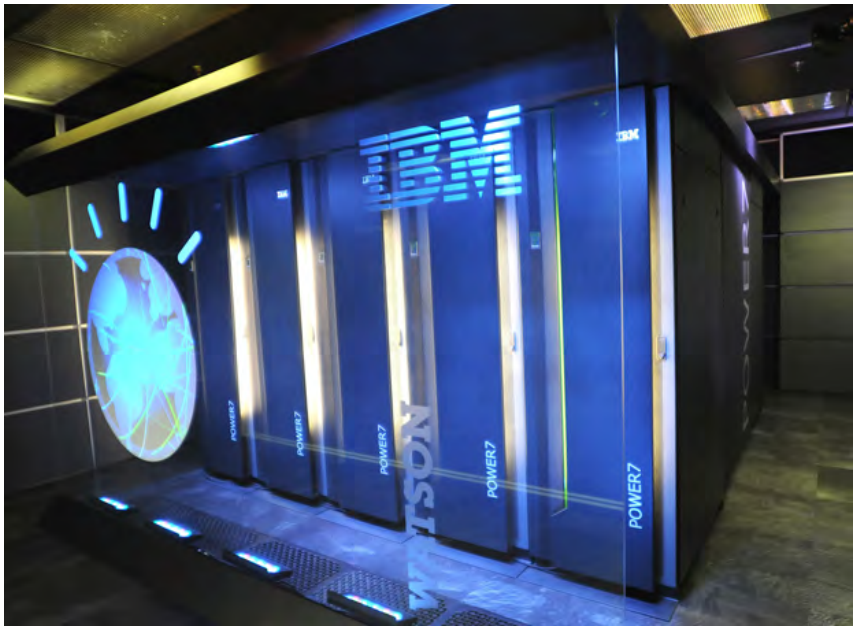
- Ditto software

Deep Blue, 1997



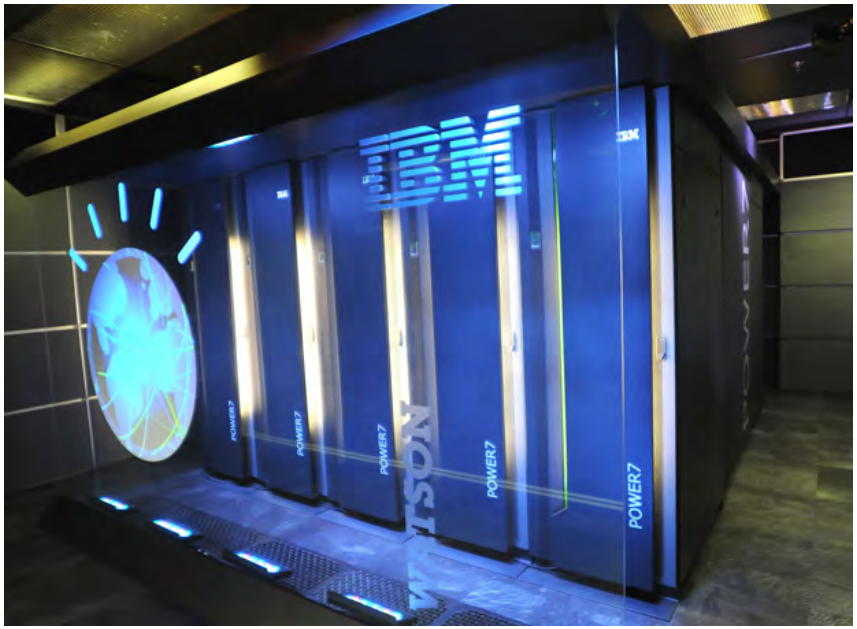
Price: $19.99 & eligible for free shipping with **Amazon Prime**

Deep Fritz, 2002



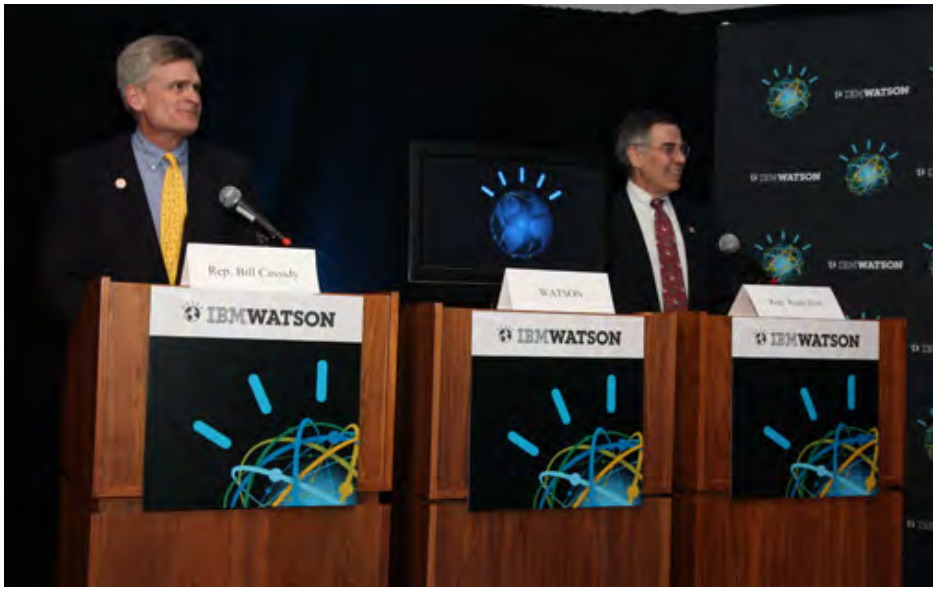
Watson, 2011

Ken Jennings, Watson, Brad Rutter

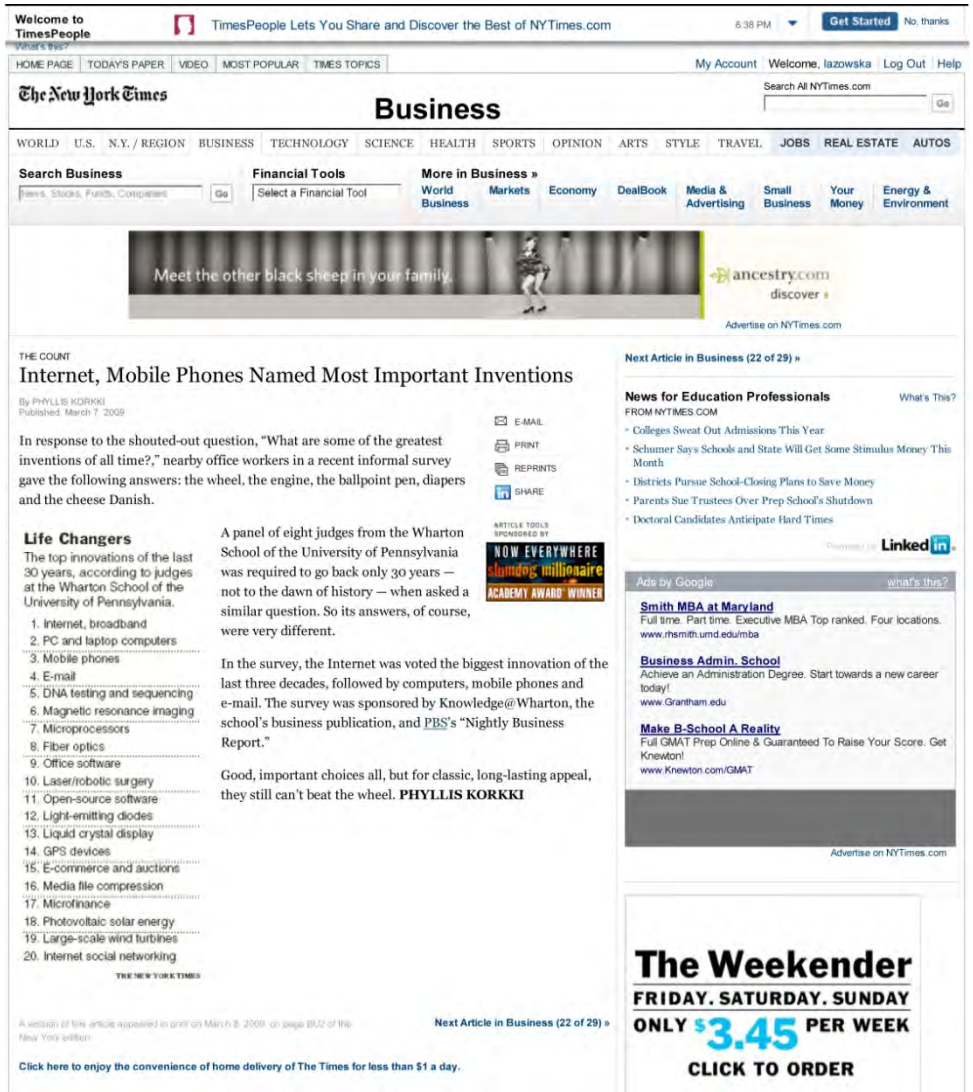


Watson, 2011

Bill Cassidy, Watson, Rush Holt



The past thirty years …



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THE COUNT

Internet, Mobile Phones Named Most Important Inventions

By PHYLLIS KORKKI
Published: March 7, 2009

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In response to the shouted-out question, "What are some of the greatest inventions of all time?," nearby office workers in a recent informal survey gave the following answers: the wheel, the engine, the ballpoint pen, diapers and the cheese Danish.

Life Changers

The top innovations of the last 30 years, according to judges at the Wharton School of the University of Pennsylvania.

1. Internet, broadband
2. PC and laptop computers
3. Mobile phones
4. E-mail
5. DNA testing and sequencing
6. Magnetic resonance imaging
7. Microprocessors
8. Fiber optics
9. Office software
10. Laser/robotic surgery
11. Open-source software
12. Light-emitting diodes
13. Liquid crystal display
14. GPS devices
15. E-commerce and auctions
16. Media file compression
17. Microfinance
18. Photovoltaic solar energy
19. Large-scale wind turbines
20. Internet social networking

THE NEW YORK TIMES

A panel of eight judges from the Wharton School of the University of Pennsylvania was required to go back only 30 years — not to the dawn of history — when asked a similar question. So its answers, of course, were very different.

In the survey, the Internet was voted the biggest innovation of the last three decades, followed by computers, mobile phones and e-mail. The survey was sponsored by Knowledge@Wharton, the school's business publication, and PBS's "Nightly Business Report."

Good, important choices all, but for classic, long-lasting appeal, they still can't beat the wheel. **PHYLLIS KORKKI**

A version of this article appeared in print on March 8, 2009, on page BU2 of the New York edition.

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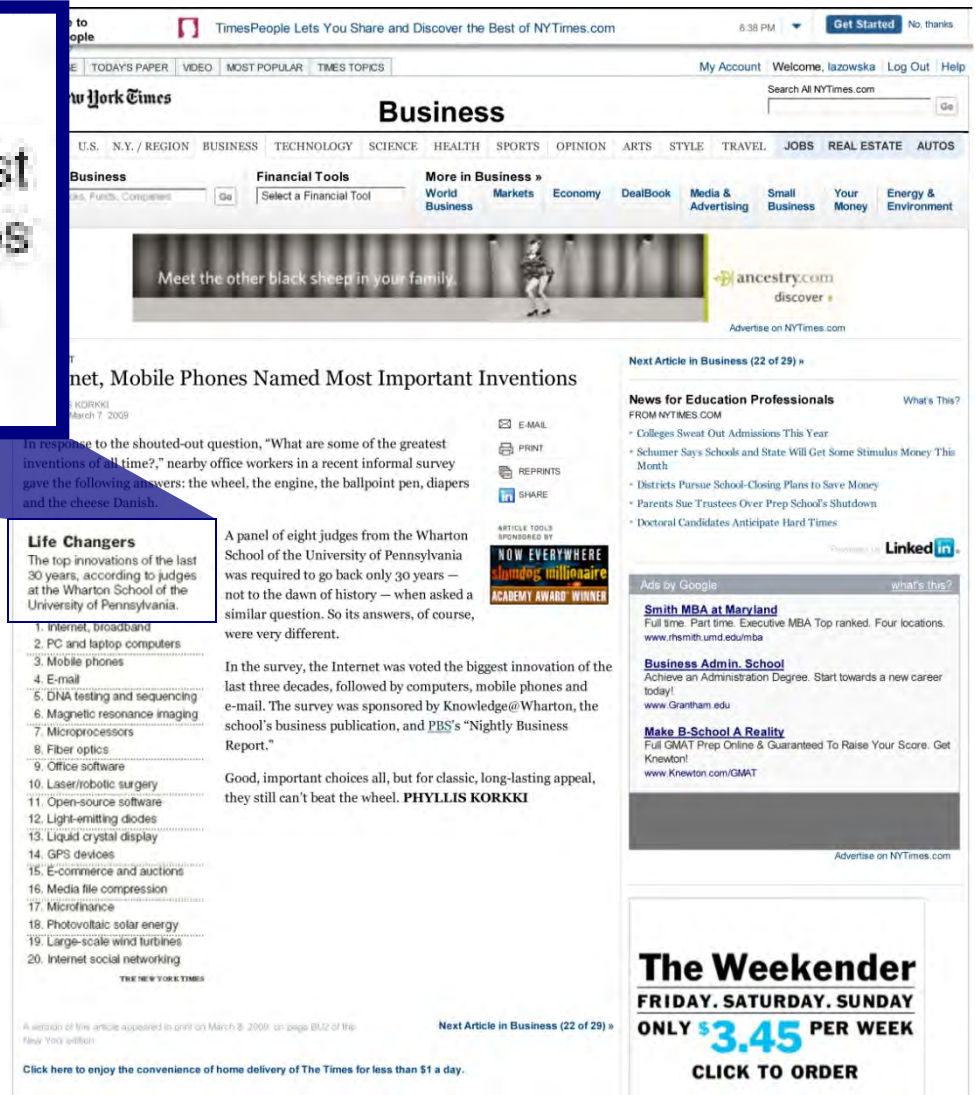

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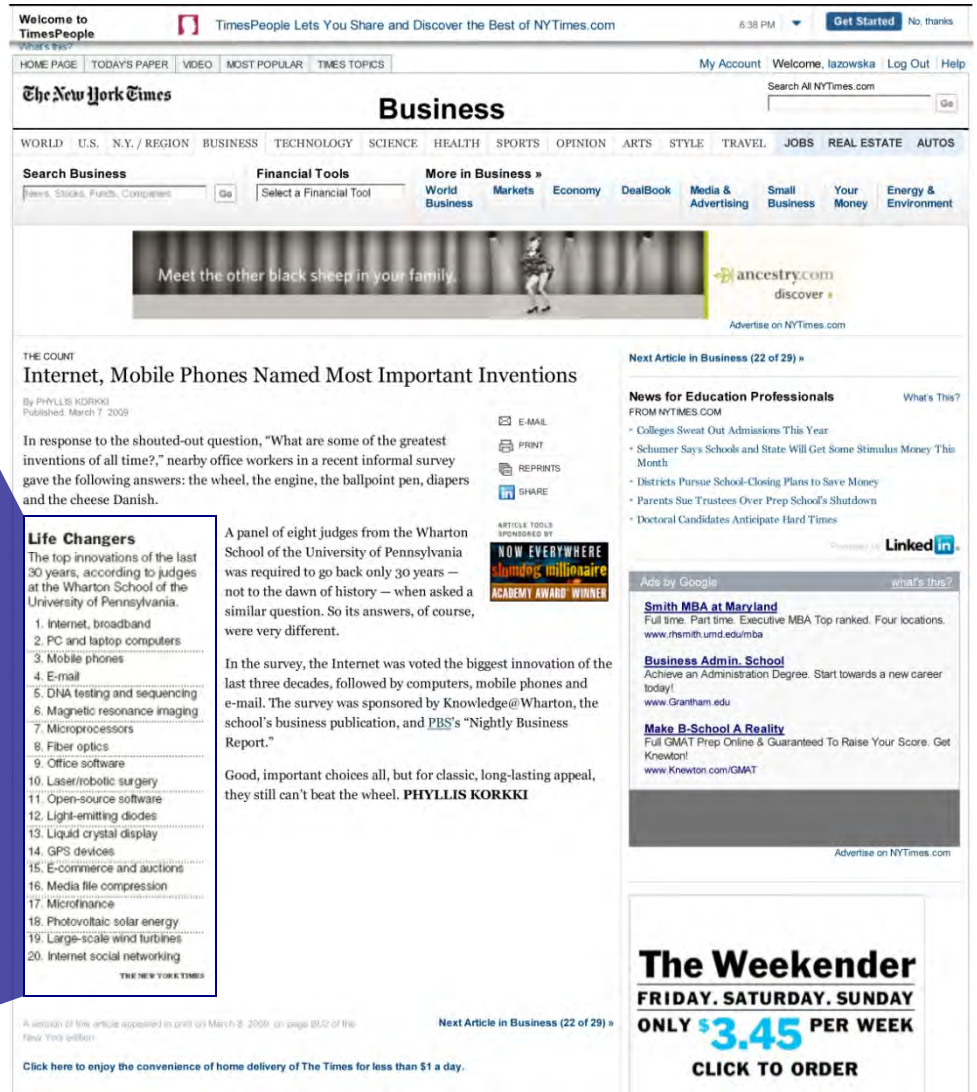

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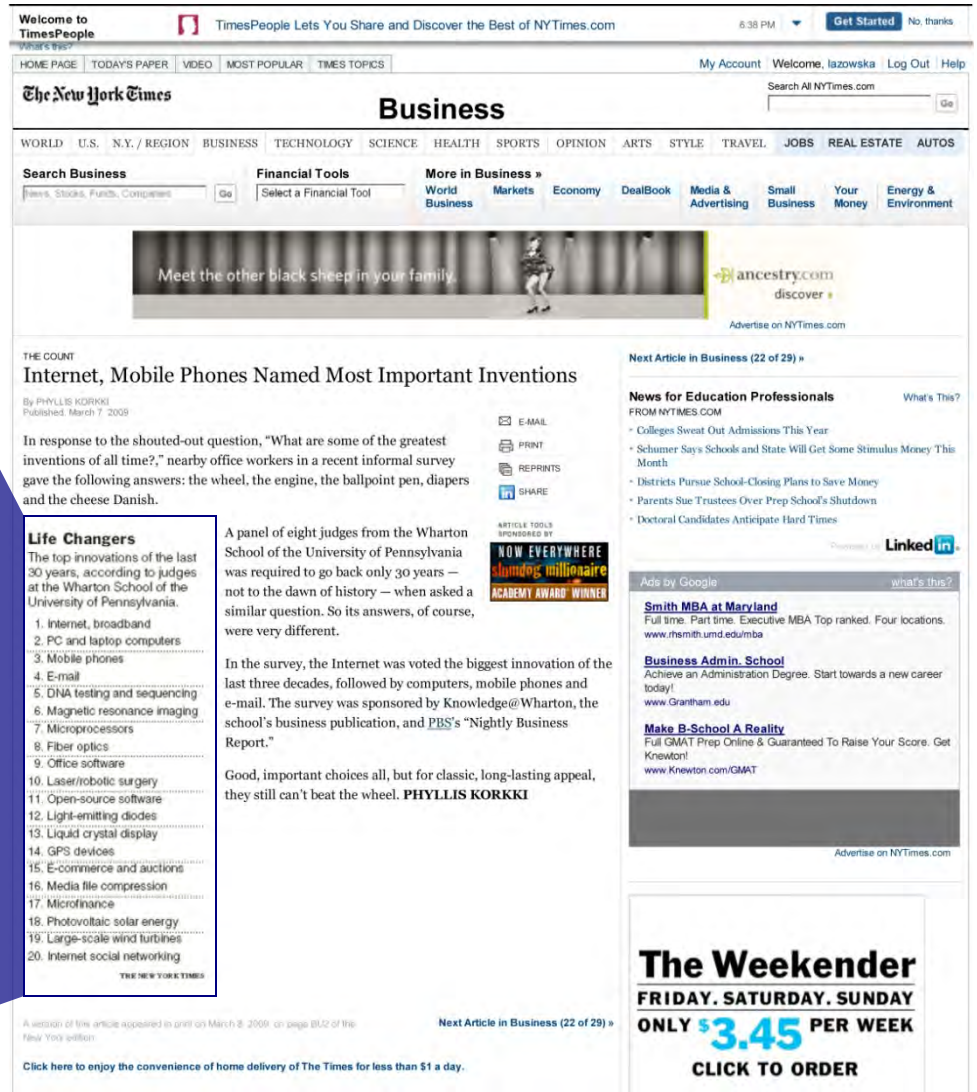


The most recent ten years …

- Search
- Scalability
- Digital media
- Mobility
- eCommerce
- The Cloud
- Social networking and crowd-sourcing

Scalability

AlphaServer 1200 product brief

Leadership
"To support our rapid growth, we had to find a highly upgradable and scaleable Internet server. The AlphaServer platform provides the upgrade path we need."

Jeff Bezos
CEO and Founder
Amazon.com

amazon.com

- A decade later …
  - Vastly greater scale
  - The cheapest imaginable components
  - Failures occur all the time
    - You couldn't afford to prevent or mask them in hardware
  - Software makes it
    - Fault-Tolerant
    - Highly Available
    - Recoverable
    - Consistent
    - Scalable
    - Predictable
    - Secure

- Operational efficiency is part of scalability
  - An IBM System/360 came with a full-time on-site support person
  - Web services of the middle 2000's typically required 1 support staff for every 250 servers
  - Microsoft Azure today requires only 12 support staff for 35,000 2 x quad-core servers
    - 6 support staff in the US, 6 on the other side of the globe, to provide 24-hour support

Digital media

- Text
- Audio
- Images
- Video

- Create
- Edit
- Consume

Mobility

This sort of progress makes it dicey to predict the future

"I think there is a world market for maybe five computers" – Thomas J. Watson, founder and Chairman of IBM, 1943

"Computers in the future may weigh no more than 1.5 tons" – *Popular Science*, 1949

"There is no reason anyone would want a computer in their home" – Ken Olsen, founder and President of Digital Equipment Corporation, 1977

Today: More than 1 billion PCs in use …

Representing less than 2% of all processors!

An Overview of the Computing Community Consortium

- A standing committee of the Computing Research Association
- Funded by NSF under a Cooperative Agreement
- Facilitates the development of a bold, multi-themed vision for computing research – and communicates this vision to stakeholders
- Led by a broad-based Council
- Chaired by Ed Lazowska and Susan Graham
- Staffed by CRA – Erwin Gianchandani and Andy Bernat

The CCC Council

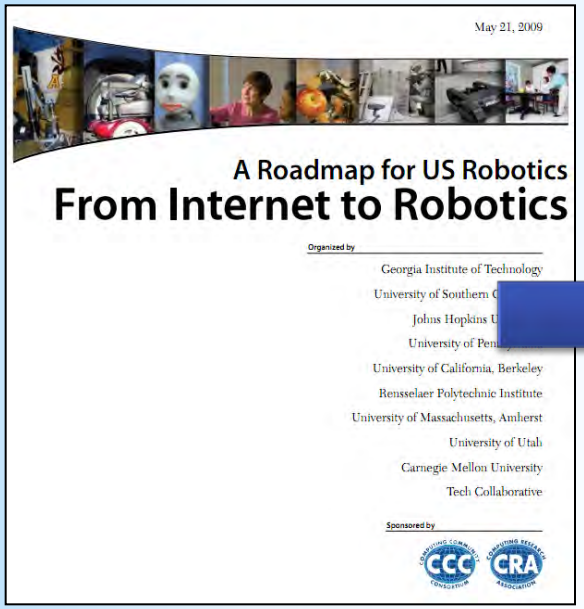
- Leadership
  - Ed Lazowska, Chair
  - Susan Graham, Vice Chair
  - Erwin Gianchandani, Director
  - Andy Bernat, CRA
- Terms ending 2014
  - Deborah Crawford
  - Gregory Hager
  - John Mitchell
  - Bob Sproull
  - Josep Torrellas
- Terms ending 2013
  - Randy Bryant
  - Lance Fortnow
  - Hank Korth
  - Eric Horvitz
  - Beth Mynatt
  - Fred Schneider
  - Margo Seltzer
- Terms ending 2012
  - Stephanie Forrest
  - Chris Johnson
  - Anita Jones
  - Frans Kaashoek
  - Ran Libeskind-Hadas
  - Robin Murphy
- Former members
  - Bill Feiereisen, 2011
  - Dave Kaeli, 2011
  - John King, 2011
  - Dick Karp, 2010
  - Andrew McCallum, 2010
  - Dave Waltz, 2010
  - Greg Andrews, 2009
  - Peter Lee, 2009
  - Karen Sutherland, 2009

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

- **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

Example: Robotics Visioning Effort


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 Penn
University of California, Berkeley
Rensselaer Polytechnic Institute
University of Massachusetts, Amherst
University of Utah
Carnegie Mellon University
Tech Collaborative

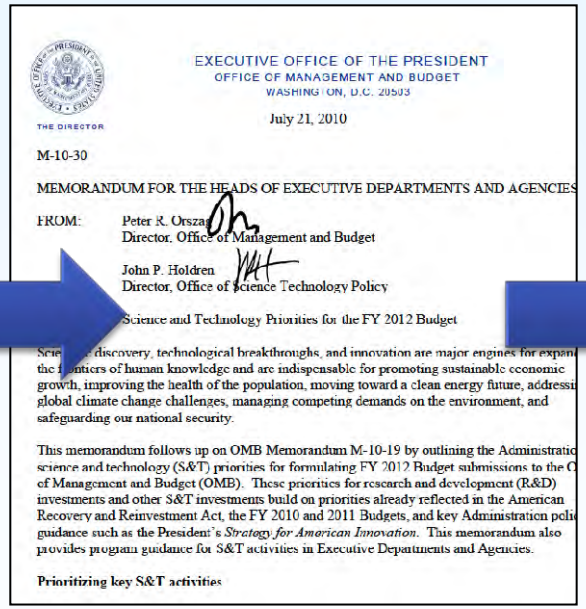
Sponsored by

CCC CRA

4 meetings during summer 2008

Roadmap published May 2009

Extensive discussions between visioning leaders & agencies


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

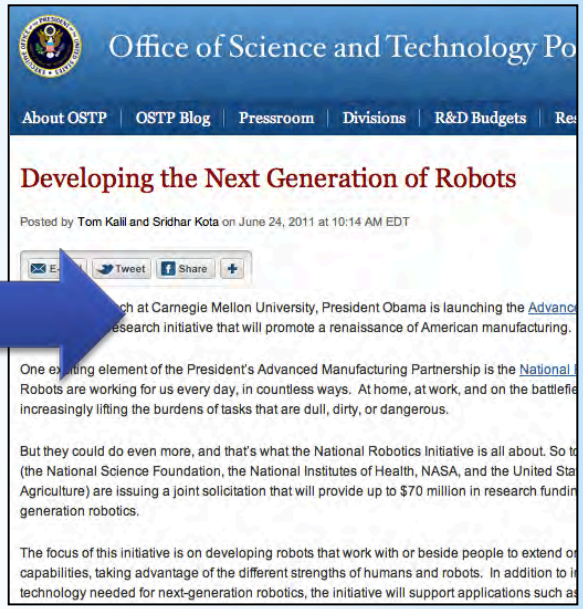
Science and Technology Priorities for the FY 2012 Budget

Sci discovery, technological breakthroughs, and innovation are major engines for expan the frontiers 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 Administratic science and technology (S&T) priorities for formulating FY 2012 Budget submissions to the C 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

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


Office of Science and Technology Po

About OSTP | OSTP Blog | Pressroom | Divisions | R&D Budgets | Re

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 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.

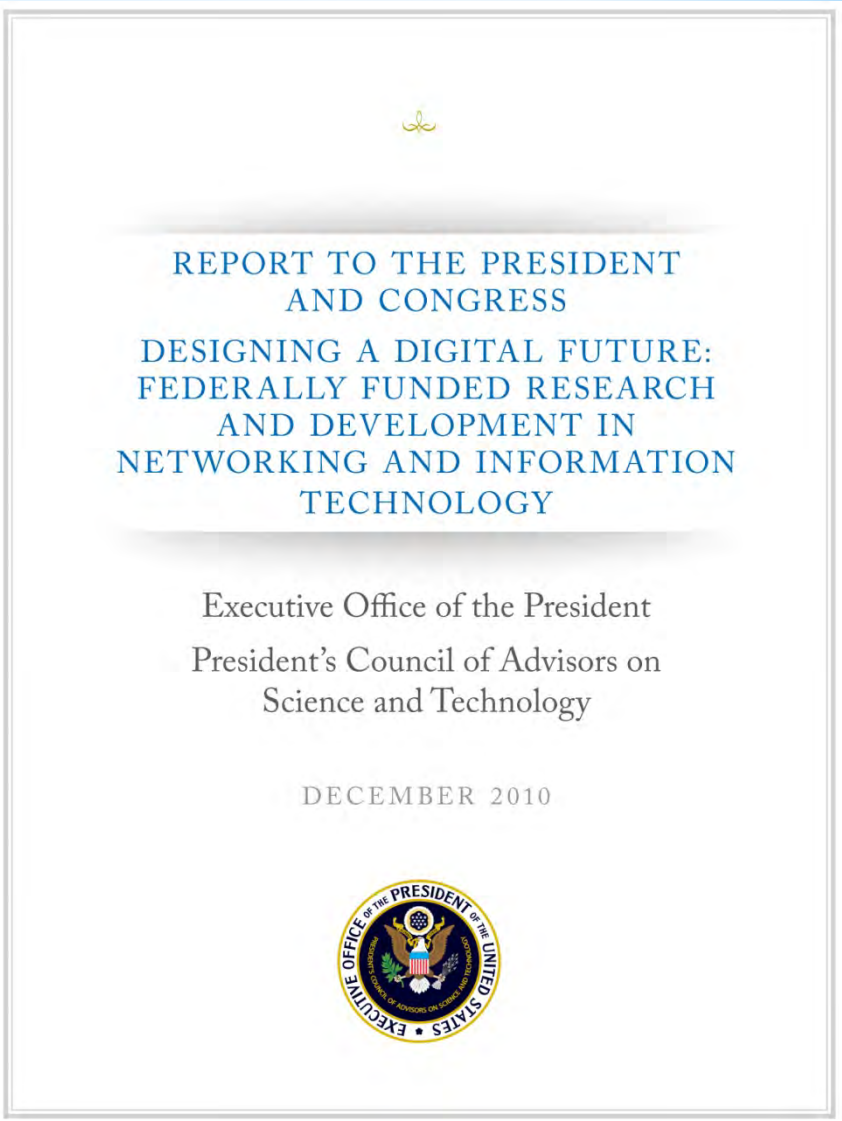
The focus of this initiative is on developing robots that work with or beside people to extend o capabilities, taking advantage of the different strengths of humans and robots. In addition to i technology needed for next-generation robotics, the initiative will support applications such a

National Robotics Initiative is announced

Henrik Chistensen
Georgia Tech

Example: PCAST NITRD Report

- 1/3 of the PCAST NITRD Working Group members were CCC Council members
- The report drew extensively on CCC White Papers
- An excellent roadmap for the field
- The challenge now: continuing to translate it into action

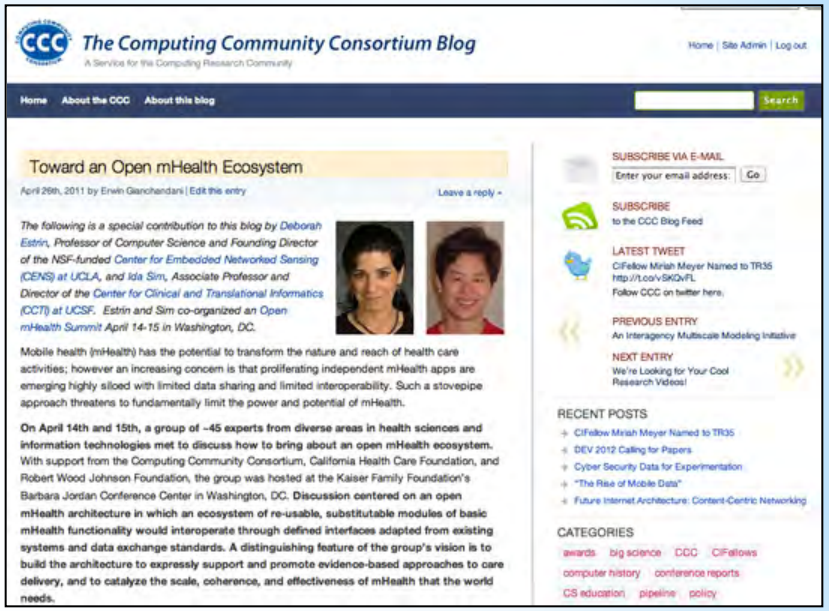


Current Areas of Emphasis

- Data analytics
  - Series of white papers written for policy makers in summer 2010
  - Ongoing discussions with OSTP and Federal agencies
- Health information technology
  - Workshop held in San Francisco in October 2009
  - NSF/CISE initiative on Smart Health & Wellbeing (SHB) announced in FY 2011
- Education (Learning) Technologies
  - Roadmap produced in summer 2010
  - President's FY 12 budget would establish "ARPA-ED"
- Role of Information Sciences & Engineering in Sustainability
  - Workshop in Washington, DC, on Feb. 3-4, 2011
  - Ongoing discussions with NSF/CISE and DoE Office of Energy Efficiency & Renewable Energy

A Community Effort – We Need You!

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



Get involved:

erwin@cra.org or 202-266-2936

http://cra.org/ccc or http://cccblog.org/

The next ten years …

Greatest Engineering Achievements of the 20th Century

Welcome!

How many of the 20th century's greatest engineering achievements will you use today? A car? Computer? Telephone? Explore our list of the top 20 achievements and learn how engineering shaped a century and changed the world.

1. Electrification
2. Automobile
3. Airplane
4. Water Supply and Distribution
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning and Refrigeration
11. Highways
12. Spacecraft
13. Internet
14. Imaging
15. Household Appliances
16. Health Technologies
17. Petroleum and Petrochemical Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High-performance Materials

Greatest Achievements

 Printer-Friendly Version. Text-Only Version. Contact Us.

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16. Health Technologies
17. Petroleum and Petrochemical Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High-performance Materials

Greatest Achievements

 Printer-Friendly Version. Text-Only Version. Contact Us.

NATIONAL ACADEMY OF ENGINEERING
OF THE NATIONAL ACADEMIES

CHALLENGES | IDEAS | NEXT STEPS | COMMITTEE

GRAND CHALLENGES FOR ENGINEERING


Make solar energy economical


Provide energy from fusion


Develop carbon sequestration methods


Manage the nitrogen cycle


Provide access to clean water


Restore and improve urban infrastructure


Advance health informatics


Engineer better medicines


Reverse-engineer the brain


Prevent nuclear terror


Secure cyberspace


Enhance virtual reality


Advance personalized learning


Engineer the tools of scientific discovery

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Reverse-engineer the brain


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Secure cyberspace


Enhance virtual reality

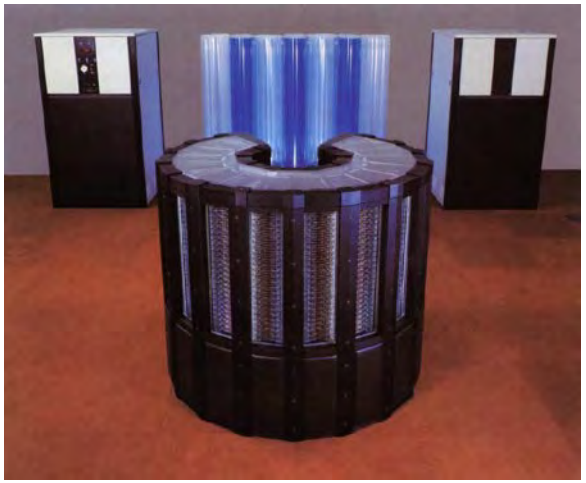

Advance personalized learning


Engineer the tools of scientific discovery

Predominant CS component

Significant CS component

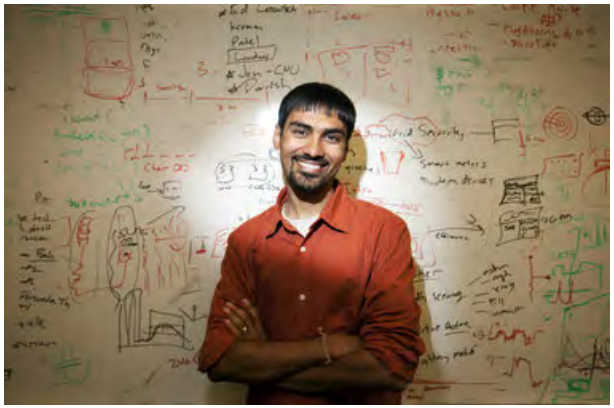
Simulation -> Communication -> Embodiment



My own (consistent) version: In the next ten years, we will put the "smarts" in …

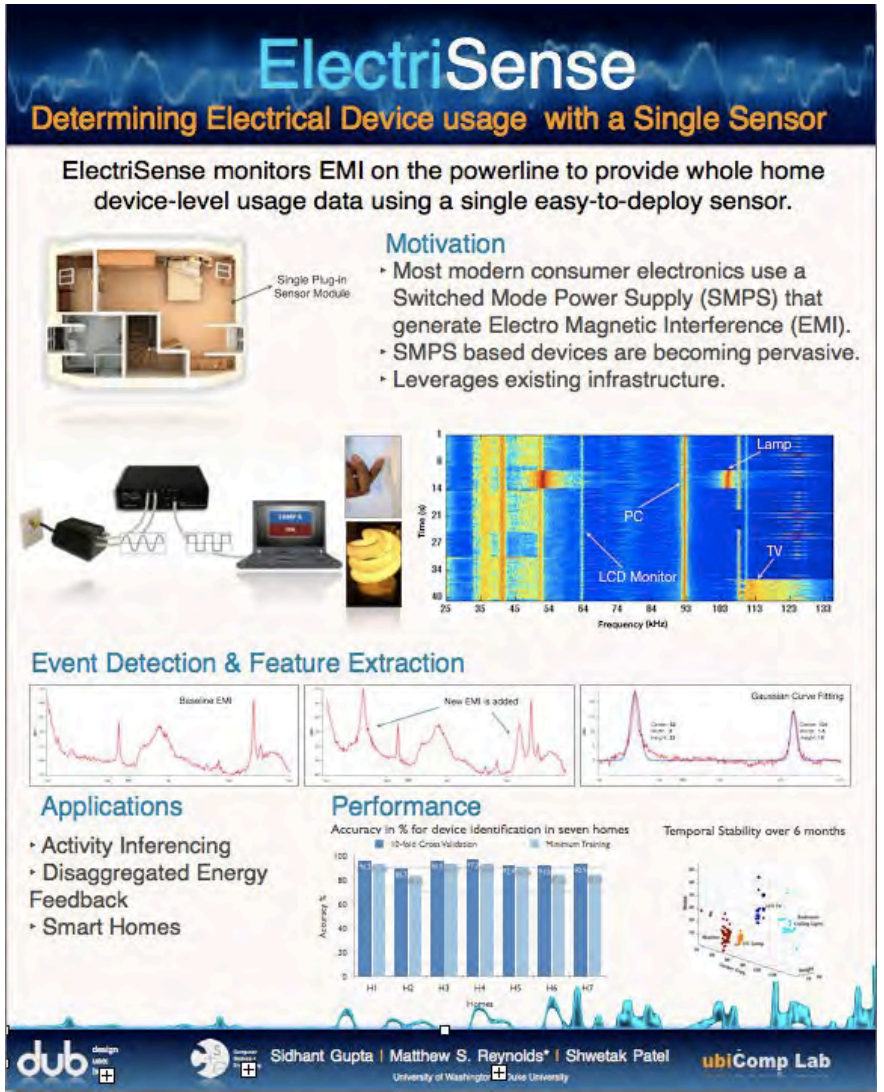
- Smart homes
- Smart cars
- Smart health
- Smart robots
- Smart science (confronting the data deluge)
- Smart crowds and human-computer systems
- Smart interaction (virtual and augmented reality)

Smart homes



Shwetak Patel,
University of Washington
2011 MacArthur Fellow

MACARTHUR
The John D. and Catherine T. MacArthur Foundation



Smart cars

DARPA Grand Challenge

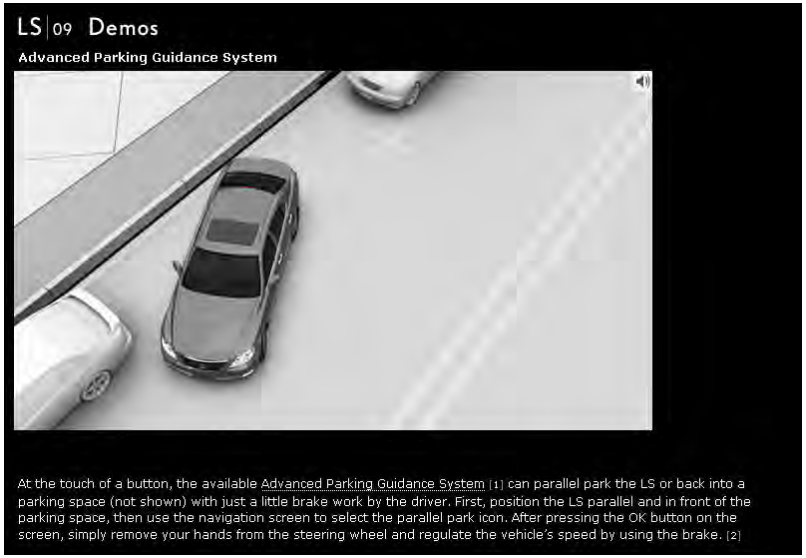
DARPA Urban Challenge

Stay on track.

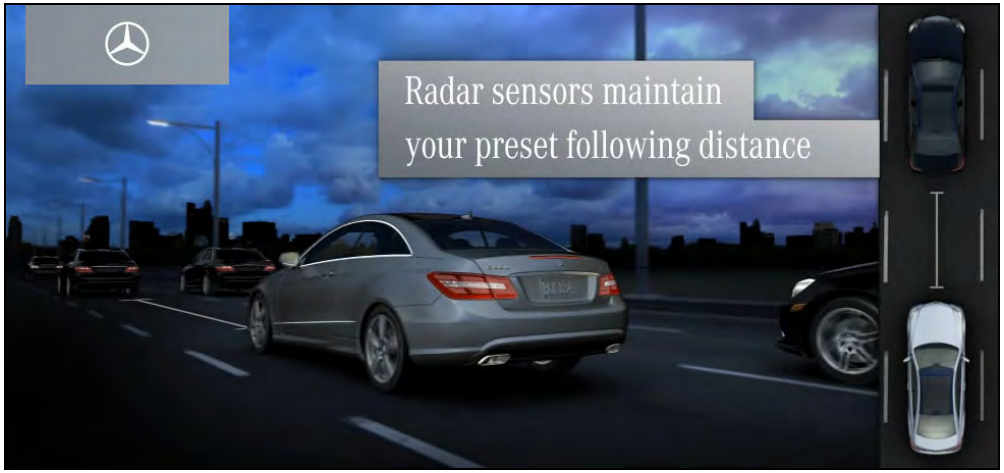
Lane Departure Warning on the BMW 5 Series Sedan.

The optional Lane Departure Warning gently vibrates the steering wheel just before you veer away from your lane - and only then. A camera mounted between the rear-view mirror and the windscreen "sees" the markings on the road ahead. Lane Departure Warning is deactivated when the indicator is used, so that you are not distracted by false signals.

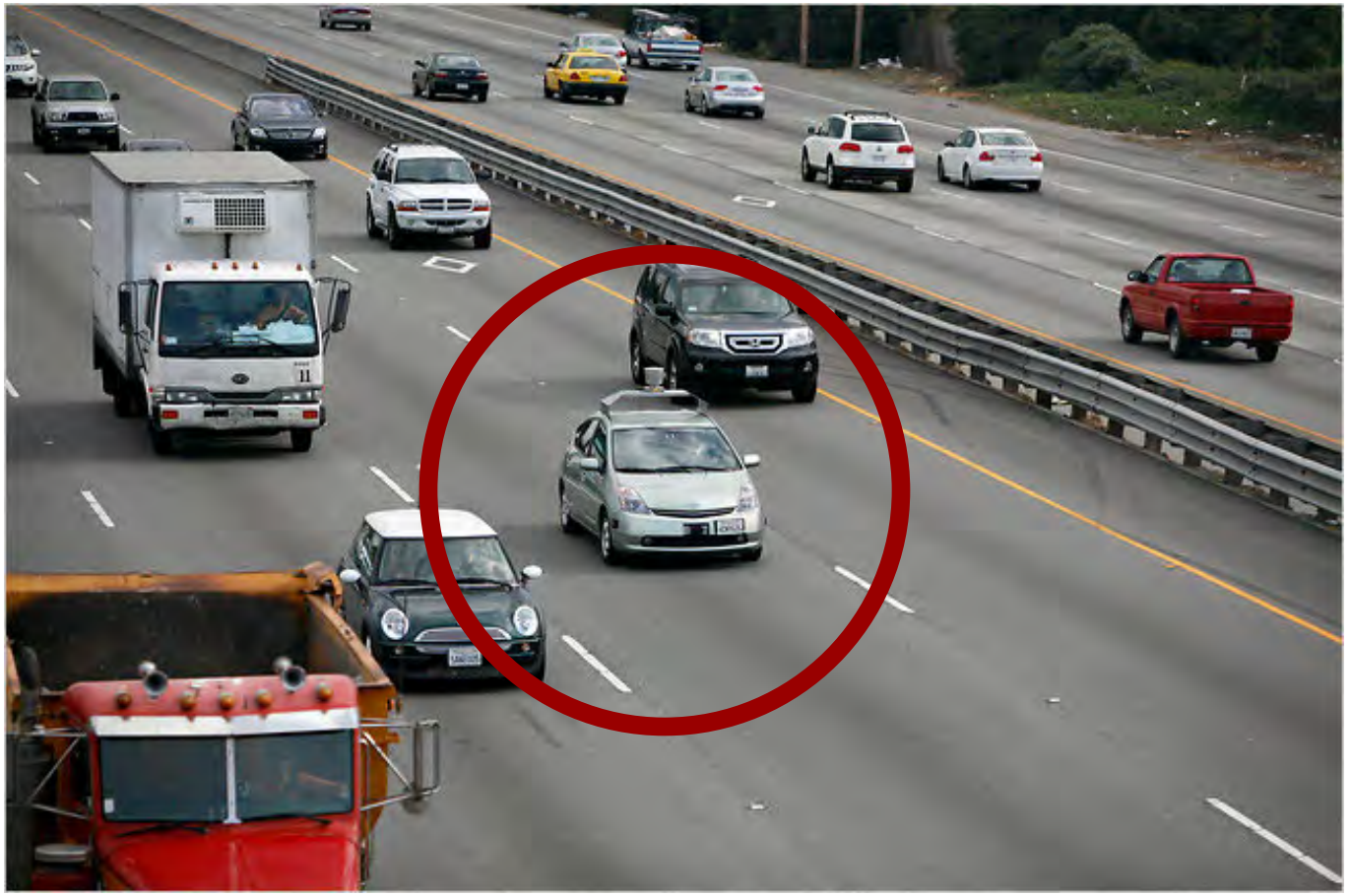
← Lane departure warning



← Self-parking



← Adaptive cruise control



Google autonomous car on US 101 near Mountain View CA

Autonomous Driving

Google's modified Toyota Prius uses an array of sensors to navigate public roads without a human driver. Other components, not shown, include a GPS receiver and an inertial motion sensor.

LIDAR
A rotating sensor on the roof scans more than 200 feet in all directions to generate a precise three-dimensional map of the car's surroundings.

POSITION ESTIMATOR
A sensor mounted on the left rear wheel measures small movements made by the car and helps to accurately locate its position on the map.

VIDEO CAMERA
A camera mounted near the rear-view mirror detects traffic lights and helps the car's onboard computers recognize moving obstacles like pedestrians and bicyclists.

RADAR
Four standard automotive radar sensors, three in front and one in the rear, help determine the positions of distant objects.

Source: Google

THE NEW YORK TIMES; PHOTOGRAPHS BY RAMIN RAHIMIAN FOR THE NEW YORK TIMES

- In 2004, in just the United States:
  - 6,181,000 police-reported traffic accidents
    - 42,636 people killed
    - 2,788,000 people injured
    - 4,281,000 had property damage only
  - ~ $250 billion (that's *one quarter of a trillion dollars* …) in *annual* economic cost
    - 100 times greater than even an extravagant estimate of the nation's annual investment in computing research
  - 

ENDNOTES

1 Availability of E 350 BlueTEC and 4MATIC models is delayed. See dealer for details.

2 DISTRONIC PLUS adaptive cruise control is no substitute for active driving involvement. It does not react to stationary objects, nor recognize or predict the curvature and lane layout of the road or the movement of vehicles ahead. It is the driver's responsibility at all times to be attentive to traffic and road conditions, and to provide the steering, braking and other driving inputs necessary to retain control of the vehicle. Drivers are cautioned not to wait for the DISTRONIC Proximity Warning System before braking, as that may not afford sufficient time and distance to brake safely. After braking the car for stopped traffic ahead, system resumes automatically only if traffic pauses for less than 3 seconds.

3 Driving while drowsy or distracted is dangerous and should be avoided. ATTENTION ASSIST may be insufficient to alert a fatigued or distracted driver of lane drift and cannot be relied on to avoid an accident or serious injury.

4 PRE-SAFE® closes the side windows and sunroof when the system's sensors detect side movement that suggests a possible accident.

But there's more at stake than safety …

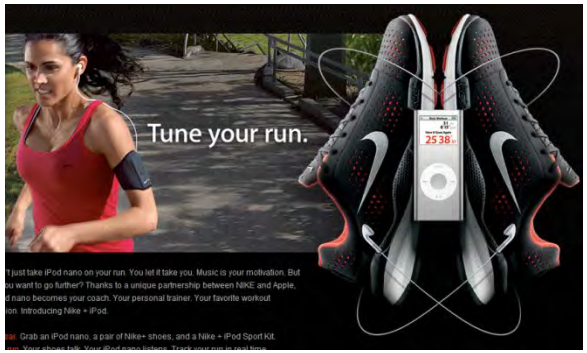
- Energy and the environment
  - Highway transportation uses 22% of all US energy
- Efficiency and productivity
  - Traffic congestion in the US is responsible for 3.6 billion vehicle hours of delay annually
- Equity
  - The elderly, and low-income individuals forced to the exurbs, are disadvantaged
- The economic and environmental costs of manufacturing automobiles

And computing research is central to the solutions

- Real-time sensor information for transit location
- Personalized, real-time information for choosing travel options
- Zipcar on steroids 
- Routing around congestion, for transit and personal vehicles
- Greater vehicle density through semi-automated control

Smart health: Personalized health monitoring

Omron pedometer



Nike + iPod

Bodymedia multi-function

Biozoom: body fat, hydration, blood oxygen, etc.

Glucowatch: measuring body chemistry

Smart health: Evidence-based medicine

- Machine learning for clinical care
- Predictive models
- Cognitive assistance for physicians

Smart health: P4 medicine

INSTITUTE FOR Systems Biology

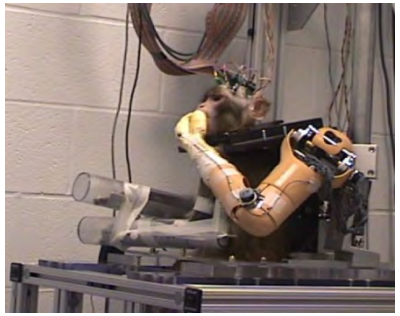
Smart robots

iRobot®

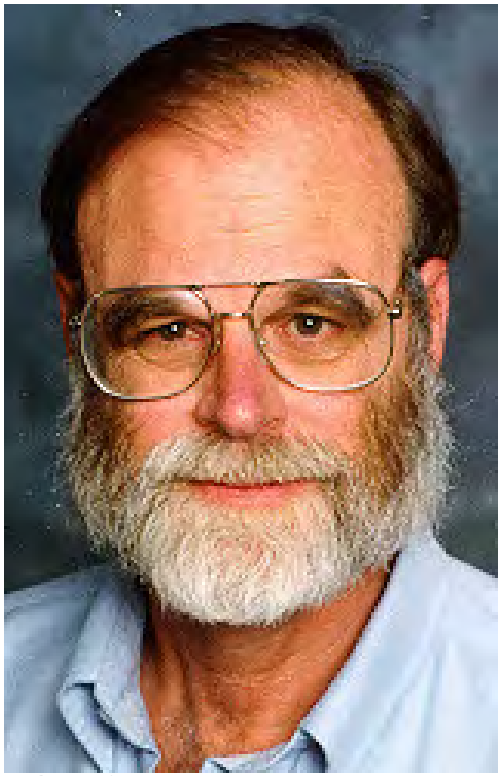
Smart health + smart robots

Yoky Matsuoka
University of Washington
2007 MacArthur Fellow

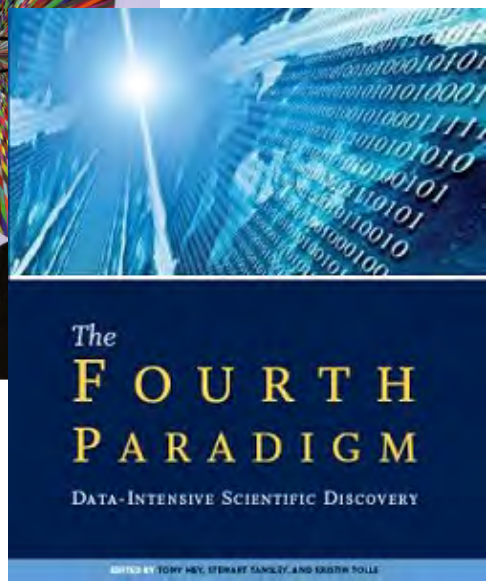
MACARTHUR
The John D. and Catherine T. MacArthur Foundation



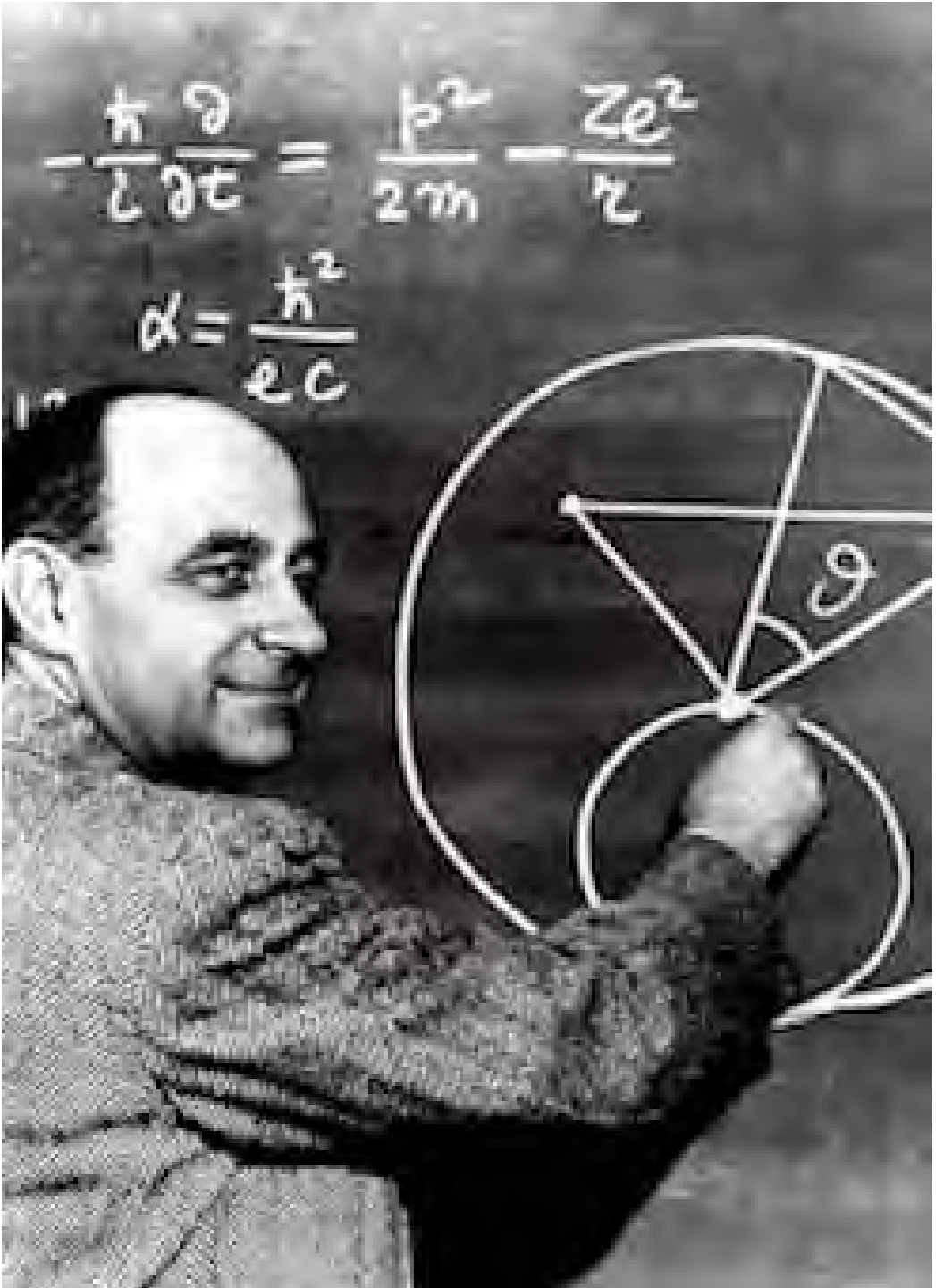
Smart science: eScience (data-intensive science and engineering)



Jim Gray,
Microsoft Research



Transforming science (again!)



Theory

Experiment

Observation

Theory

Experiment

Observation

Credit: John Delaney, University of Washington

Theory

Experiment

Observation

Computational Science

SLOAN DIGITAL SKY SURVEY

Theory

Experiment

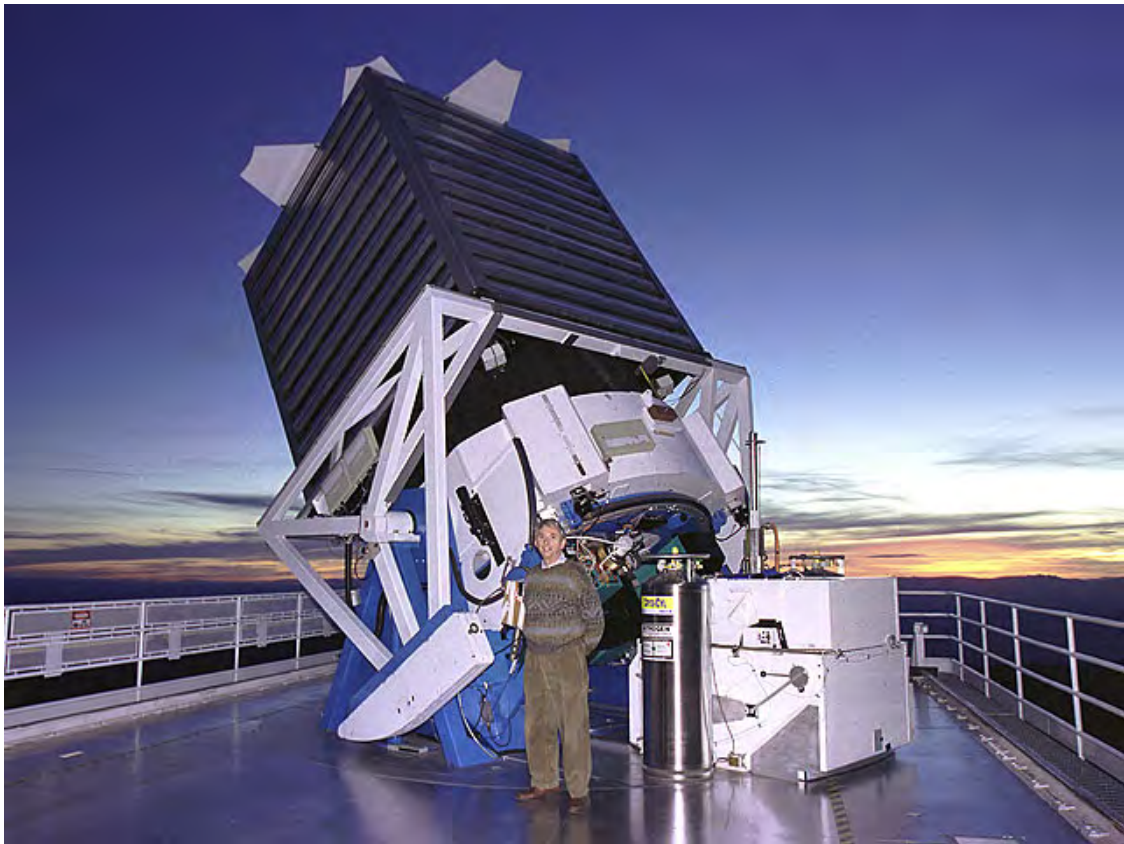
Observation

Computational Science

eScience

eScience is driven by *data* more than by cycles

- Massive volumes of data from sensors and networks of sensors



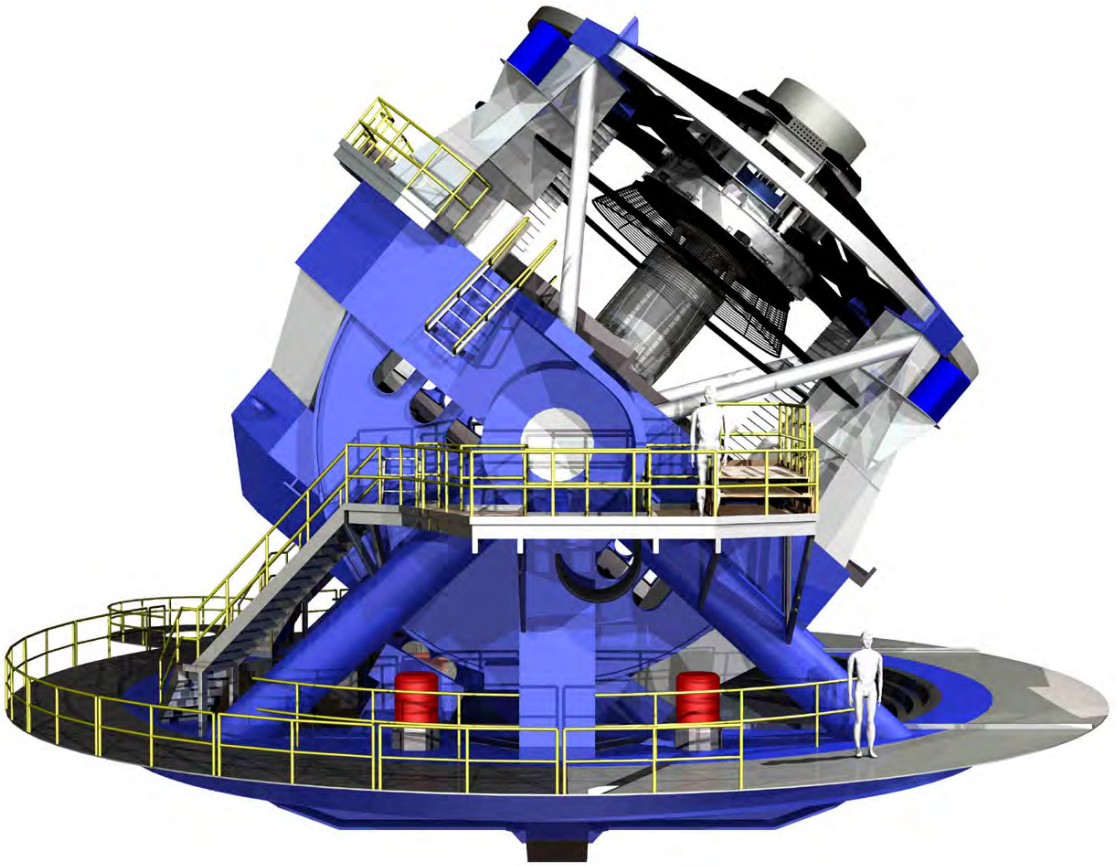
Apache Point telescope, SDSS

80TB of raw image data (80,000,000,000,000 bytes) over a 7 year period

Large Synoptic Survey Telescope (LSST)

40TB/day (an SDSS every two days), 100+PB in its 10-year lifetime

400mbps sustained data rate between Chile and NCSA



Large Hadron Collider

700MB of data per second, 60TB/day, 20PB/year

Illumina HiSeq 2000 Sequencer

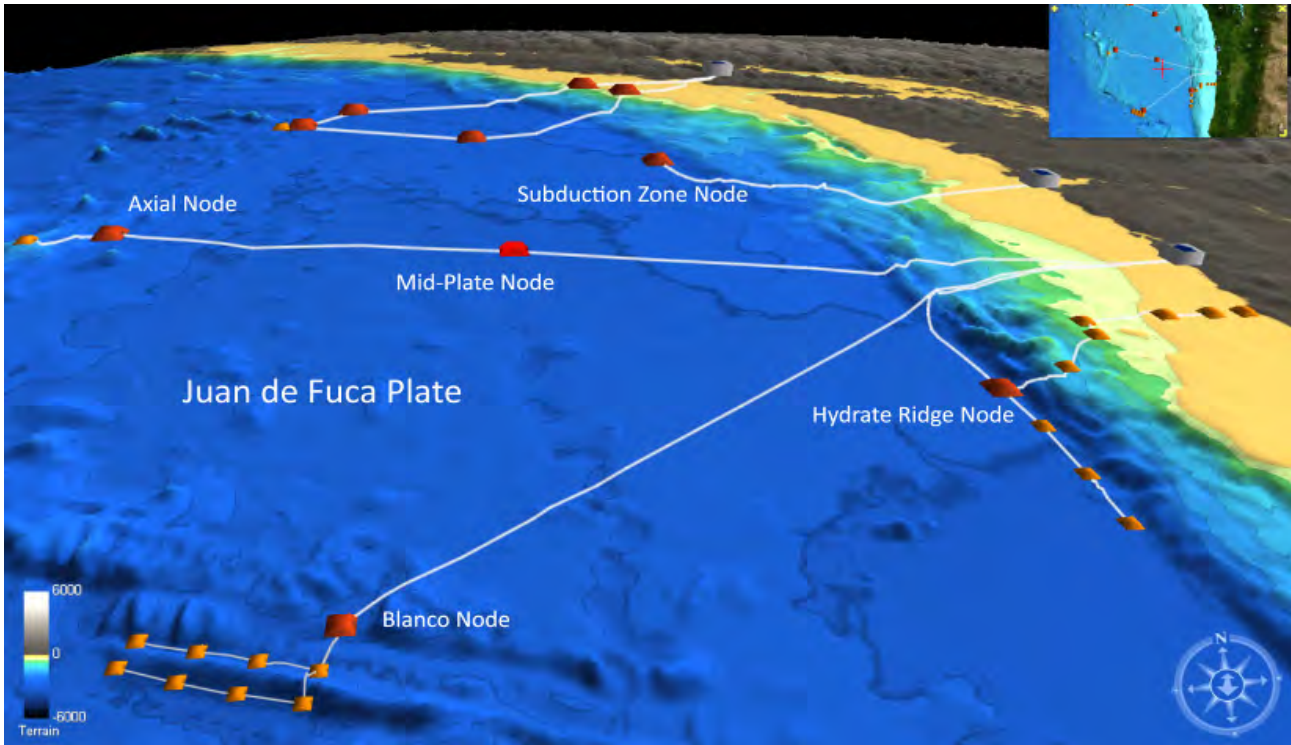
~1TB/day

Major labs have 25-100 of these machines

OCEAN OBSERVATORIES INITIATIVE

Regional Scale Nodes of the NSF Ocean Observatories Initiative

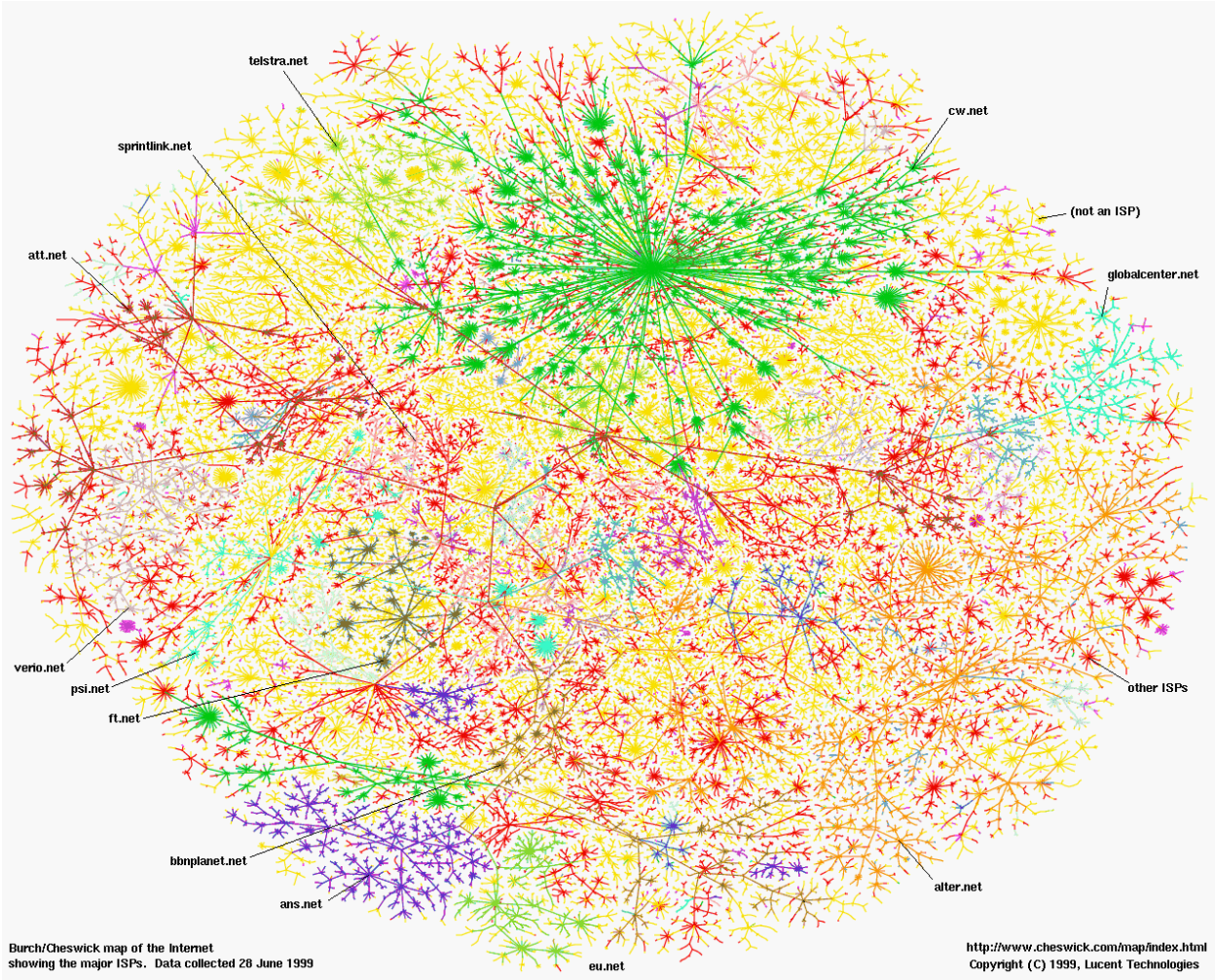
1000 km of fiber optic cable on the seafloor, connecting thousands of chemical, physical, and biological sensors



The Web

20+ billion web pages x 20KB = 400+TB

One computer can read 30-35 MB/sec from disk => 4 months just to read the web



Point-of-sale terminals

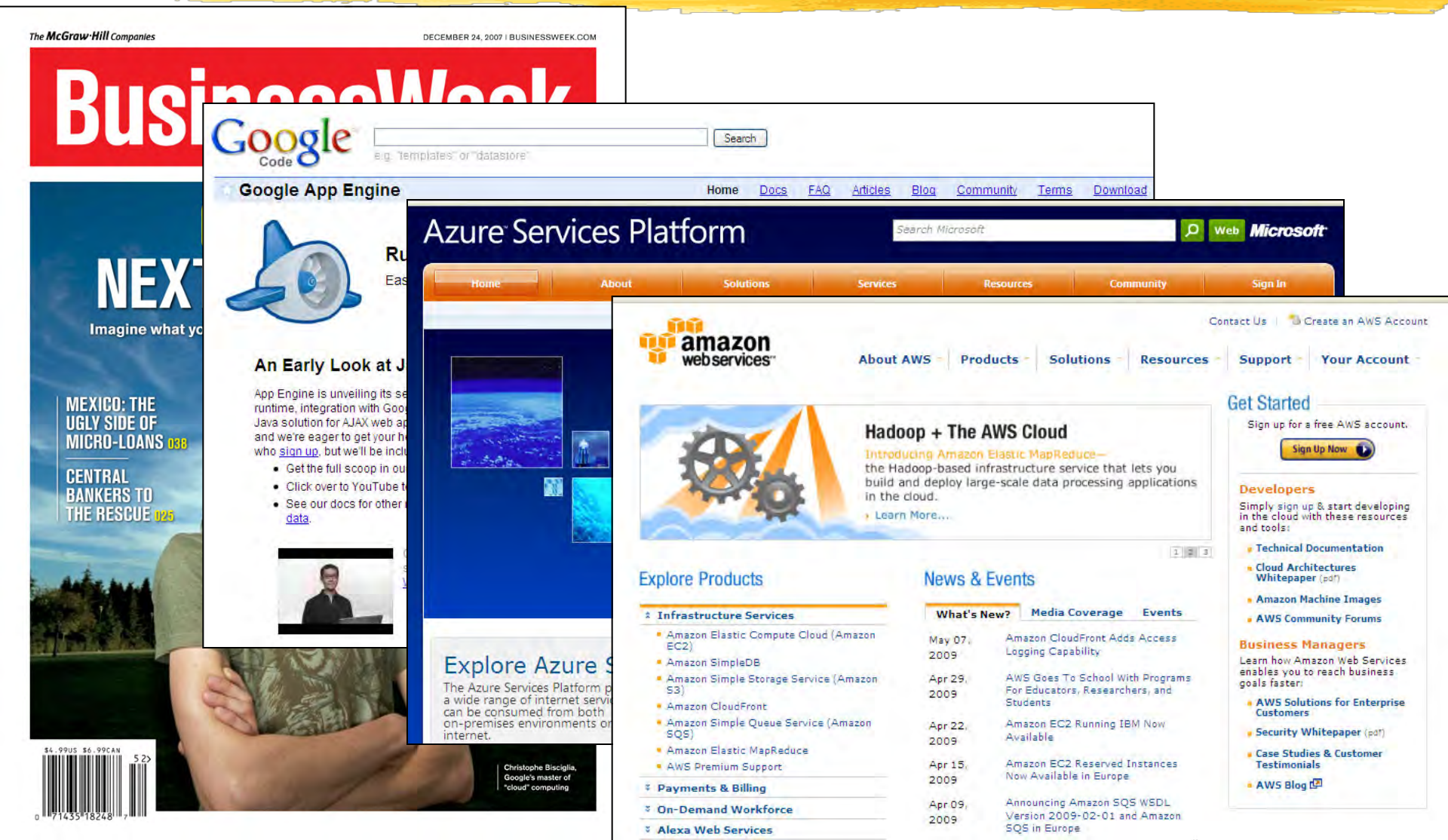
eScience is about the *analysis* of data

- The automated or semi-automated extraction of knowledge from massive volumes of data
  - There's simply too much of it to look at
- It's not just a matter of volume
  - Volume
  - Rate
  - Complexity / dimensionality

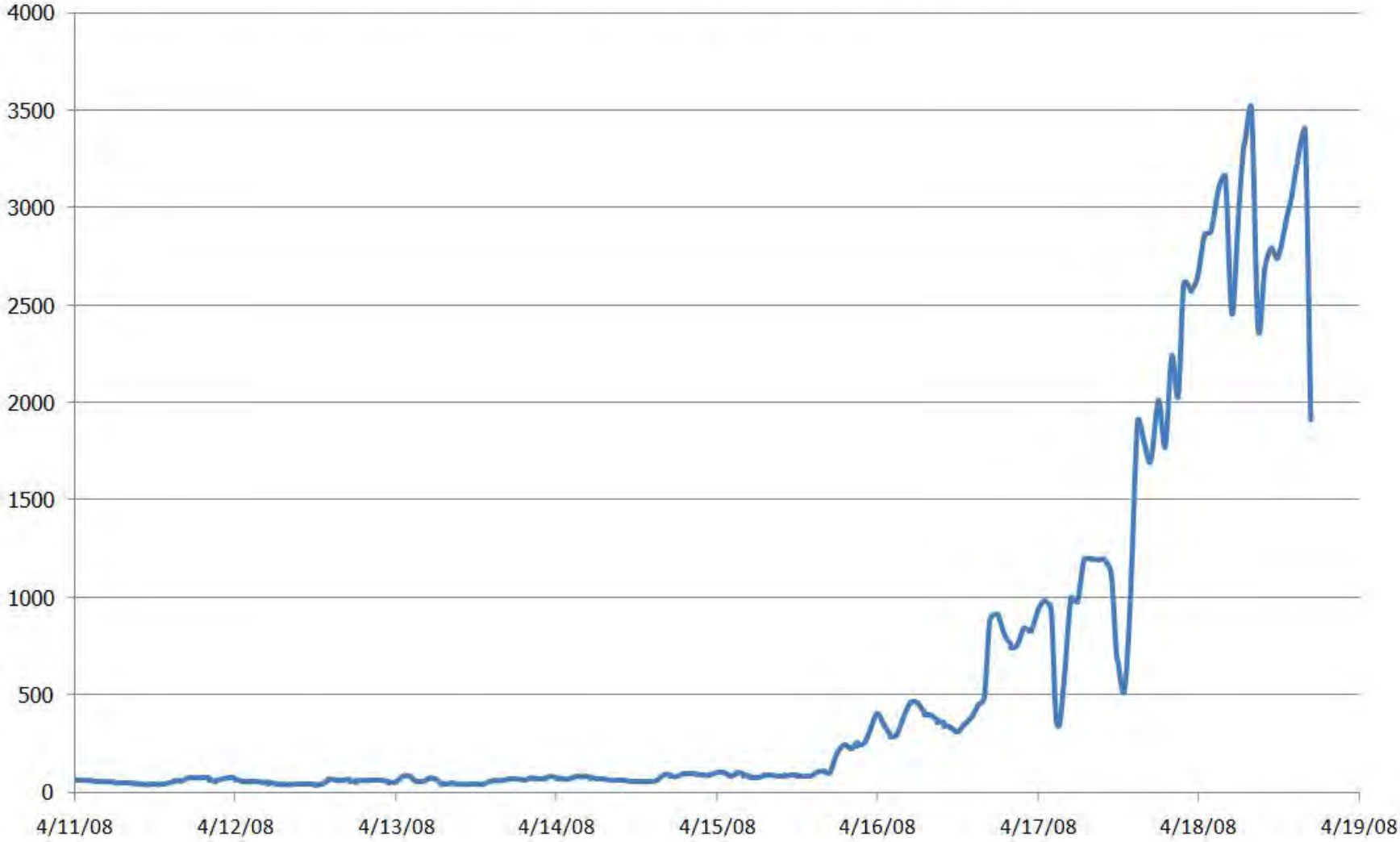
eScience utilizes a spectrum of computer science techniques and technologies

- Sensors and sensor networks
- Backbone networks
- Databases
- Data mining
- Machine learning
- Data visualization
- Cluster computing at enormous scale

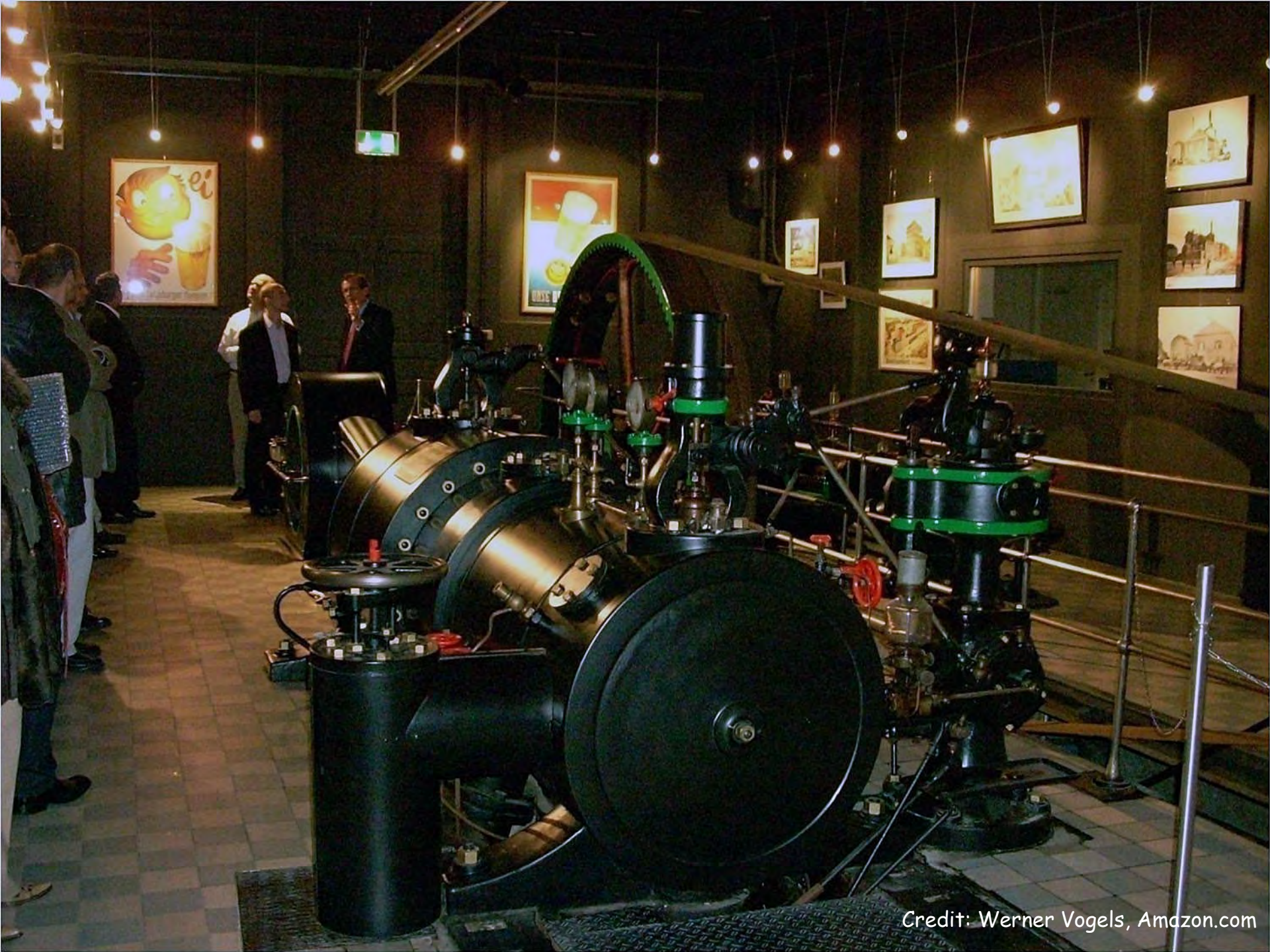
eScience is married to the cloud: Scalable computing and storage for everyone



Animoto: EC2 Instance Usage



Credit: Werner Vogels, Amazon.com

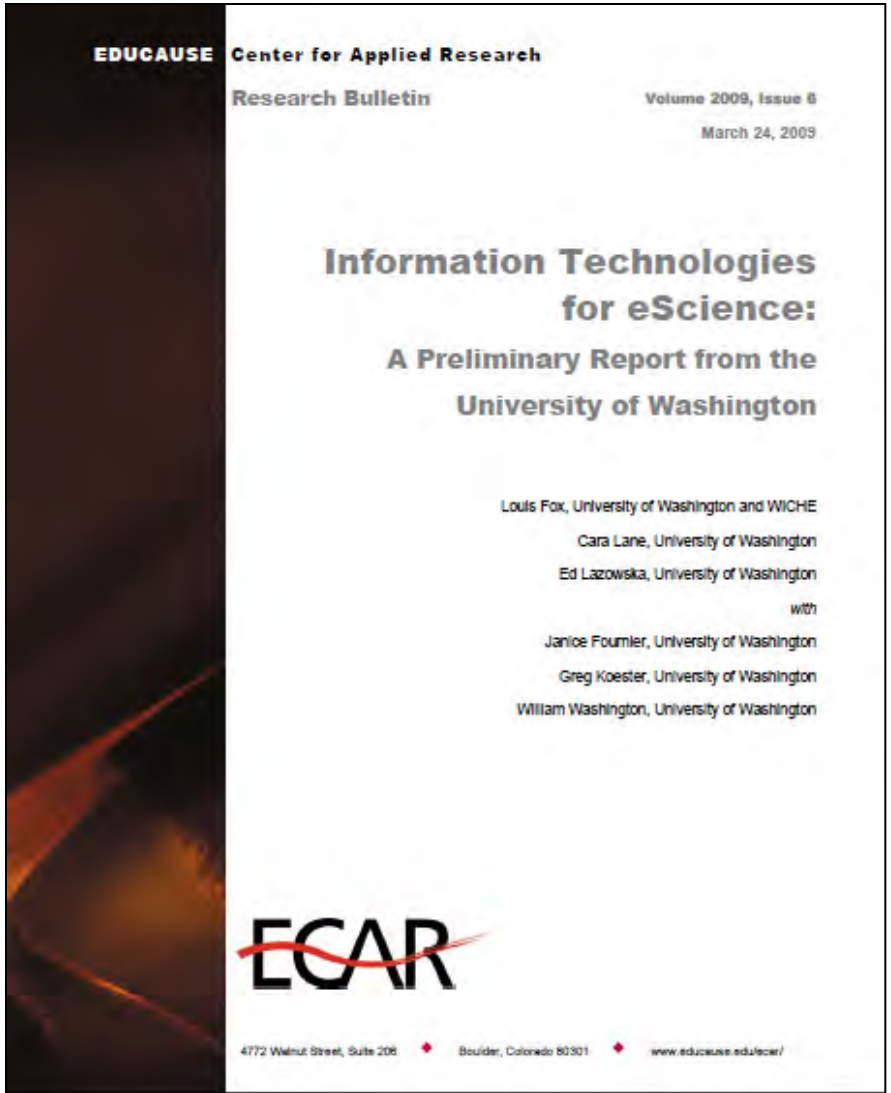


Credit: Werner Vogels, Amazon.com

eScience will be pervasive

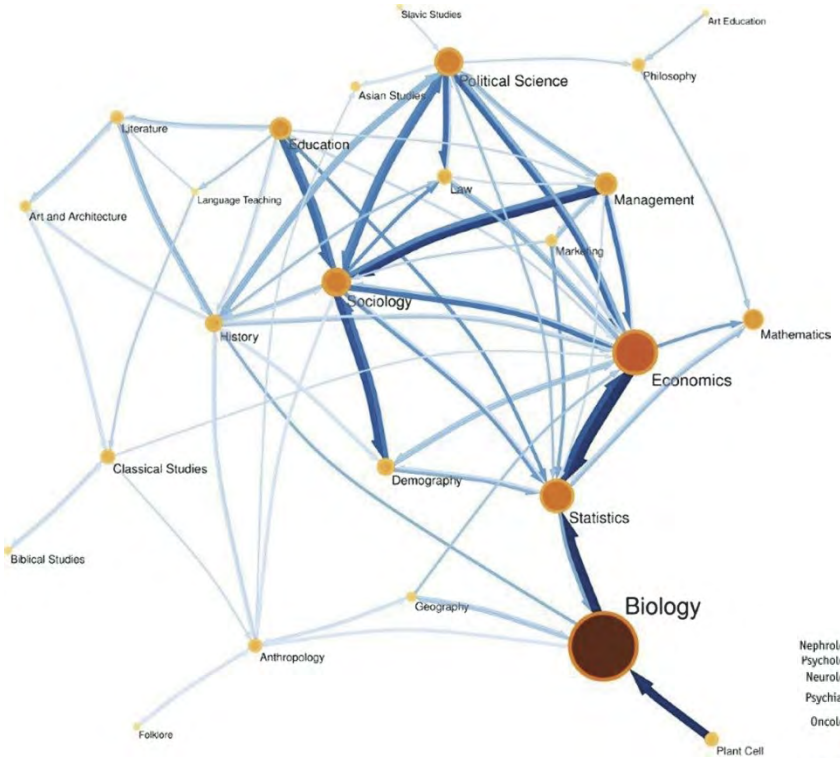
- Simulation-oriented computational science has been transformational, but it has been a niche
  - As an institution (e.g., a university), you didn't need to excel in order to be competitive
- eScience capabilities must be broadly available in any institution
  - If not, the institution will simply cease to be competitive

Top scientists across all fields grasp the implications of the looming data tsunami



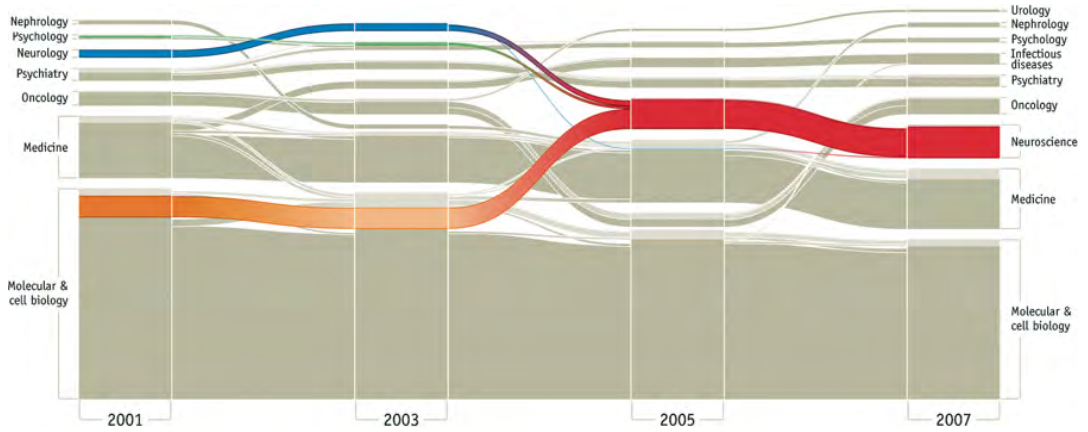
- Survey of 125 top investigators
  - "Data, data, data"
- Flat files and Excel are the most common data management tools
  - Great for Microsoft … lousy for science!
- Typical science workflow:
  - 2 years ago: 1/2 day/week
  - Now: 1 FTE
  - In 2 years: 10 FTE
- Need tools, tools, tools!

And "Big Data" is about far more than scientific discovery, of course



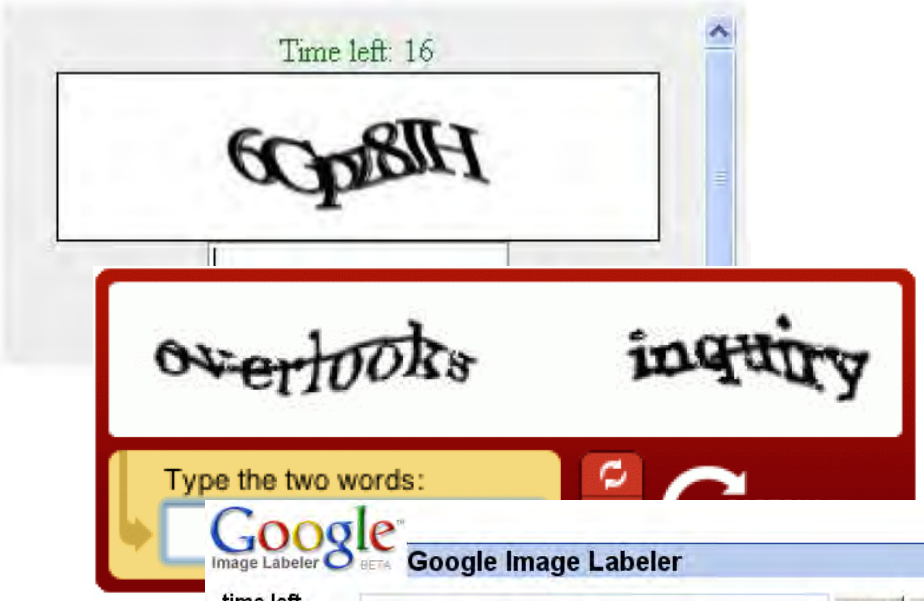
eigenFACTOR.org
RANKING AND MAPPING SCIENTIFIC KNOWLEDGE

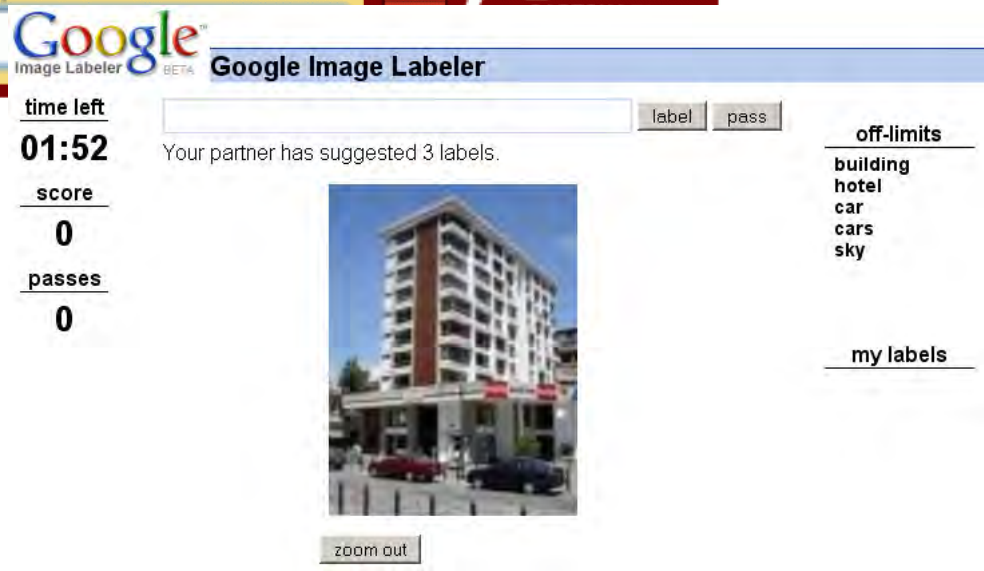
Carl Bergstrom, Jevin West, and Martin Rosvall,
University of Washington Biology



Smart crowds and human-computer systems

Luis von Ahn, CMU

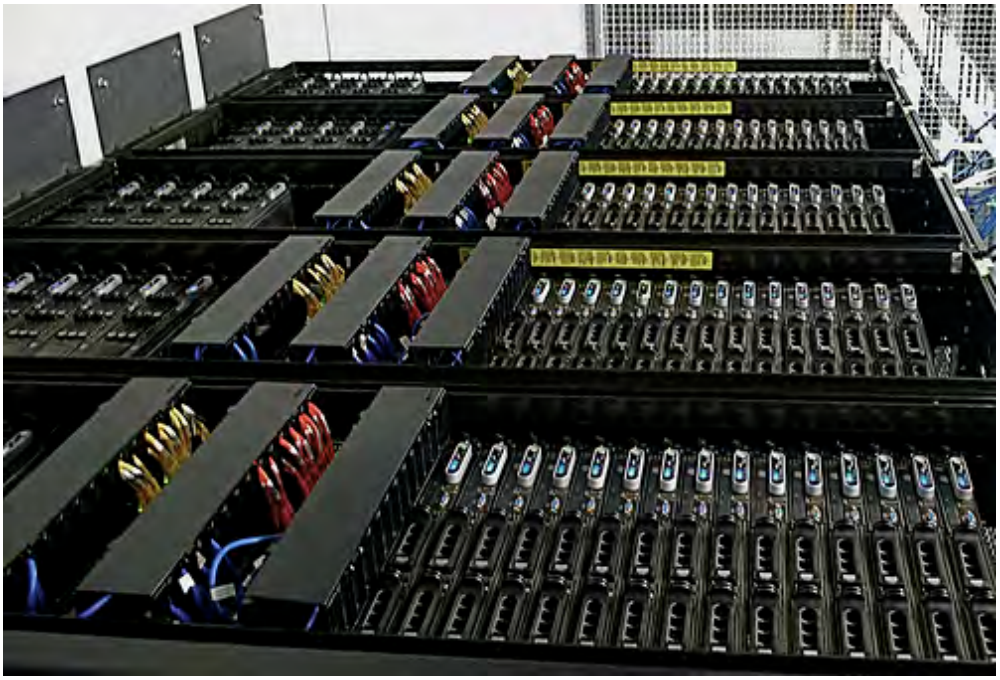




Hours per year, world-wide, spent playing computer solitaire: 9 billion

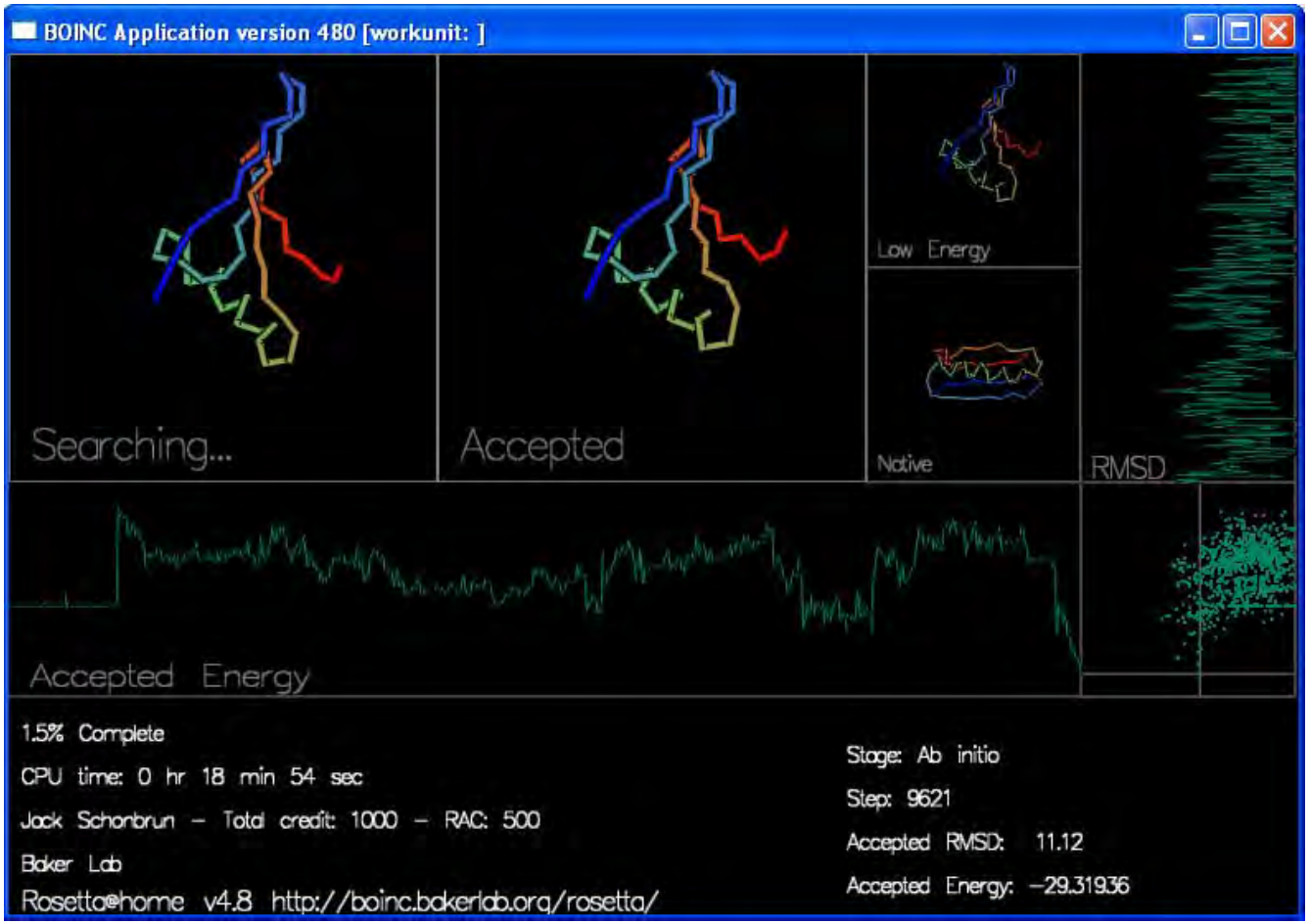
Hours spent building the Panama Canal: 20 million (less than a day of solitaire)

David Baker,
University of Washington



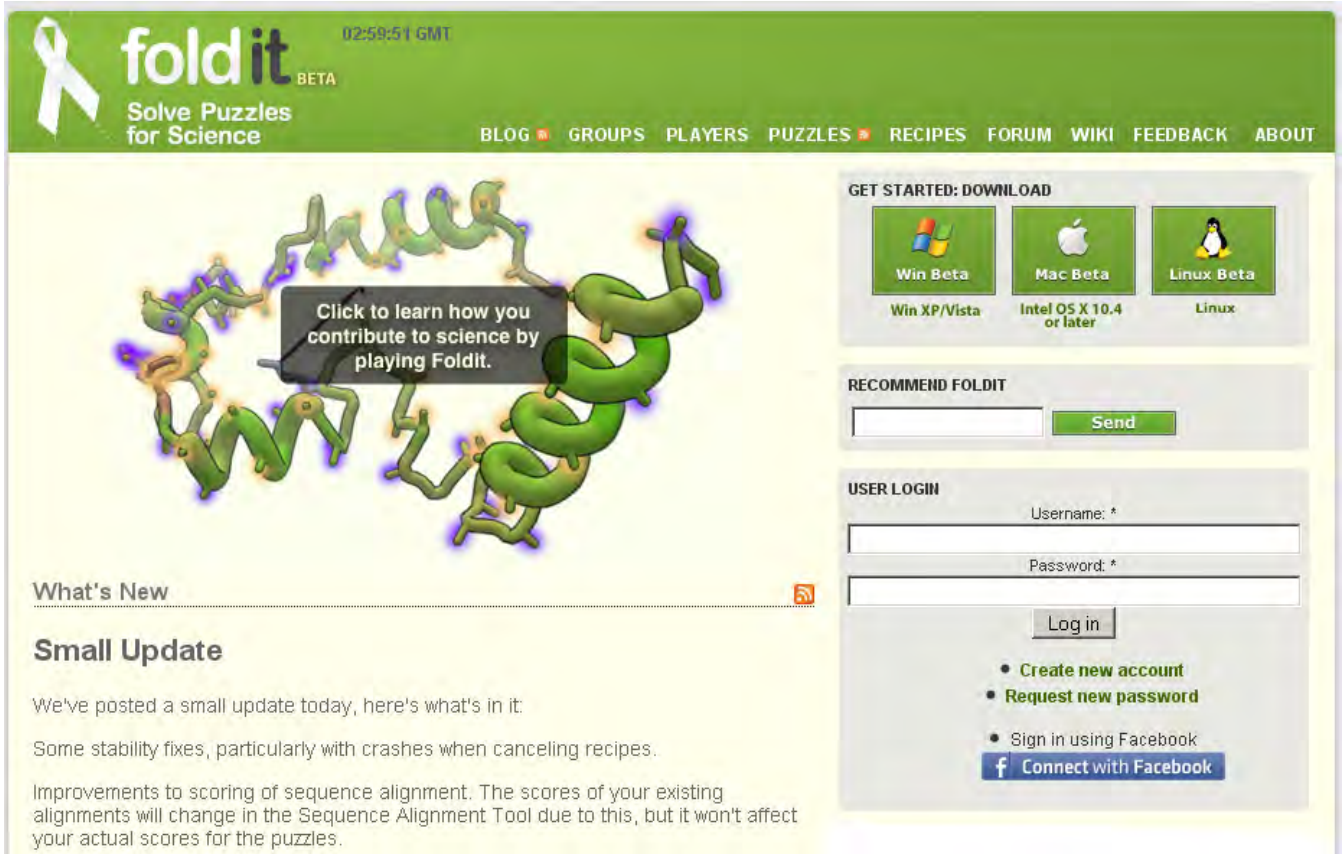
Rosetta@home

Protein Folding, Design, and Docking



Zoran Popovic,
University of Washington

Center for Game Science



fold it BETA

20:46:49 GMT

Solve Puzzles for Science

BLOG GROUPS PLAYERS PUZZLE

BootsMcGraw

Global Soloist Rank: #6

Global Soloist Score: 3784

Cases

Profile

Name: BootsMcGraw

Location: Dallas, Texas USA

Started Folding: 12/06/08

About me: An educated redneck here, from Dallas, Texas.

When I was in grad school in 1985 at the State University of New York at Buffalo, my master's thesis was to construct and present a computer program that predicted the secondary structures (helix, sheet, loop) of proteins based on their amino acid sequences. Tertiary structure (i.e. folding) prediction was a pie-in-the-sky fantasy.

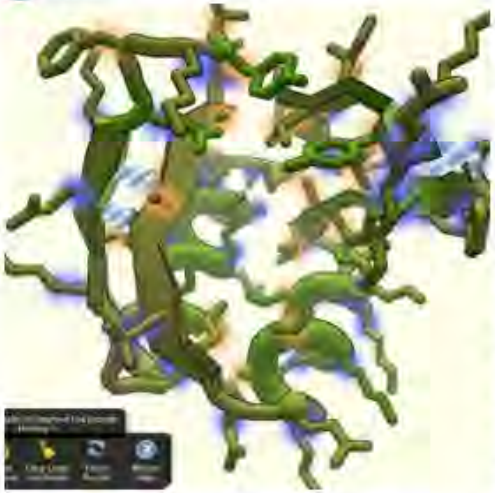
Imagine my delight, a quarter century later, to find out that not only are people determining tertiary structures of proteins, but they've made a *game* of it.

Hobbies: Licensed Massage Therapist; also a photographer, videographer, and webmaster. I have studied health and nutrition for over twenty years. Ask me my opinions about the subject.

Group: Contenders

Gamers Unlock Protein Mystery That Baffled AIDS Researchers For Years

By Leslie Horn | September 19, 2011 10:42am EST | 51 Comments | Email | Print



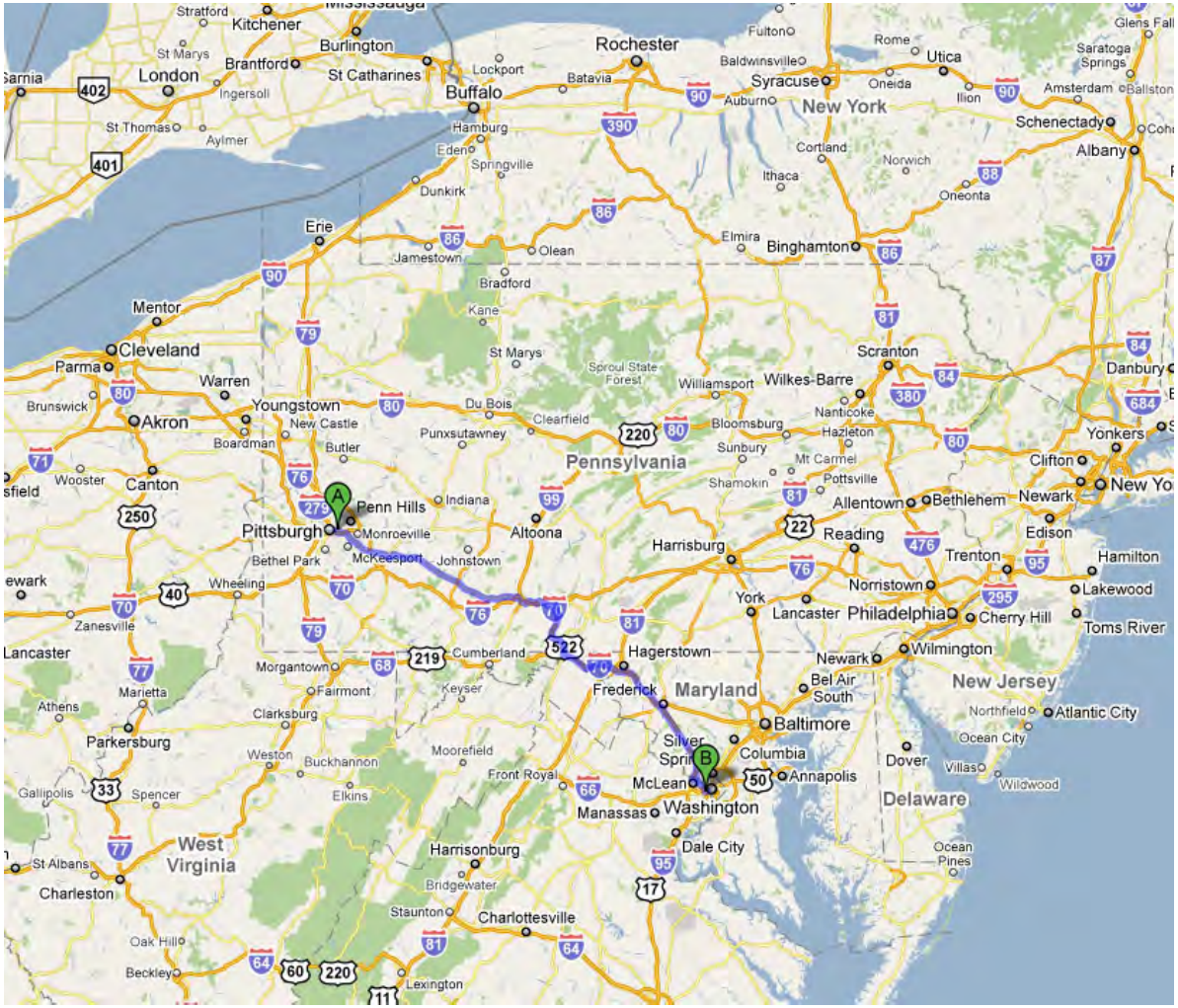
In just three weeks, gamers deciphered the structure of a key protein in the development of AIDS that has stumped scientists for years. According to a study published Sunday in the journal *Nature Structural & Molecular Biology*, the findings could present a significant breakthrough for AIDS and HIV research.

Using an online game called Foldit, players were able to predict the structure of a protein called retroviral protease, an enzyme that plays a critical role in the way HIV multiplies. Unlocking the build of the protein could theoretically aid scientists in developing drugs that would stop protease from spreading.

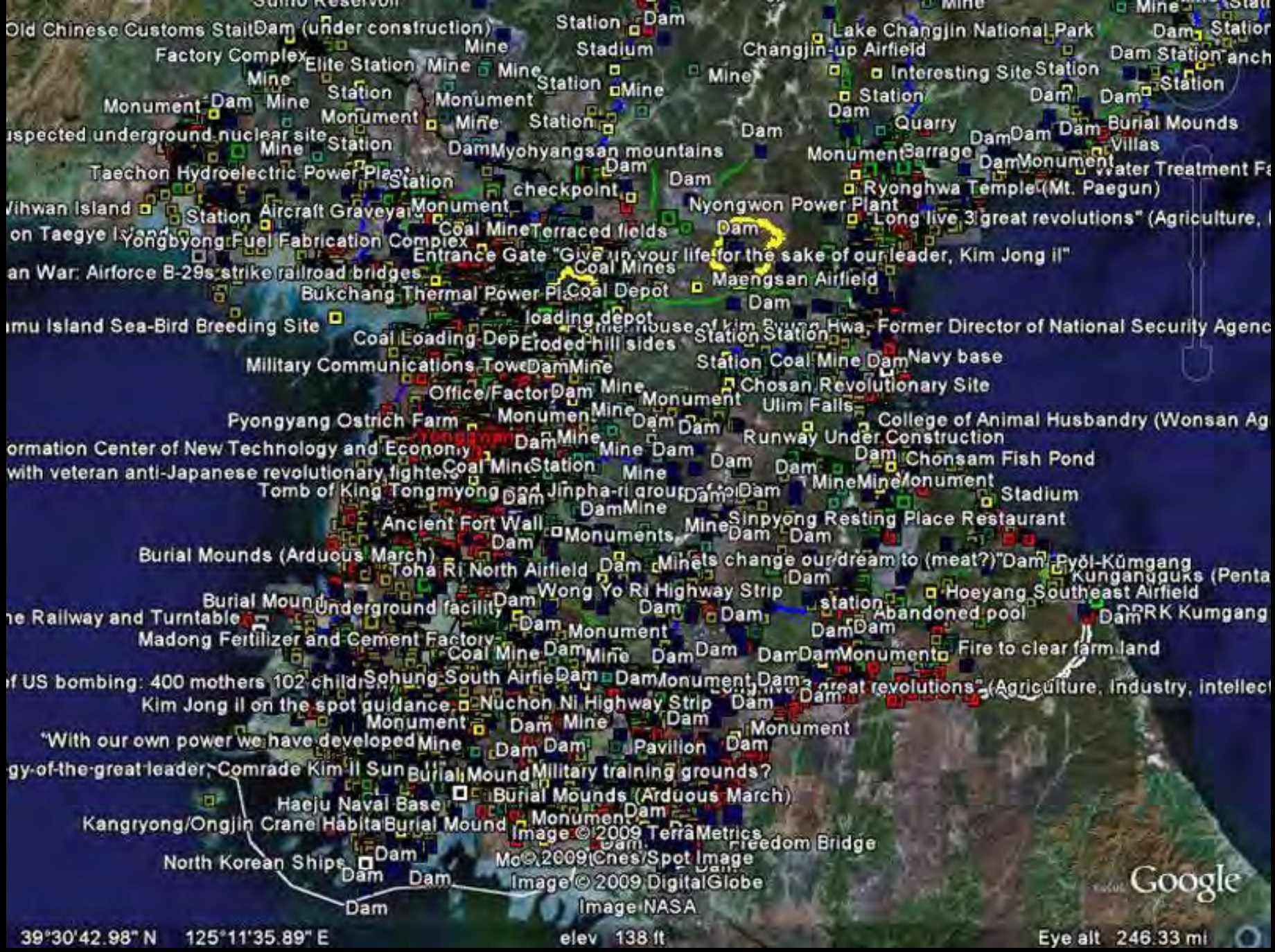
"Following the failure of a wide range of attempts to solve the crystal structure of M-PMV retroviral protease by molecular replacement, we challenged players of the protein folding game Foldit to produce accurate models of the protein," the study reads. "Remarkably, Foldit players were able to generate models of sufficient quality for successful molecular replacement and subsequent structure determination. The refined structure provides new insights for the design of antiretroviral drugs."

Regina Dugan

Peter Lee



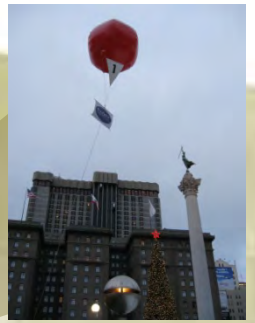
Credit: Peter Lee, DARPA



Credit: Peter Lee, DARPA

DARPA NETWORK CHALLENGE

40th Anniversary of the Internet



29 Oct – Announced
5 Dec – Balloons Up

$40k Prize

Waterfront Park
Portland, OR

Union Square
San Francisco, CA

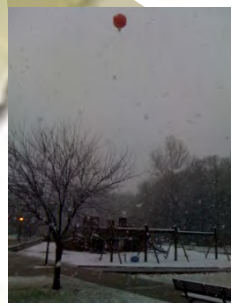
Chase Palm Park
Santa Barbara, CA

Chaparral Park
Scottsdale, AZ

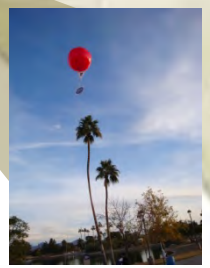
Glasgow Park
Christiana, DE

Tonsler Park
Charlottesville, VA

Lee Park
Memphis, TN



Centennial Park
Atlanta, GA



Katy Park
Katy, TX

Collins Avenue
Miami, FL

4367 registrants
39 countries
922 submissions
370 correct locations

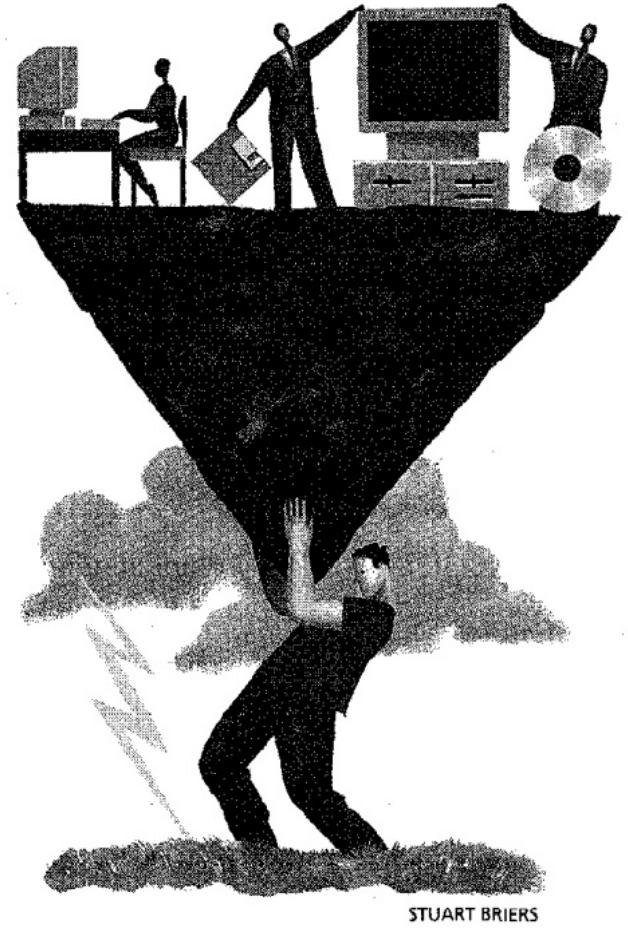
Credit: Peter Lee, DARPA

Smart interaction

KINECT™
for XBOX 360

- Speech recognition (MSR Redmond)
  - No push-to-talk
  - 4-meter distance, no headset
  - 80db ambient noise
  - Microphone array costs 30 cents
- Identity recognition (MSR Asia)
  - VGA camera
  - 4-meter distance
  - Varying ambient light
  - Sibling differentiation
- Tracking (MSR Cambridge)
  - Real-time
  - 100% on – deal with compounding errors
  - All body types, all numbers of bodies
  - People are jumping like monkeys
- System performance (MSR Silicon Valley)
  - Machine learning training utilized massive parallelism
  - Xbox GPU implementation of key functions yielded several-thousand-fold performance gains

Exhortation #1: Embrace applications as part of our field!



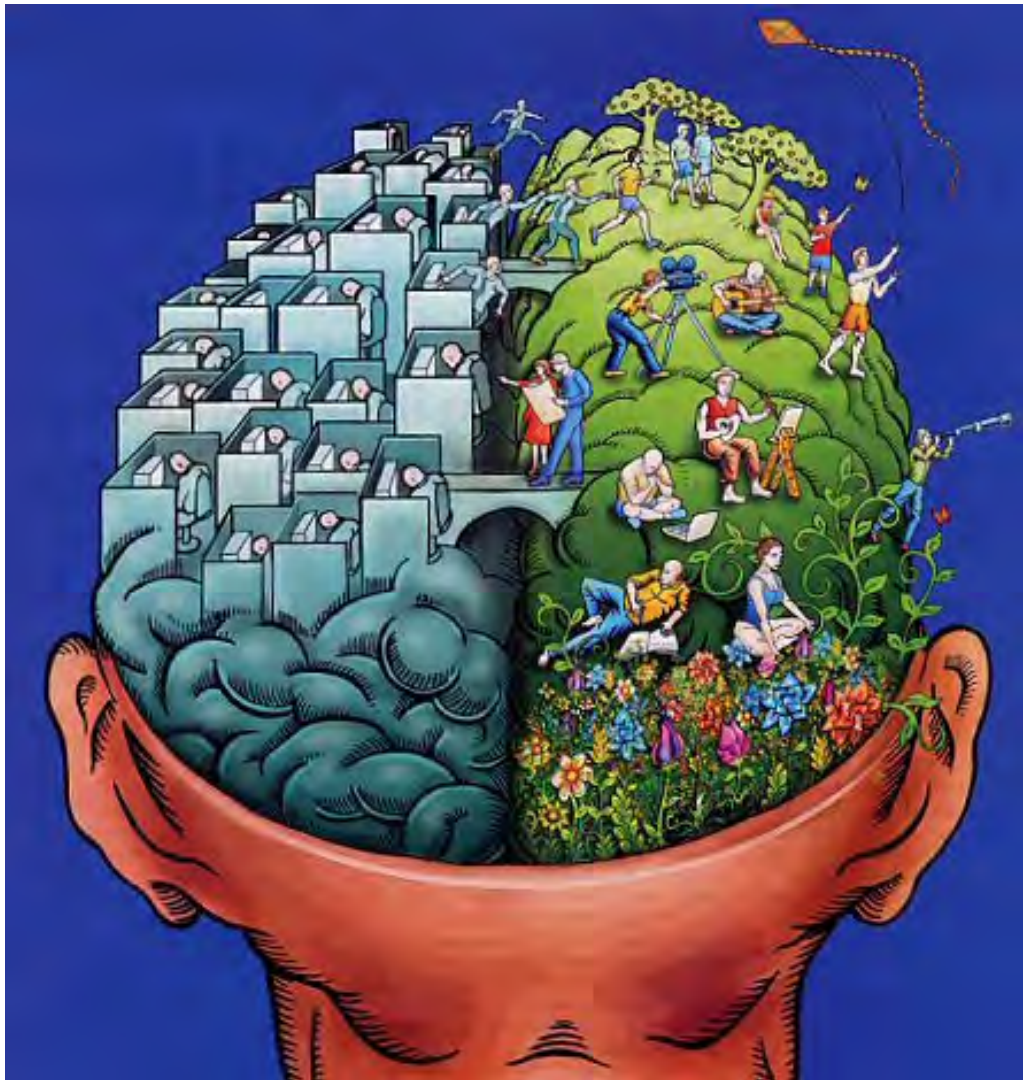
STUART BRIERS

"The last electrical engineer"

If current trends endure, future computers will consist of a single chip. No one will have the foggiest idea what is on it. Somewhere in the basement of Intel or its successor will be a huge computer file with the chip's listing. The last electrical engineer will sit nearby, handcuffed to the disk drive in a scene out of *Ben Hur*. That engineer will be extremely well paid, and his or her every demand will be immediately satisfied. That engineer will be the last keeper of the secret of the universe: E = IR.

ROBERT W. LUCKY
Rlucky@bellcore.com

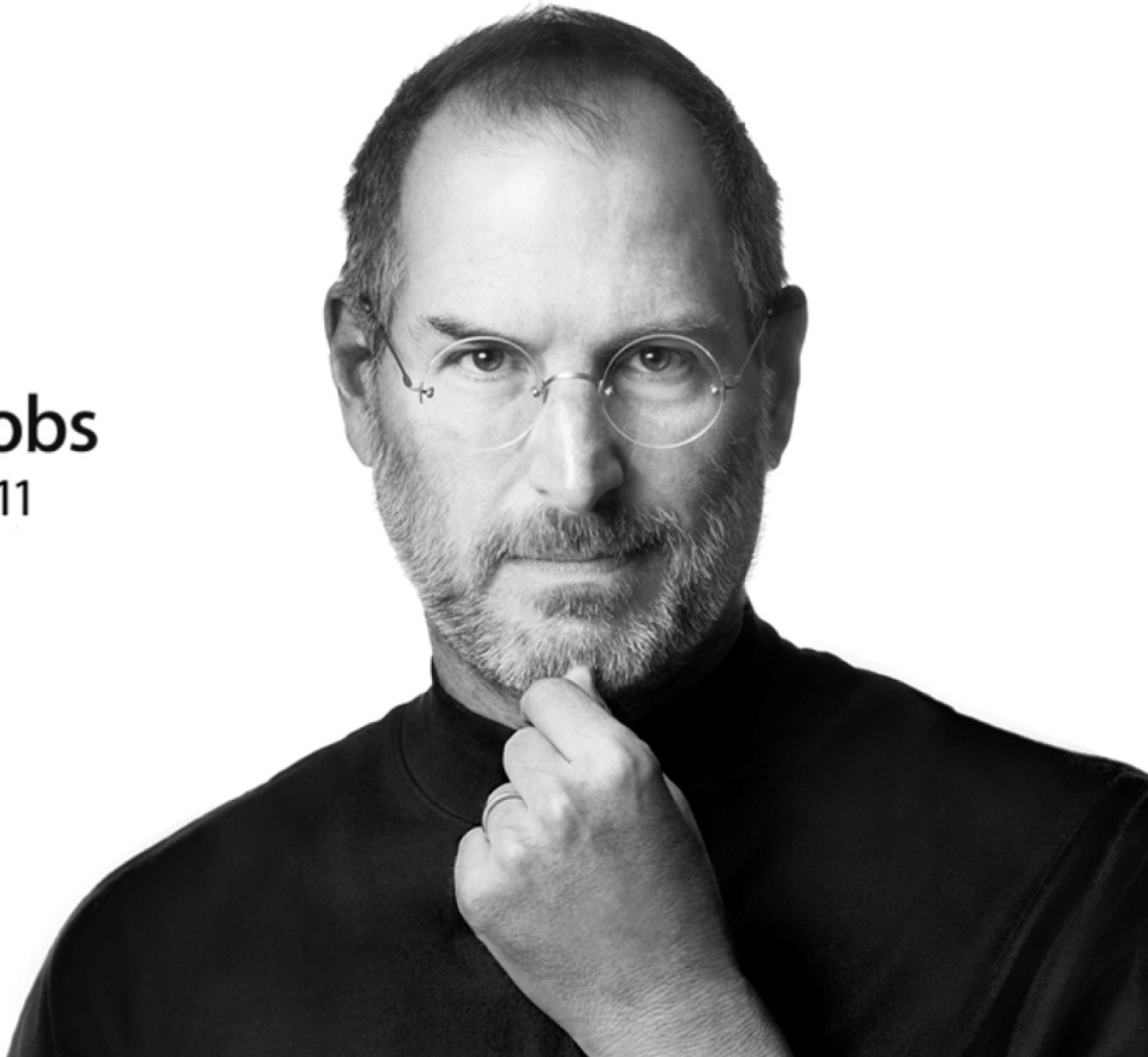
Exhortation #2: Use both sides of your brain!



Credit: Julio Ottino, Northwestern

Steve Jobs

1955-2011

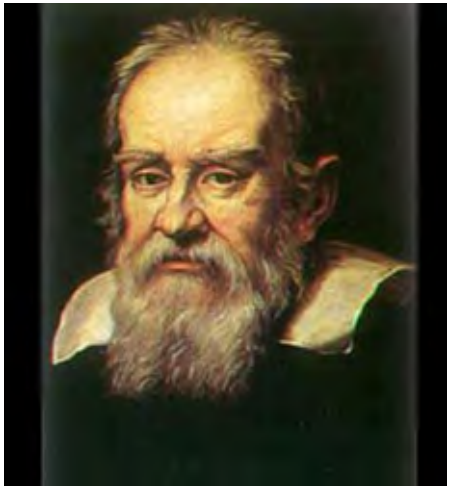


NEWS

Last American Who Knew What The Fuck He Was Doing Dies

OCTOBER 6, 2011 | ISSUE 47•40

Harriot



Galileo

Credit: Julio Ottino, Northwestern

Exhortation #3: Be a Mythbuster!

VIEWER Q&A >>

Get the truth on how the team really feels about the show.

MUSIC MYTHS >>

Can that high note really shatter glass? Bust it now.

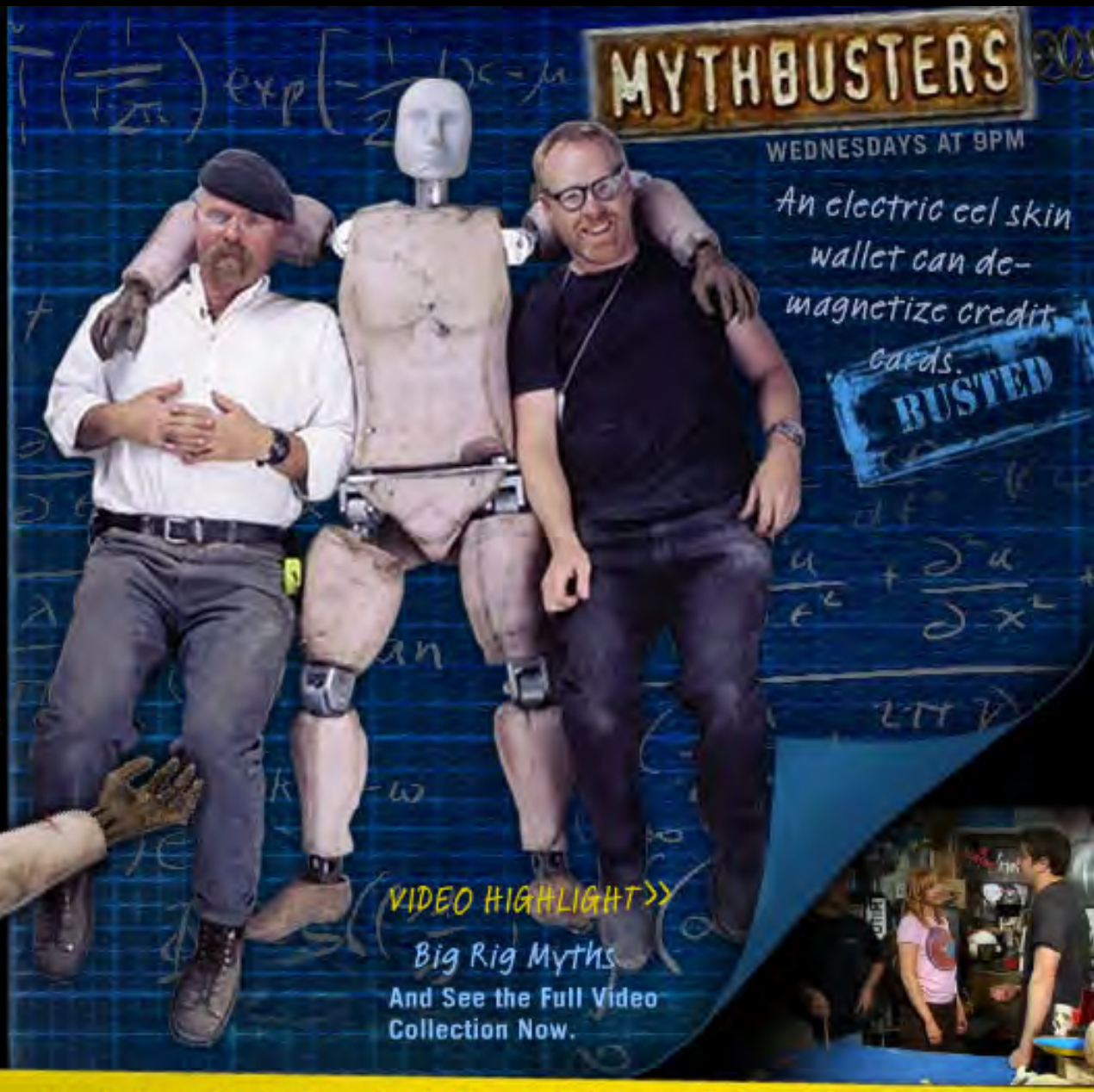
JOIN THE MESSAGE BOARD

"Baby snakes do not have control of how much venom they use and will shoot it all into you while a full grown snake conserves their venom. Is this true?" -- jeredweaver56

SUBMIT A MYTH >>

BE A MYTHBUSTER >>

Debunk a few classic myths. Give this interactive a whirl.



How's Your Brain Function? Watch Video and Take a Memory Exam.

Dispel these myths!

- You need to have programmed in high school to pursue computer science in college
- A computer science degree leads only to a career as a programmer
- Programming is a solitary activity
- Employment continues to be in a trough
- Eventually, all the programming jobs will be overseas
- Student interest in computer science continues to be in a trough, and is lower than in most other STEM fields
- Computer science lacks opportunities for making a positive impact on society
- There's nothing intellectually challenging in computer science
- There have been no recent breakthroughs in computer science
- Computer science lacks compelling research visions

Is this a great time, or what?!?!

http://lazowska.cs.washington.edu/waterloo.pdf
http://www.cra.org/ccc/
http://www.cs.washington.edu/WhyCSE/