Computer Science: Past, Present, and Future

Ed Lazowska

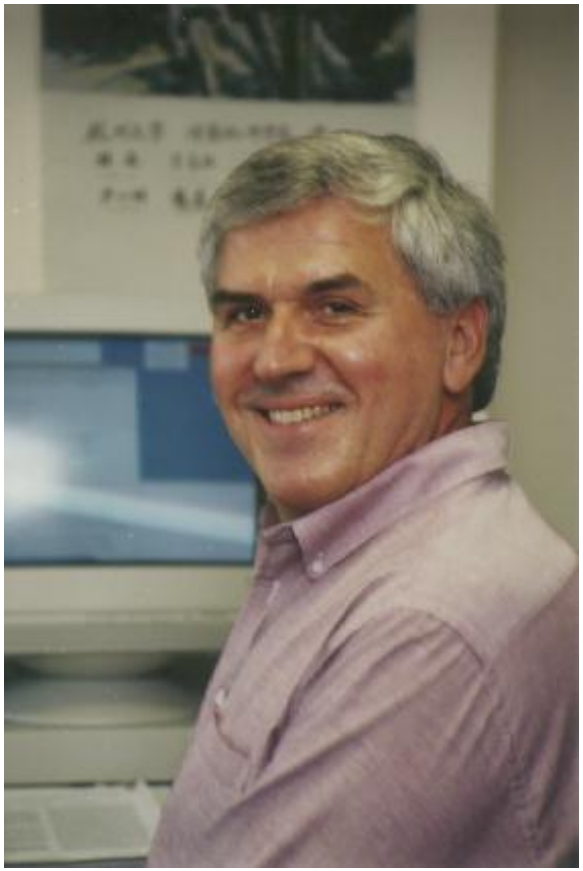
Bill & Melinda Gates Chair in
Computer Science & Engineering
University of Washington

Chair, Computing Community Consortium

University of Toronto

September 2009

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



This morning …

- 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
- Be a Myth Buster!

THE COUNT

Internet, Mobile Phones Named Most Important Inventions

By PHYLLIS KORKKI
Published: March 7, 2009

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.

Next Article in Business (22 of 29) »

Next Article in Business (22 of 29) »

Life Changers

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

amed Most Important Inventions

Next Article in Business (22 of 29) »

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.

Next Article in Business (22 of 29) »

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

THE COUNT

Internet, Mobile Phones Named Most Important Inventions

By PHYLLIS KORKKI
Published: March 7, 2009

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."

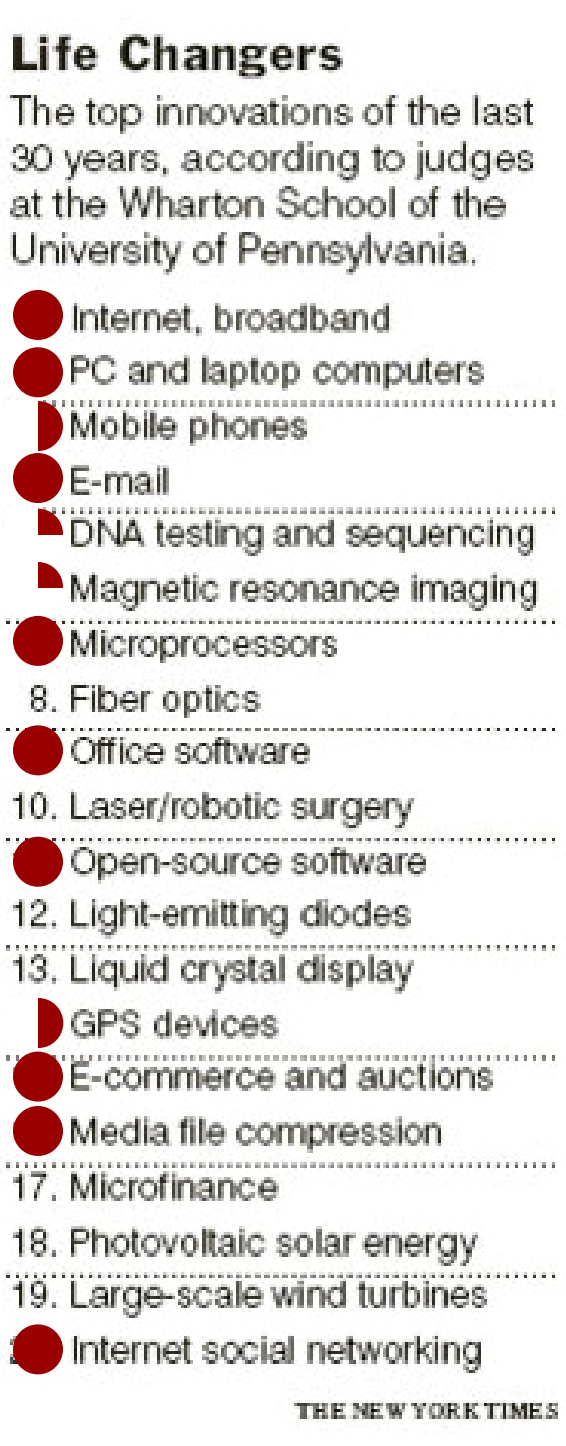
Good, important choices all, but for classic, long-lasting appeal, they still can't beat the wheel. **PHYLLIS KORKKI**

E-MAIL
PRINT
REPRINTS
SHARE

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

Next Article in Business (22 of 29) »

Next Article in Business (22 of 29) »



Life Changers

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

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

THE NEW YORK TIMES

THE COUNT

Internet, Mobile Phones Named Most Important Inventions

By PHYLLIS KORKKI
Published: March 7, 2009

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.

Next Article in Business (22 of 29) »

Landmark contributions by students

- Use of Boolean logic to model digital circuits
  - Claude Shannon, MIT, 1937
- Huffman coding
  - David Huffman, MIT, 1951
- Mathematical foundation of packet communication
  - Len Kleinrock, MIT, 1962
- Interactive computer graphics
  - Ivan Sutherland, MIT, 1963
- Computer vision
  - Larry Roberts, MIT, 1963
- Symbolic mathematics
  - William A. Martin & Joel Moses, MIT, 1967

- The FLEX language and machine
  - Alan Kay, Utah, 1969
- The Boyer-Moore theorem prover
  - Robert S. Boyer and J Strother Moore, Edinburgh, 1971
- Efficient graph planarity testing using depth-first search
  - Bob Tarjan, Stanford, 1972
- Ethernet
  - Bob Metcalfe, Harvard, 1973
- BSD Unix
  - Bill Joy, Berkeley, 1977 (with Fabry and Ferrari)
- VisiCalc
  - Bob Frankston & Dan Bricklin, MIT, 1979

- Public key cryptography
  - Ralph Merkle, Berkeley & Stanford, 1979 (with Diffie & Hellman)
- The SUN workstation
  - Andy Bechtolsheim, Stanford, 1982 (with Baskett)
- The Connection Machine
  - Danny Hillis, MIT, 1983
- Sphinx
  - Kai-Fu Lee, Carnegie Mellon, 1988
- Linux
  - Linus Torvalds, Helsinki, 1991
- BDD-based symbolic model checking
  - Ken McMillan, Carnegie Mellon, 1992

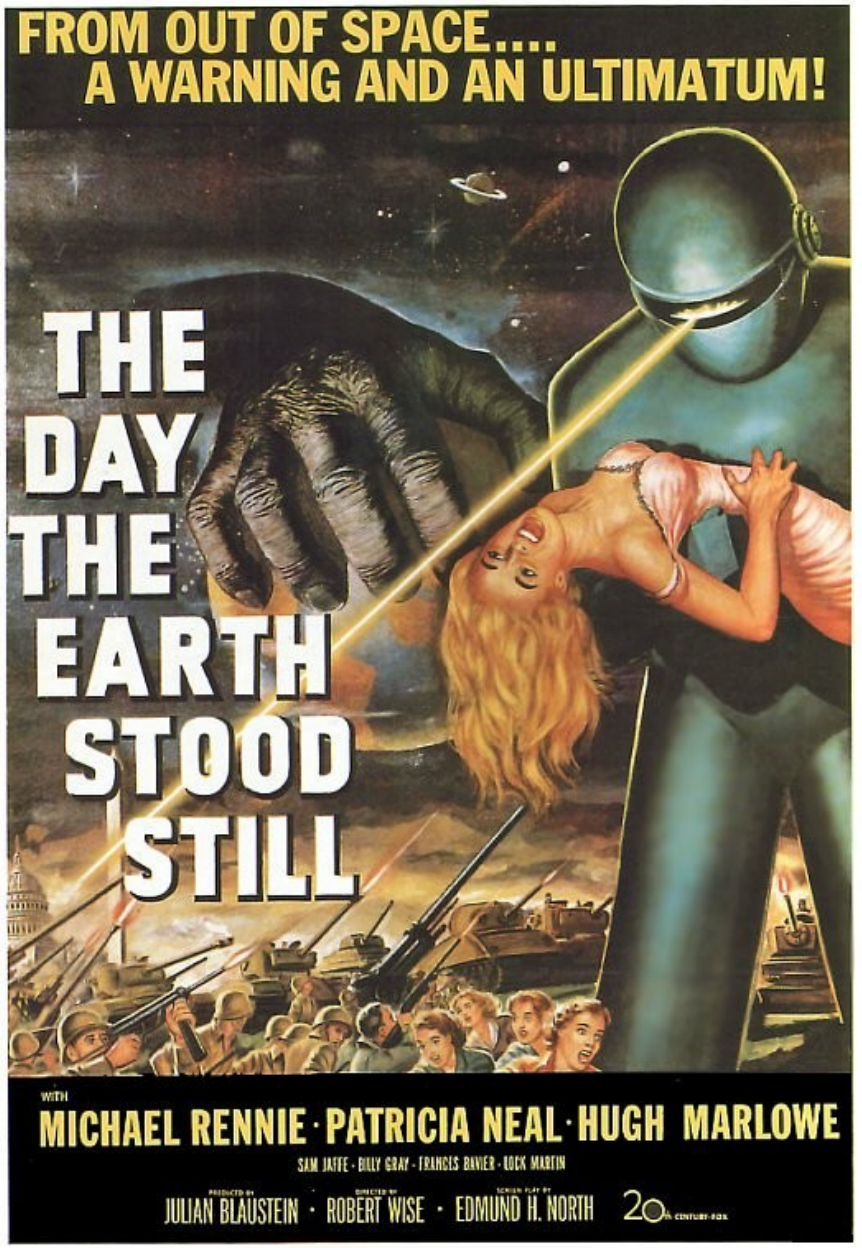
- Mosaic
  - Mark Andreessen, Illinois, 1994
- The PCP theorem
  - Sanjeev Arora, Berkeley, 1994
- Google
  - Larry Page & Sergey Brin, Stanford, 1998
- Akamai
  - Danny Lewin, MIT, 1999 (with Leighton)
- Peer-to-peer file sharing
  - Shawn Fanning, Northeastern, 1999

Imagine spending a day without information technology

- A day without the Internet and all that it enables
- A day without diagnostic medical imaging
- A day during which automobiles lacked electronic ignition, antilock brakes, and electronic stability control
- A day without digital media – without wireless telephones, high-definition televisions, MP3 audio, DVD video, computer animation, and videogames
- A day during which aircraft could not fly, travelers had to navigate without benefit of GPS, weather forecasters had no models, banks and merchants could not transfer funds electronically, factory automation ceased to function, and the US military lacked technological supremacy

Imagine spending a day without information technology

- A day without the Internet and
- A day without diagnostic medic
- A day during which automobiles antilock brakes, and electronic
- A day without digital media – w high-definition televisions, MP3 computer animation, and videog
- A day during which aircraft cou to navigate without benefit of had no models, banks and mercl funds electronically, factory au function, and the US military lo supremacy

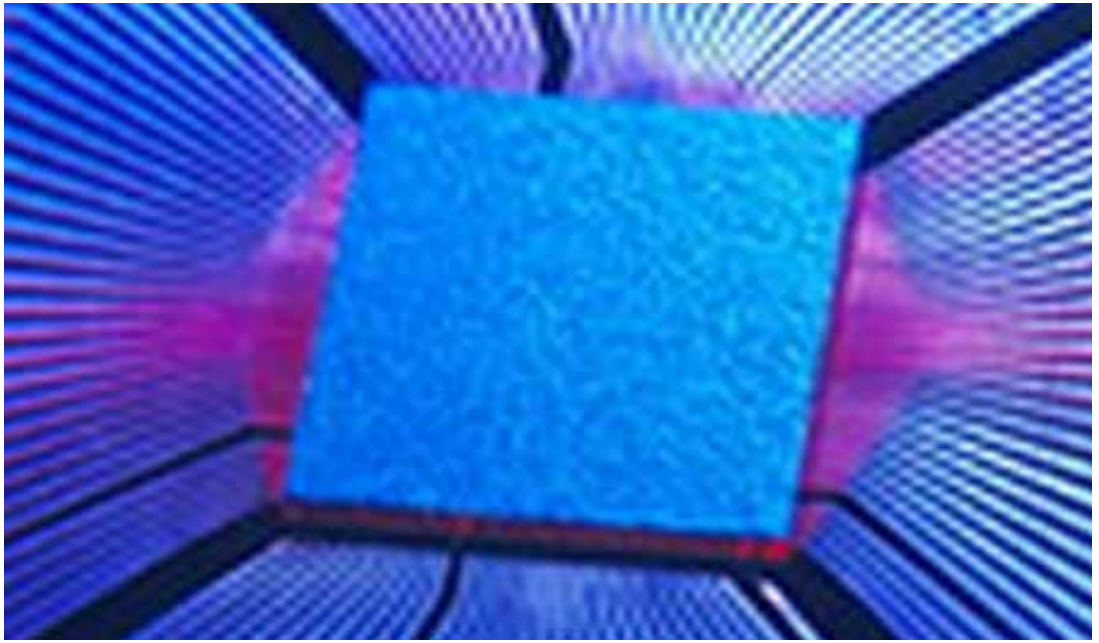


10,000,000,000,000,000,000 grains of rice

- Ten quintillion: $10*10^{18}$
  - The number of grains of rice harvested in 2004

10,000,000,000,000,000,000 transistors

- Ten quintillion: $10*10^{18}$
  - The number of grains of rice harvested in 2004
  - The number of transistors fabricated in 2004

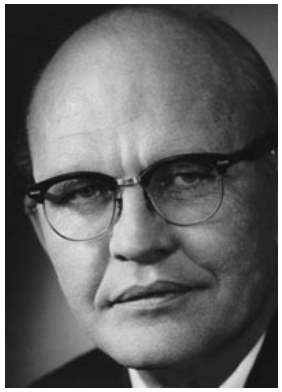


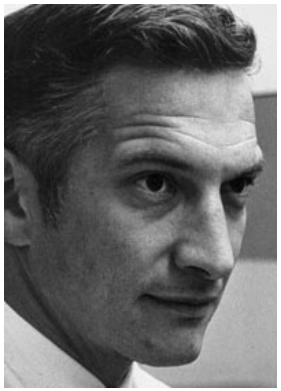
The transistor

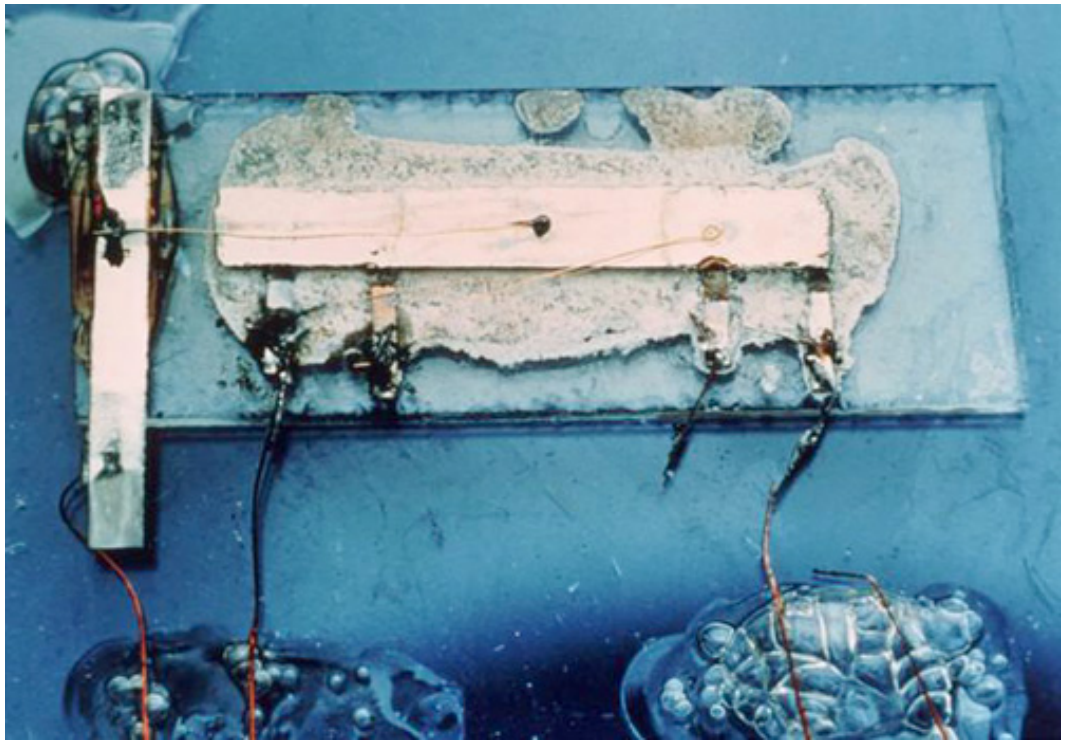
- William Shockley, Walter Brattain and John Bardeen, Bell Labs, 1947

The integrated circuit

- Jack Kilby, Texas Instruments, and Bob Noyce, Fairchild Semiconductor Corporation, 1958

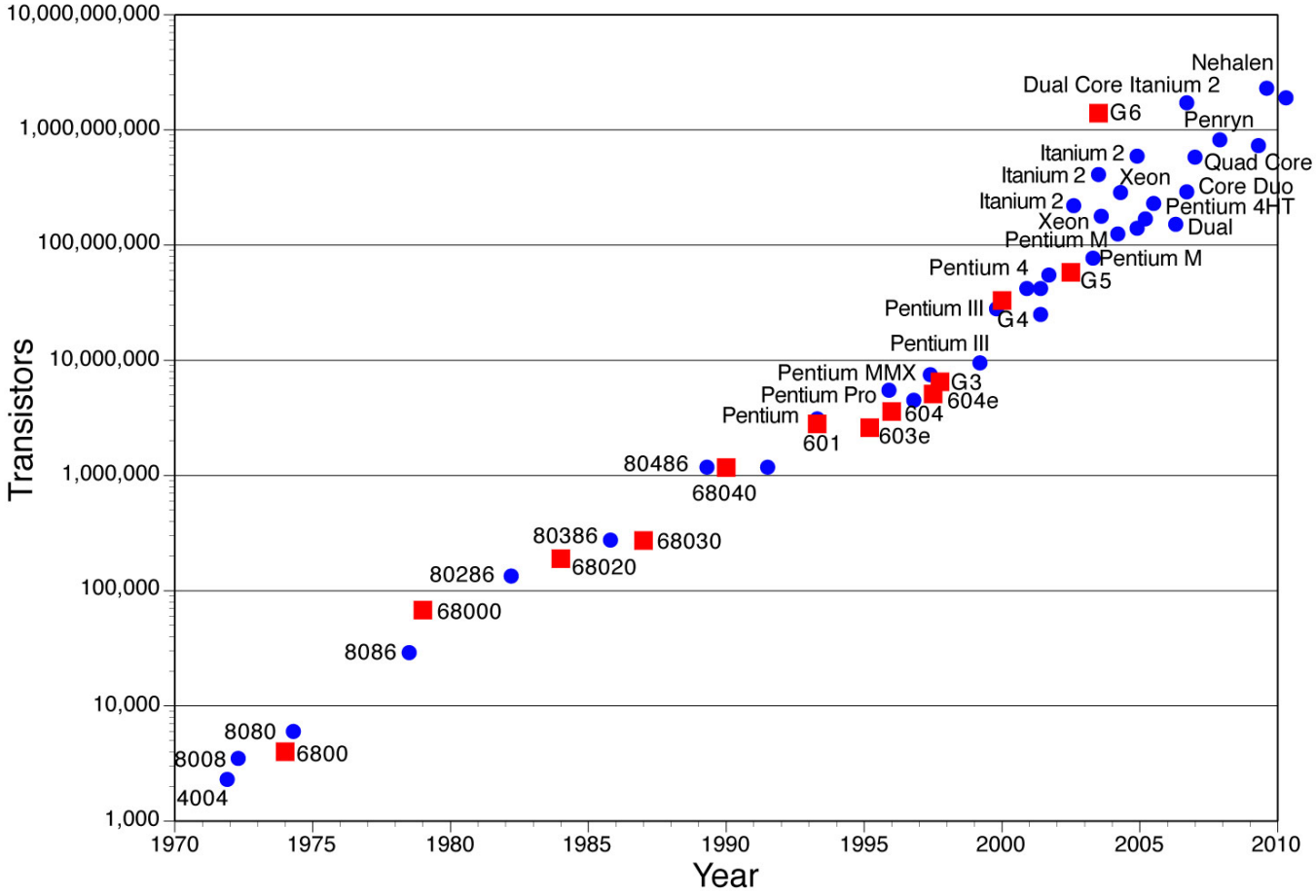






Exponential progress

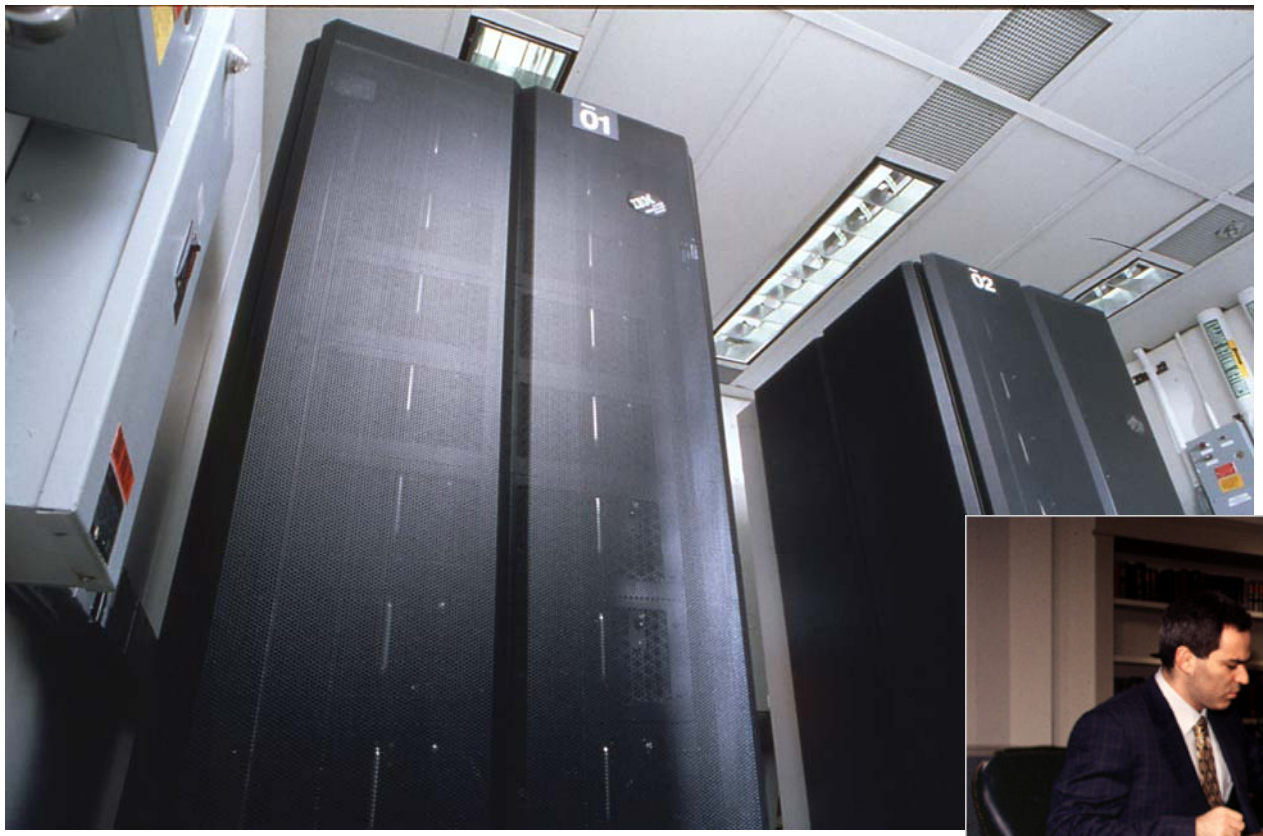
- Gordon Moore, 1965



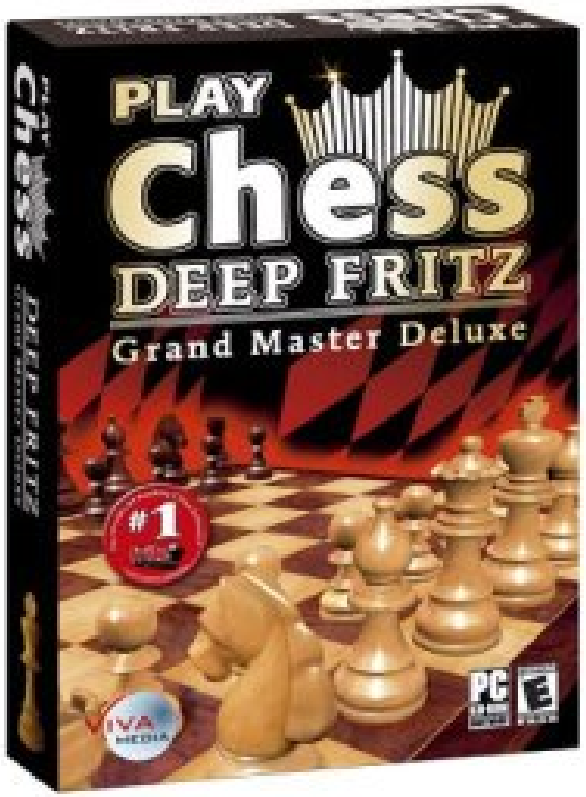

UNIVAC


UNIVAC

Algorithms make remarkable progress too!



Deep Blue, 1997



Price: $19.99 & eligible for **FREE Super Saver Shipping** on orders over $25.

Deep Fritz, 2002

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

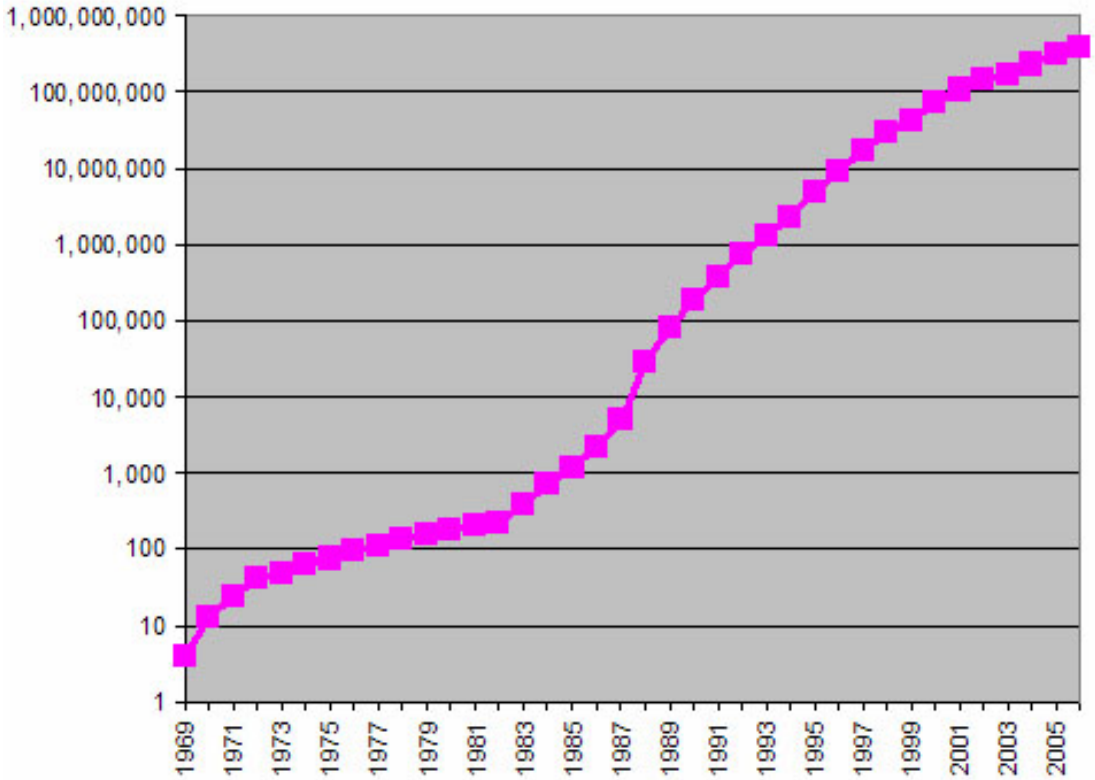
"There is no reason anyone would want a computer in their home" – Ken Olsen, founder and President of Digital Equipment Corporation, 1977

Today: More than 1 billion PCs in use …

Representing less than 2% of all processors!

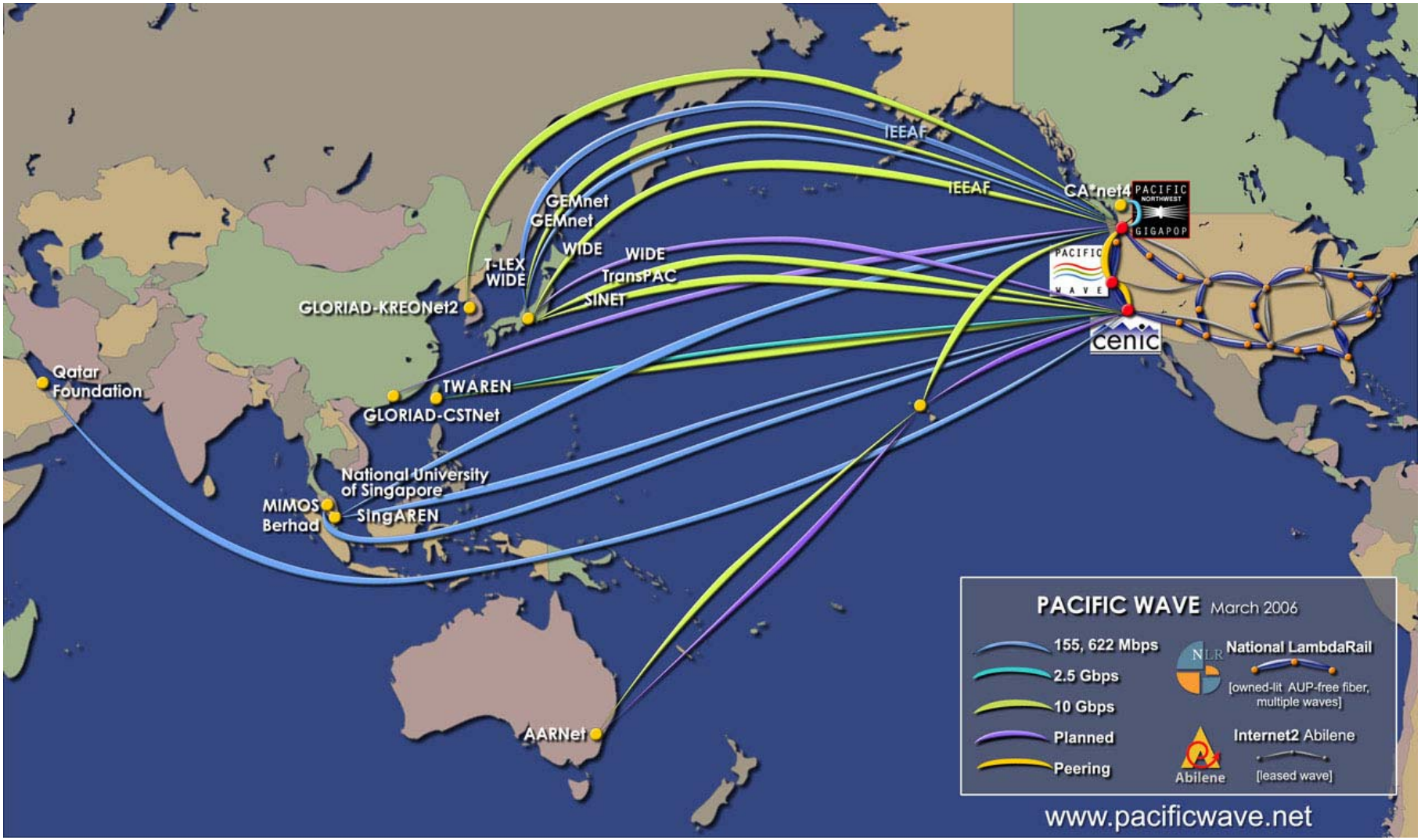
Number of Internet hosts

- 1970: 10
- 1975: 100
- 1980: 200
- 1985: 2,000
- 1990: 350,000
- 1995: 10,000,000
- 2000: 100,000,000
- 2005: 400,000,000

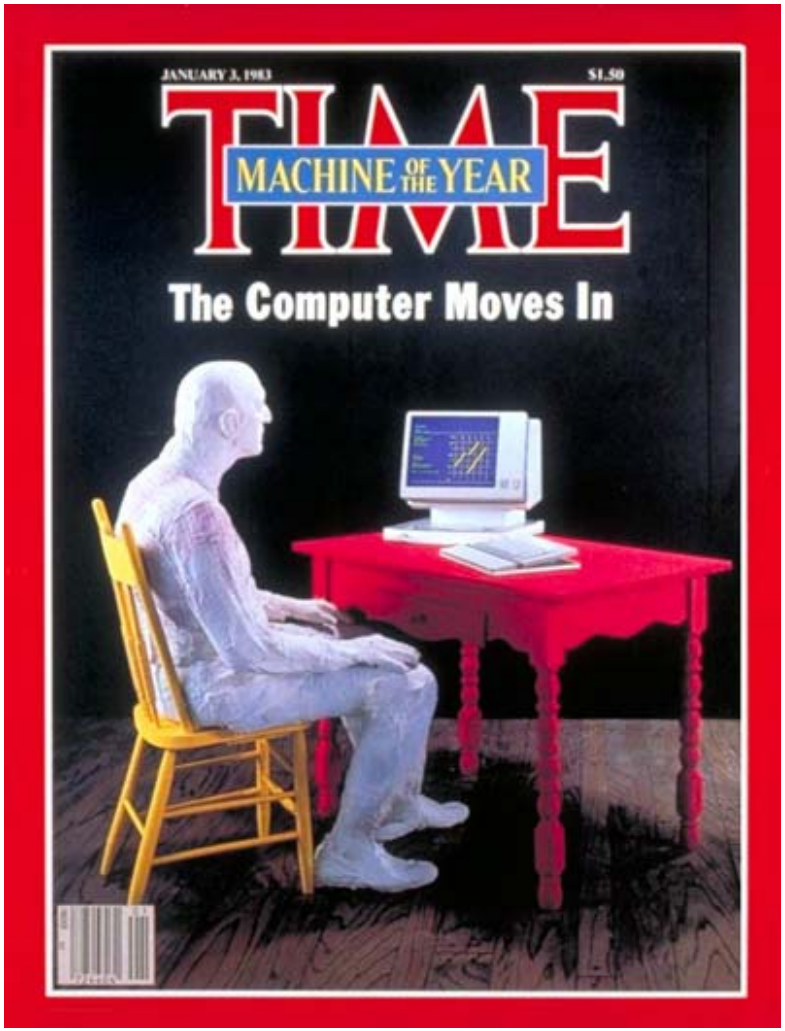


A connected region – then

A connected region – now



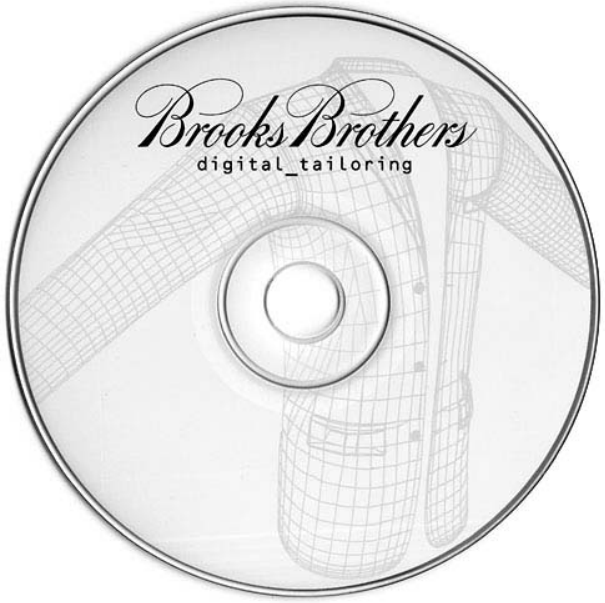
The Computer: *Time* Magazine's 1982 "Machine of the Year"



- "In medicine, the computer, which started by keeping records and sending bills, now suggests diagnoses. The process may sound dehumanized, but in one hospital … a survey of patients showed that they found the machine 'more friendly, polite, relaxing and comprehensible' than the average physician.'"

- "When the citizen of tomorrow wants a new suit, one futurist scenario suggests, his personal computer will take his measurements and pass them on to a robot that will cut his choice of cloth with a laser beam and provide him with a perfectly tailored garment."

- "When the citizen of tomorrow wants a new suit, one futurist scenario suggests, his personal computer will take his measurements and pass them on to a robot that will cut his choice of cloth with a laser beam and provide him with a perfectly tailored garment."



- "In the home, computer enthusiasts delight in imagining machines performing domestic chores."

- "In the home, computer enthusiasts delight in imagining machines performing domestic chores."

vacuum your carpet

iRobot®

- "In the home, computer enthusiasts delight in imagining machines performing domestic chores."

wash your floor

iRobot®

- "In the home, computer enthusiasts delight in imagining machines performing domestic chores."

scrub your pool

iRobot®

- "In the home, computer enthusiasts delight in imagining machines performing domestic chores."

clean your gutters

iRobot®

- "In the home, computer enthusiasts delight in imagining machines performing domestic chores."

amuse your pet

iRobot®

- "In the home, computer enthusiasts delight in imagining machines performing domestic chores."

detonate your IED's

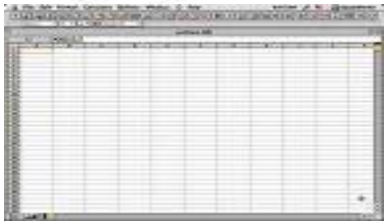
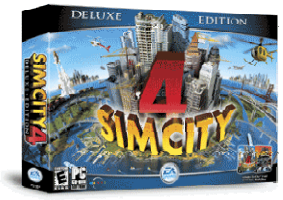
iRobot®

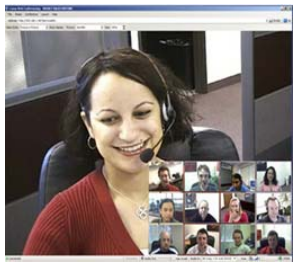
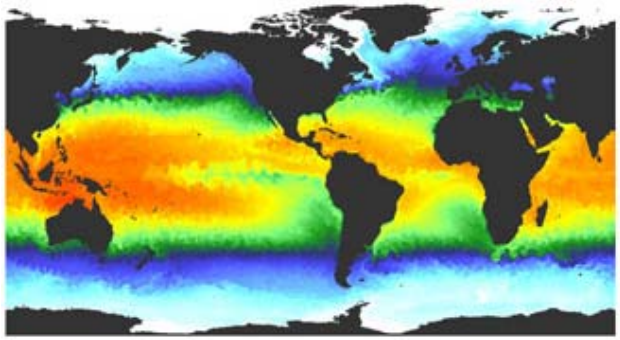
The Computing Community Consortium

Computing has changed the world

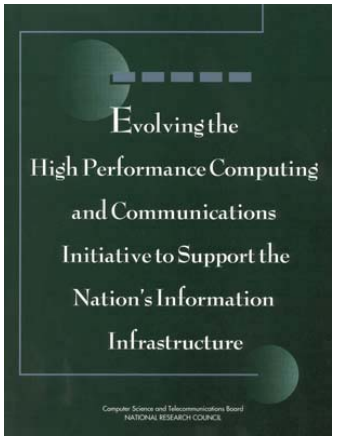
- Advances in computing change the way we live, work, learn, and communicate
- Advances in computing drive advances in nearly all other fields
- Advances in computing power our economy
  - Not just through the growth of the IT industry – through productivity growth across the entire economy

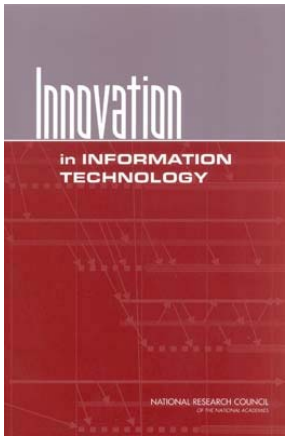


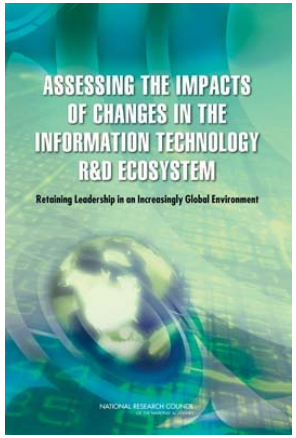



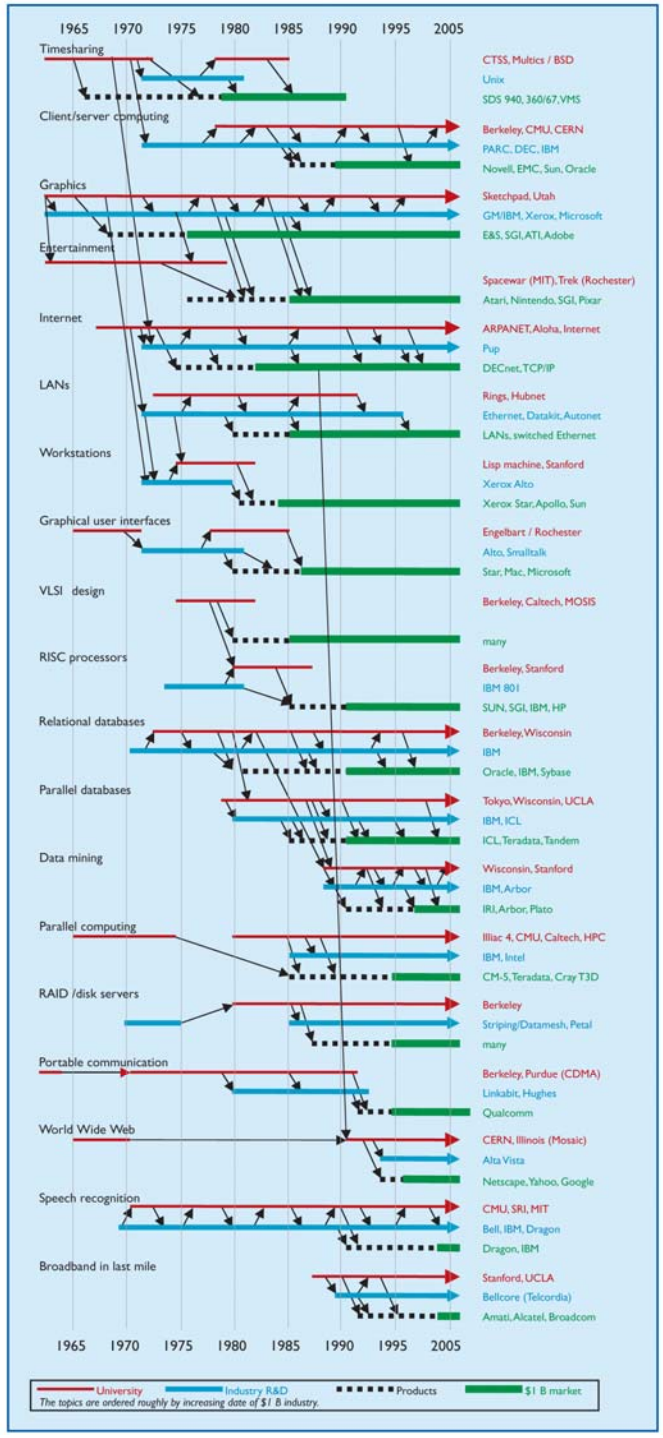



Research has built the foundation



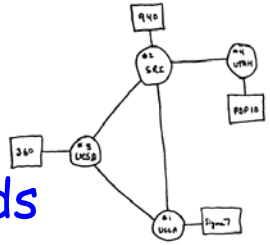


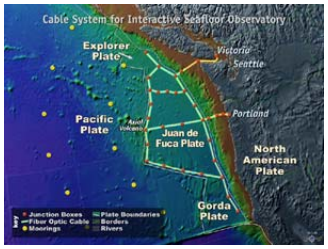


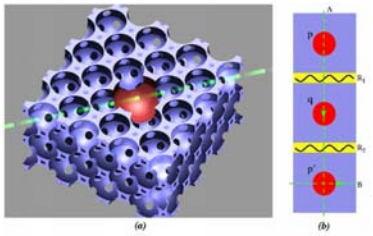


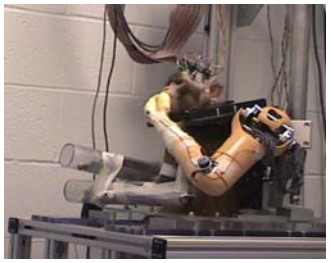
The future is full of opportunity

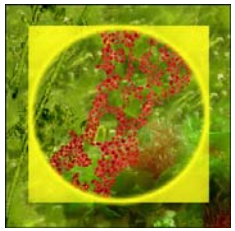
- Creating the future of networking
- Driving advances in all fields of science and engineering
- Revolutionizing transportation
- Personalized education
- The smart grid
- Predictive, preventive, personalized medicine
- Quantum computing
- Empowerment for the developing world
- Personalized health monitoring => quality of life
- Harnessing parallelism
- Neurobotics
- Synthetic biology











We must work together to establish, articulate, and pursue visions for the field

- The challenges that will shape the intellectual future of the field
- The challenges that will catalyze research investment and public support
- The challenges that will attract the best and brightest minds of a new generation

To this end, NSF asked CRA to create the Computing Community Consortium

- To catalyze the computing research community to consider such questions
  - To envision long-range, more audacious research challenges
  - To build momentum around such visions
  - To state them in compelling ways
  - To move them towards funded initiatives
  - To ensure "science oversight" of large-scale initiatives
- *A "cooperative agreement" with NSF*
  - Close coordination

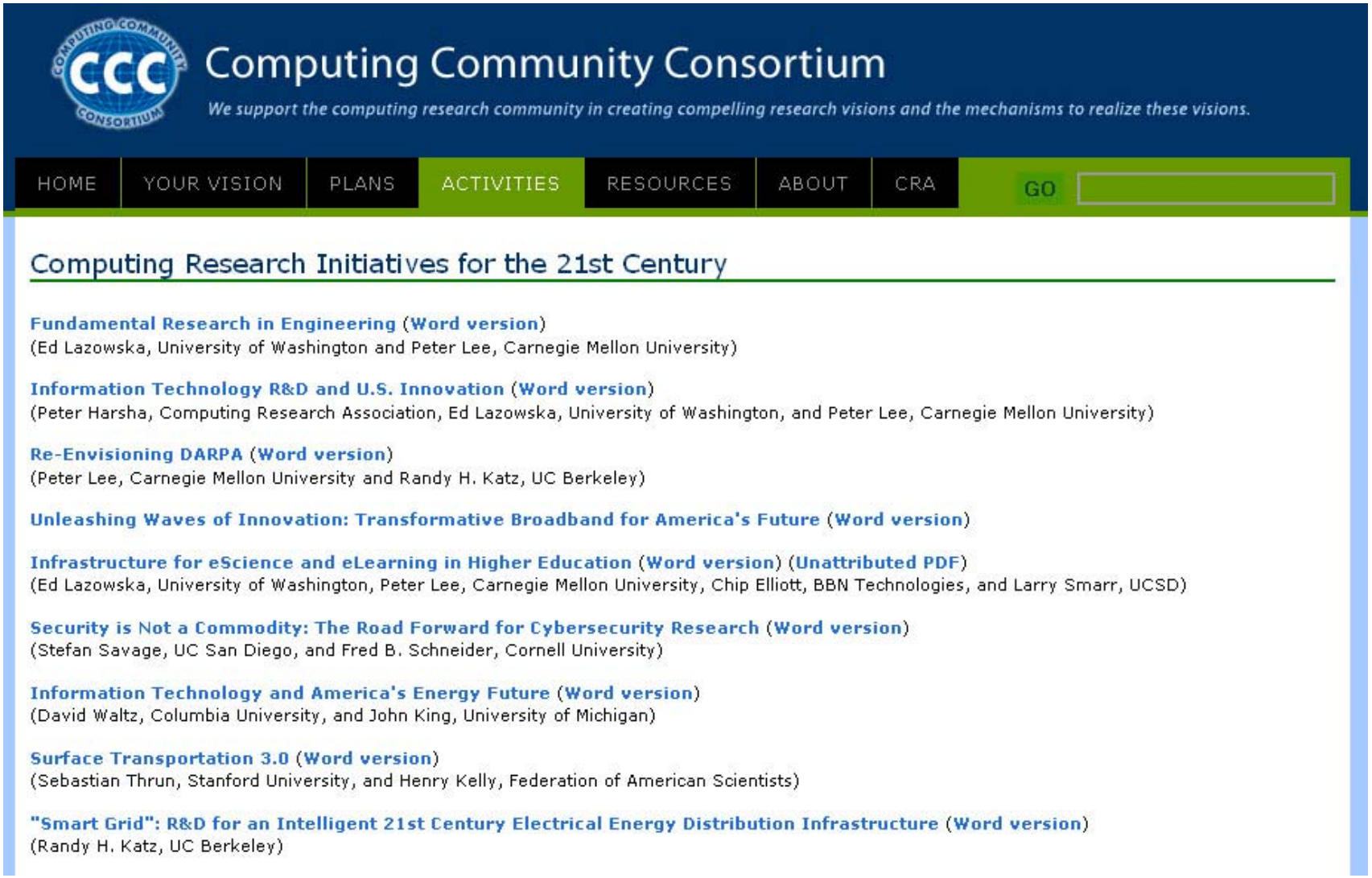
Ongoing activities

Research agenda workshops

Highlight of the week

Research blog

November-December: Transition Team white papers



Computing Community Consortium

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

HOME | YOUR VISION | PLANS | ACTIVITIES | RESOURCES | ABOUT | CRA | GO

Computing Research Initiatives for the 21st Century

Fundamental Research in Engineering (**Word version**)
(Ed Lazowska, University of Washington and Peter Lee, Carnegie Mellon University)

Information Technology R&D and U.S. Innovation (**Word version**)
(Peter Harsha, Computing Research Association, Ed Lazowska, University of Washington, and Peter Lee, Carnegie Mellon University)

Re-Envisioning DARPA (**Word version**)
(Peter Lee, Carnegie Mellon University and Randy H. Katz, UC Berkeley)

Unleashing Waves of Innovation: Transformative Broadband for America's Future (**Word version**)

Infrastructure for eScience and eLearning in Higher Education (**Word version**) (**Unattributed PDF**)
(Ed Lazowska, University of Washington, Peter Lee, Carnegie Mellon University, Chip Elliott, BBN Technologies, and Larry Smarr, UCSD)

Security is Not a Commodity: The Road Forward for Cybersecurity Research (**Word version**)
(Stefan Savage, UC San Diego, and Fred B. Schneider, Cornell University)

Information Technology and America's Energy Future (**Word version**)
(David Waltz, Columbia University, and John King, University of Michigan)

Surface Transportation 3.0 (**Word version**)
(Sebastian Thrun, Stanford University, and Henry Kelly, Federation of American Scientists)

"Smart Grid": R&D for an Intelligent 21st Century Electrical Energy Distribution Infrastructure (**Word version**)
(Randy H. Katz, UC Berkeley)

Synthetic Biology (**Word version**)
(Drew Endy, Stanford, and Ed Lazowska, University of Washington)

Innovation in Networking (**Word version**)
(Nick McKeown, Stanford University, Guru Parulkar, Stanford University, and Jennifer Rexford, Princeton University)

Big-Data Computing (**Word version**)
(Randal E. Bryant, Carnegie Mellon University, Randy H. Katz, UC Berkeley, and Edward D. Lazowska, University of Washington)

Robotics (**Word version**)
(Rodney Brooks, MIT)

The Ocean Observatories Initiative (**Word version**)
(John Delaney, University of Washington, John Orcutt, Scripps Institute of Oceanography, and Robert Weller, Woods Hole Oceanographic Institution)

Quality of Life Technology (**Word version**)
(Howard Wactlar, Carnegie Mellon University, and Takeo Kanade, Carnegie Mellon University)

P4 Medicine (**Word version**)
(Leroy Hood, Institute for Systems Biology, and David Galas, Battelle Memorial Institute)

Quantum Computing (**Word version**)
(Scott Aaronson, MIT, and Dave Bacon, University of Washington)

Computer Architecture (**Word version**)
(David Patterson, UC Berkeley)

Cyber-Physical Systems: A National Priority for Federal Investment in Infrastructure and Competitiveness (**Word version**)
(Janos Sztipanovits, Vanderbilt University, and John Stankovic, University of Virginia)

Post your comments on the **Computing Community Consortium blog**!

1100 17th Street, NW | Suite 507 | Washington, D.C. 20036-4632
Phone: 202-234-2111 | Fax: 202-667-1066 | E-mail: webmaster @ cra.org

March: Library of Congress Symposium

Session 1: The Internet and the World Wide Web

9:00 - 10:20

Why We're Able to Google
Alfred Spector (Google)

The Magic of the "Cloud": Supercomputers for Everybody, Everywhere
Eric Brewer (University of California, Berkeley)

Human Computation
Luis von Ahn (Carnegie Mellon University)

Discussion by the speakers of future challenges and synergies

Session 2: Evolving Foundations — 10:40 - 12:00

Security of Online Information
Barbara Liskov (Massachusetts Institute of Technology)

Learning to Improve Our Lives
Daphne Koller (Stanford University)

Global Information Networks
Jon Kleinberg (Cornell University)

Discussion by the speakers of future challenges and synergies

Session 3: The Transformation of the Sciences via Computation 1:00 - 2:20

Supercomputers and Supernetworks are Transforming Research
Larry Smarr (University of California, San Diego)

Computing and Visualizing the Future of Medicine
Chris Johnson (University of Utah)

Zooming In On Life
Gene Myers (Howard Hughes Medical Institute)

Discussion by the speakers of future challenges and synergies

Session 4: Computing Everywhere! 2:30 - 3:50

Sensing Everywhere!
Deborah Estrin (University of California, Los Angeles)

Pixels Everywhere!
Pat Hanrahan (Stanford University)

Robotics Everywhere!
Rodney Brooks (Massachusetts Institute of Technology and Heartland Robotics)

Discussion by the speakers of future challenges and synergies

April-July: Computing Innovation Fellows Project

Computing Innovation Fellows Project

Home CRA CCC CISE

The 2009 Computing Innovation Fellows have been selected!

We will publicize the names, institutions, and mentors of all CI Fellows as soon as **all awards** are finalized.

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

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

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

- > 1200 prospective mentors
- > 500 applicants
- 60 awardees
  - > 40 distinct Ph.D. institutions
  - > 40 distinct mentoring institutions
    - 85% academic, 15% industrial
  - 75% citizen or permanent resident
  - 40% female
  - 12% under-represented minority

August-September: DARPA transition

Regina Dugan

Peter Lee

September: NetSE Research Agenda

Network Science and Engineering (NetSE) Research Agenda

A Report of the Network Science and Engineering Council
Release Version 1.1
September 2009

Ellen Zegura

Current

- Computing research and health care
- Computing research and energy

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.

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

NATIONAL ACADEMY OF ENGINEERING
OF THE NATIONAL ACADEMIES

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

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

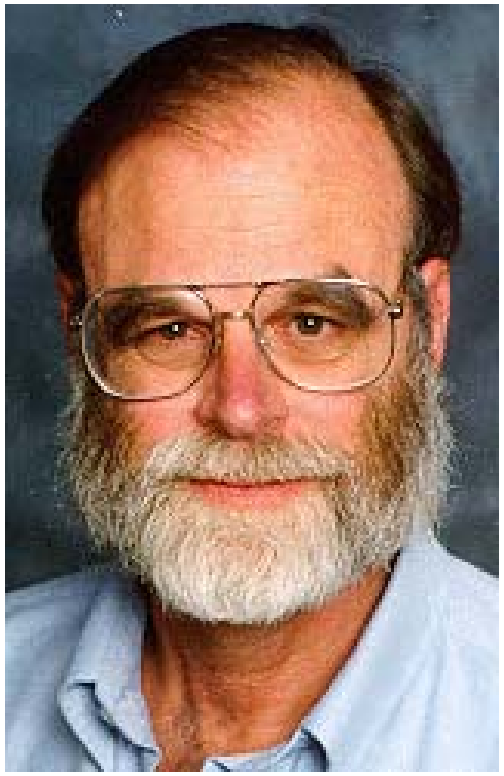

Advance personalized learning


Engineer the tools of scientific discovery

Predominant CS component

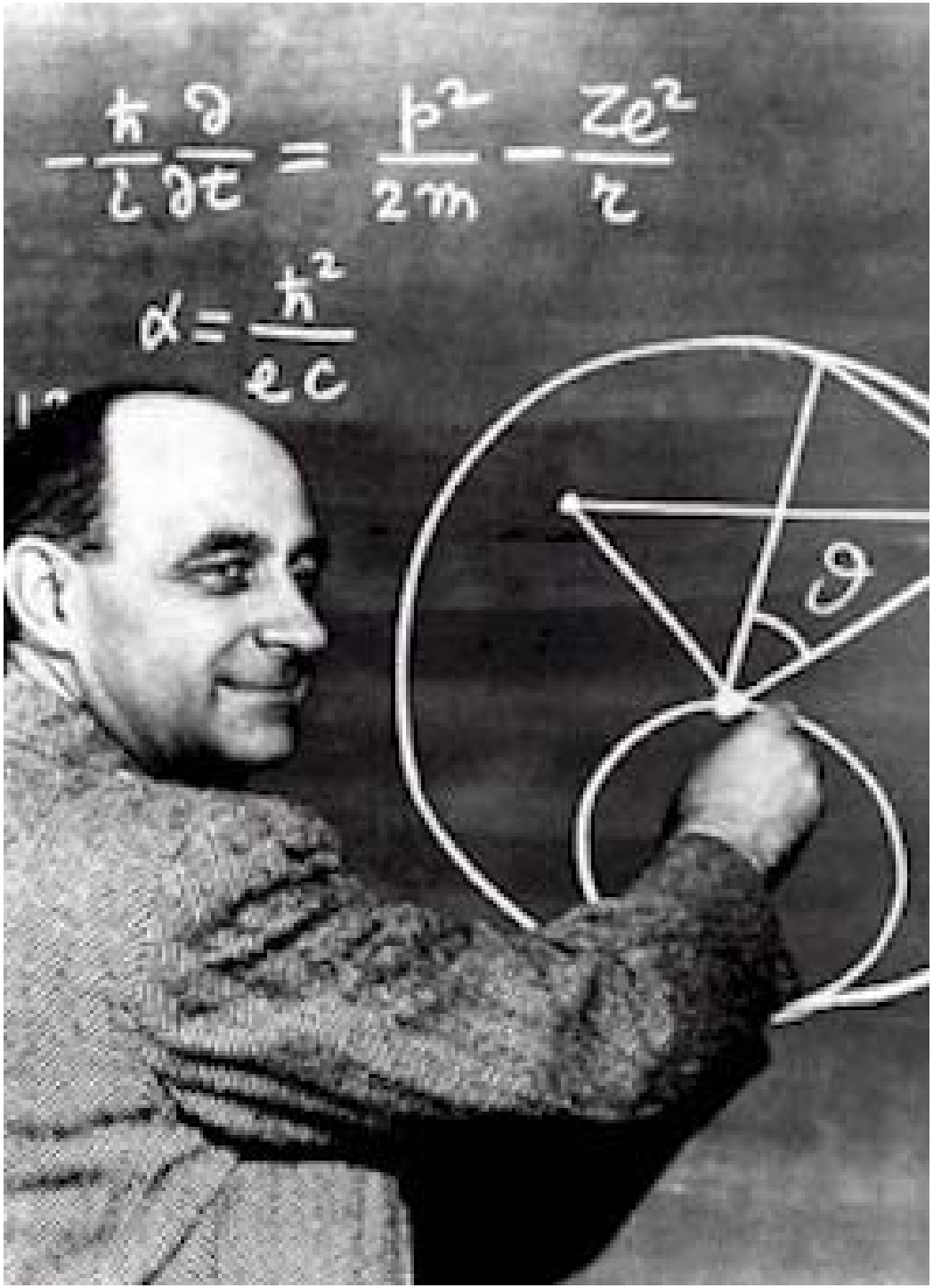
Significant CS component

eScience: Computational science for the 21st century



2020 SCIENCE

Transforming science (again!)



Theory

Experiment

Observation

Theory

Experiment

Observation


Theory
Experiment
Observation
[John Delaney, University of Washington]

Theory

Experiment

Observation

Computational Science

Theory

Experiment

Observation

Computational Science

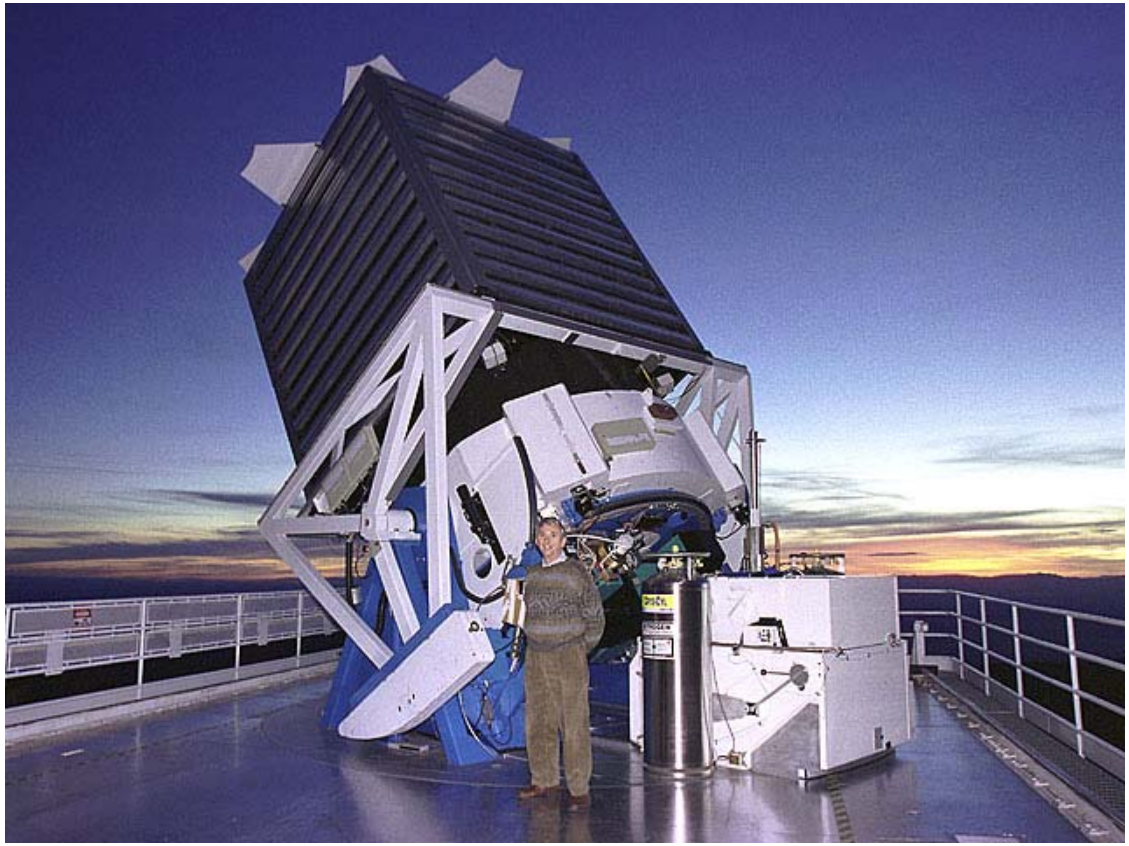
eScience

eScience is driven by *data*

- Massive volumes of data from sensors and networks of sensors

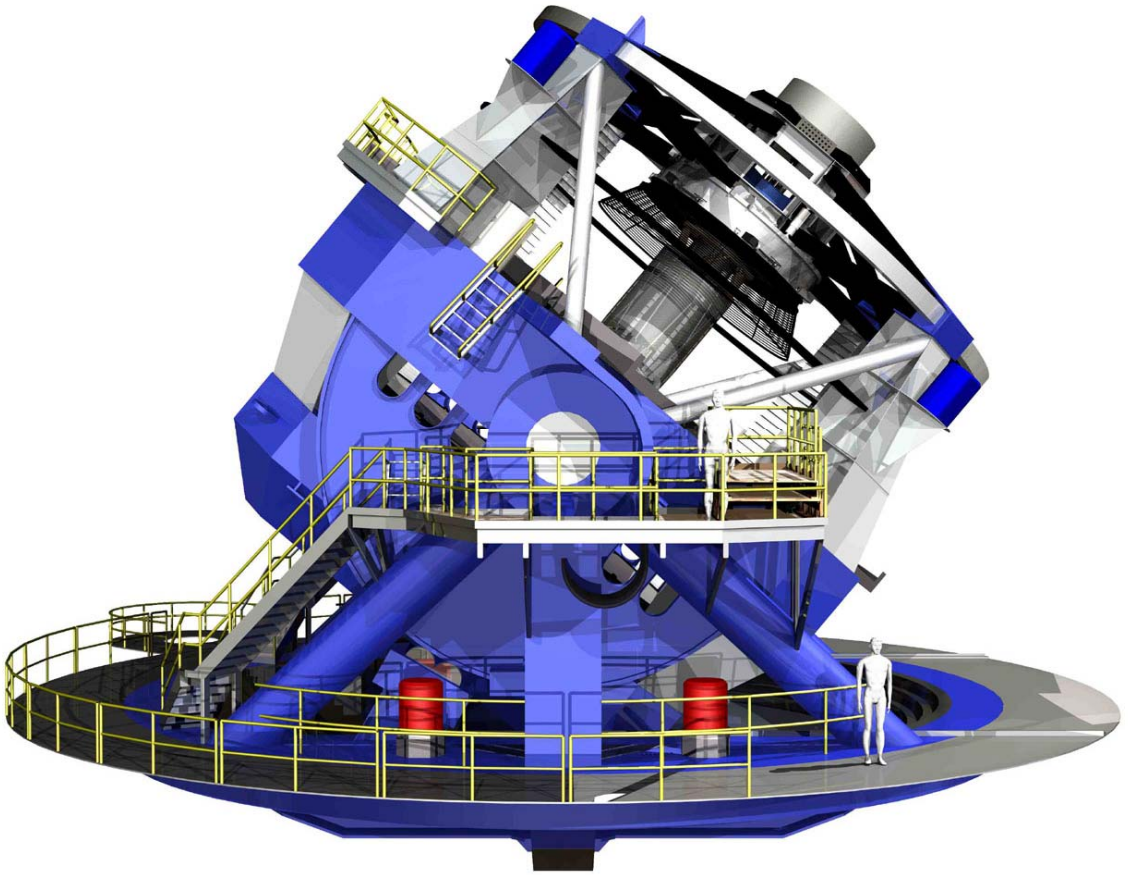
Apache Point telescope, SDSS

15TB of data (15,000,000,000,000 bytes)



Large Synoptic Survey Telescope (LSST)

30TB/day, 60PB in its 10-year lifetime

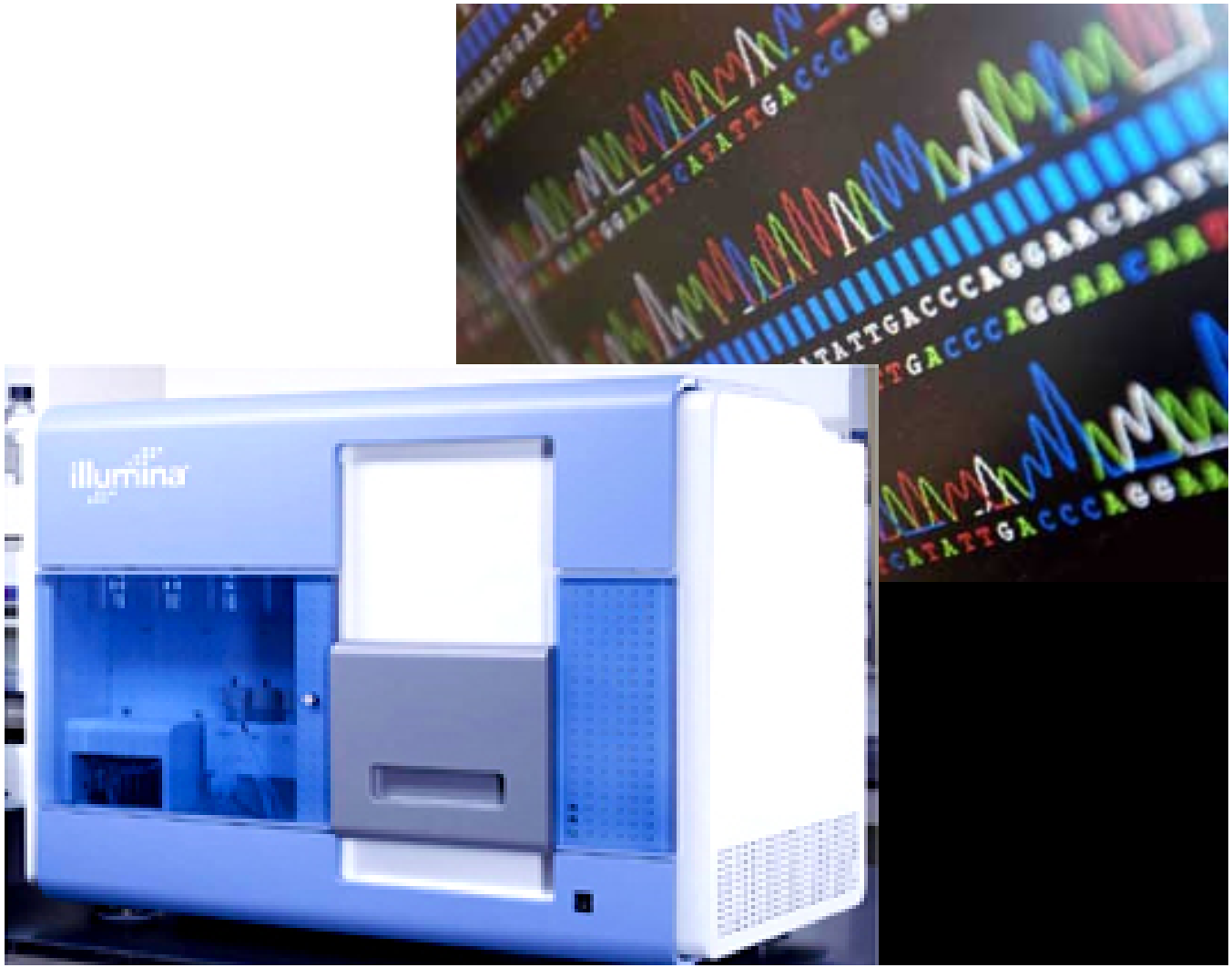


Large Hadron Collider

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

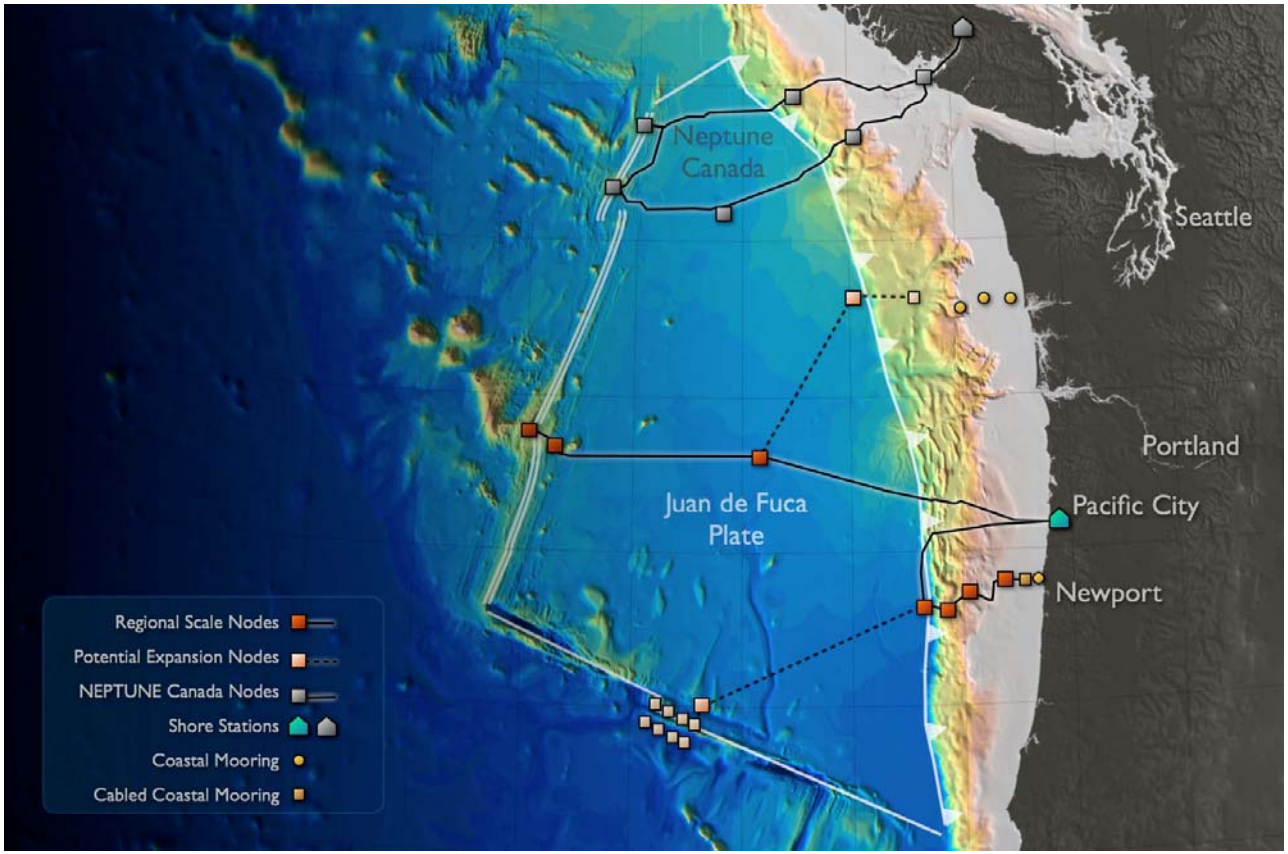
Illumina Genome Analyzer

~1TB/day



Regional Scale Nodes of the NSF Ocean Observatories Initiative

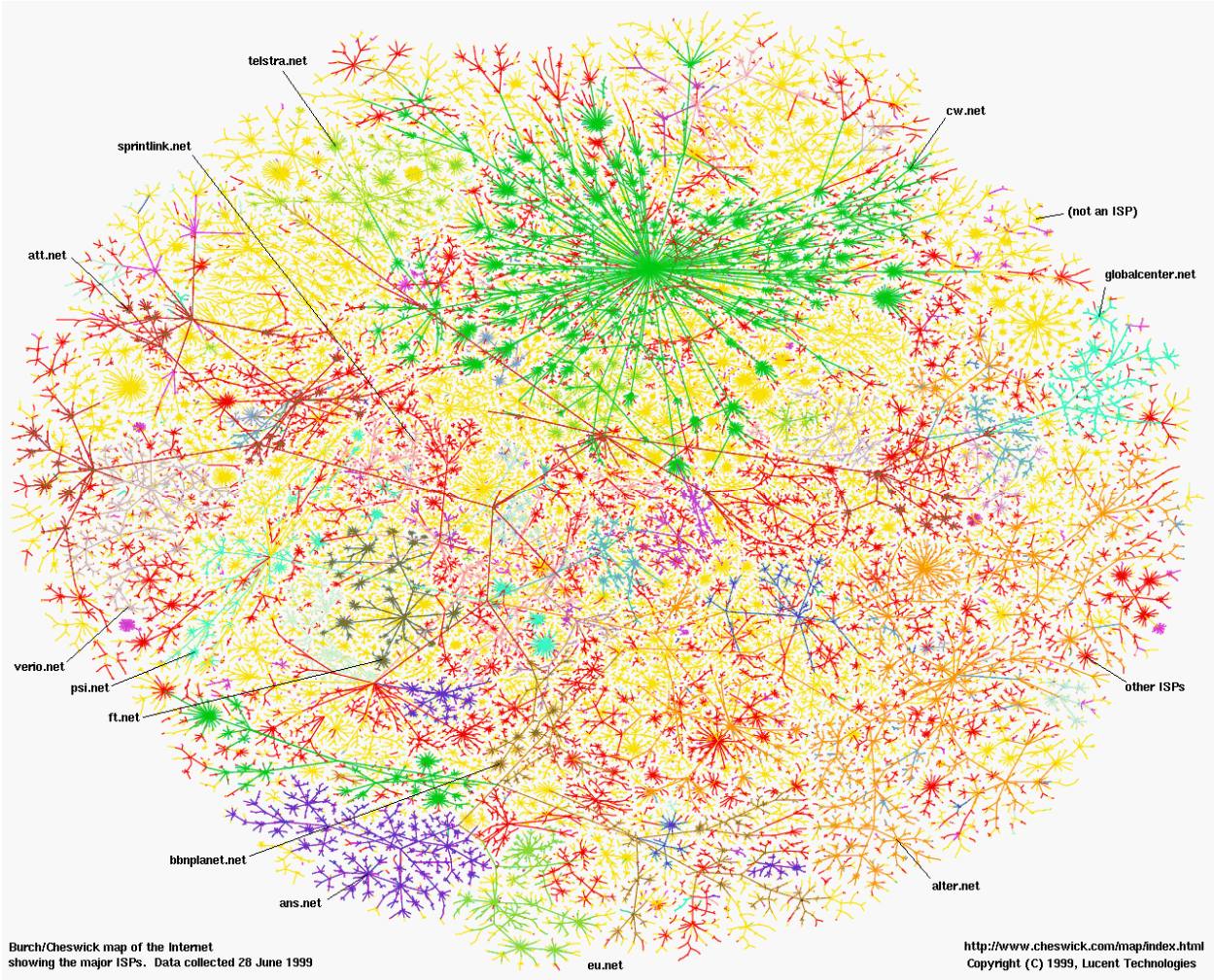
1000 km of fiber optic cable on the seafloor, connecting thousands of chemical, physical, and biological sensors



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

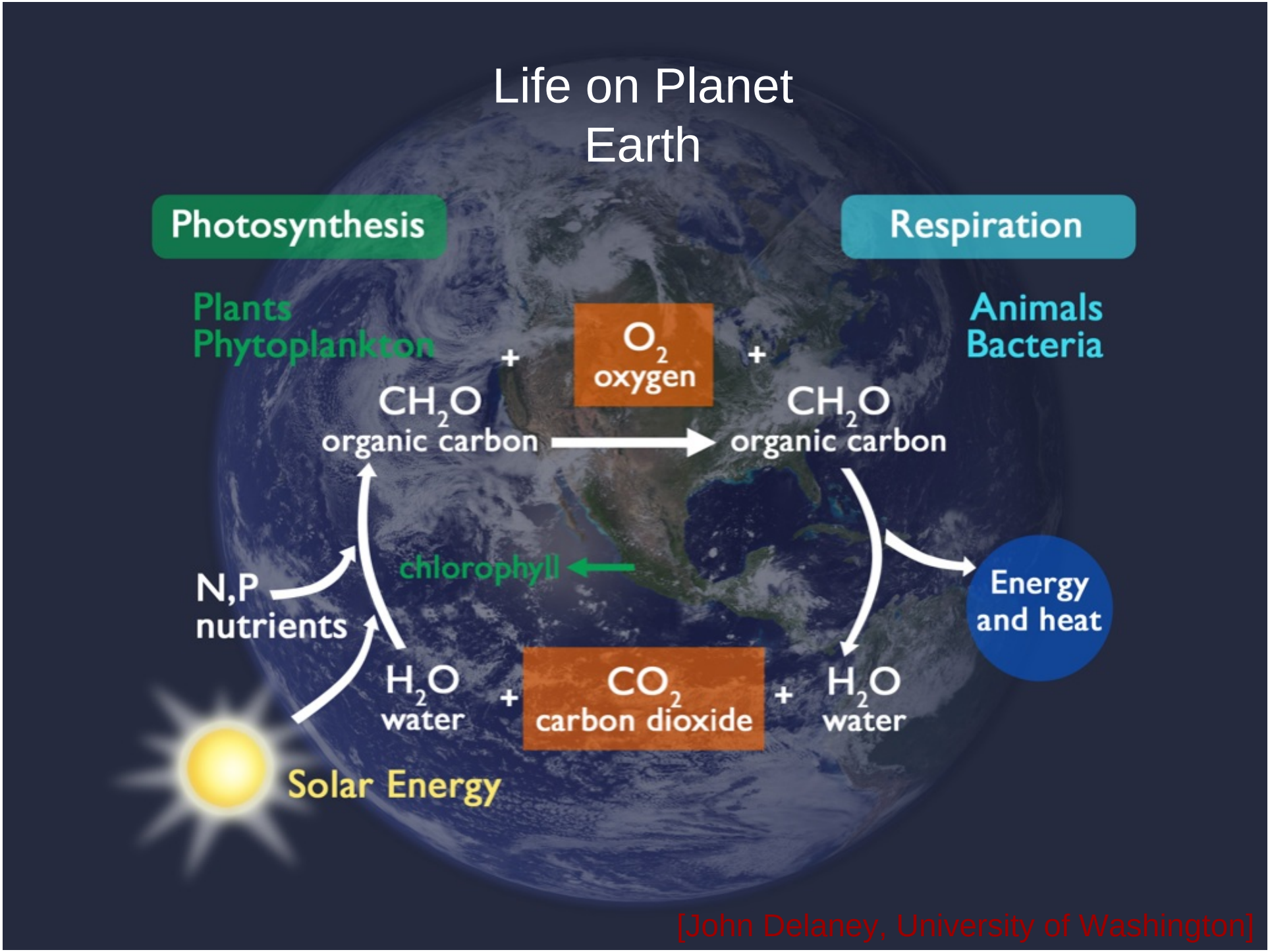
eScience is about the *analysis* of data

- The automated or semi-automated extraction of knowledge from massive volumes of data
  - There's simply too much of it to look at
- Technologies of eScience
  - Sensors and sensor networks
  - Databases
  - Data mining
  - Machine learning
  - Data visualization
  - Cluster computing at enormous scale

eScience will be pervasive

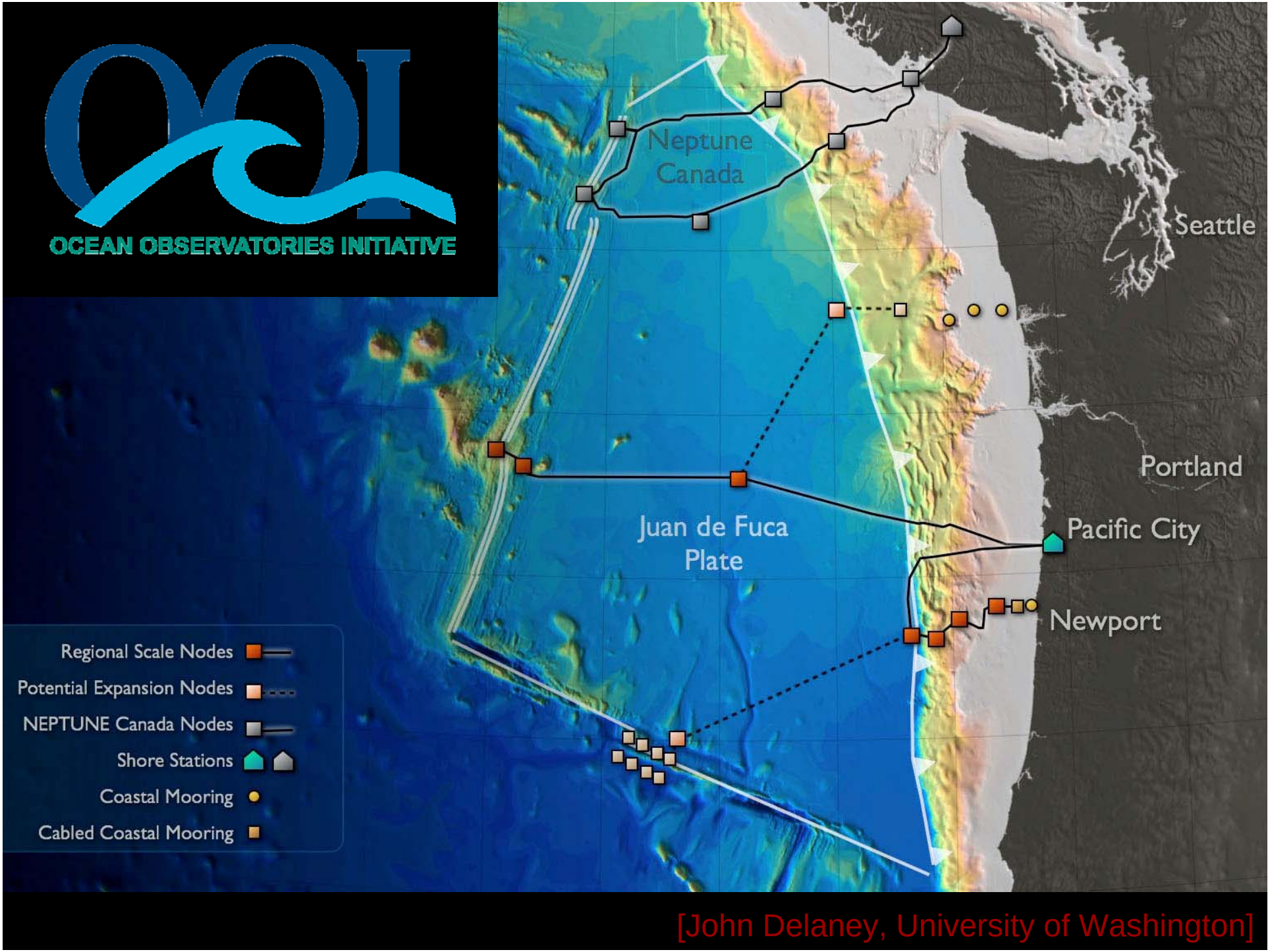
- Computational science has been transformational, but to some extent it has been a niche
  - As an institution (e.g., a university), you didn't need to employ it broadly in order to be competitive
- eScience capabilities must be broadly available and broadly practiced
  - If not, the institution will simply cease to be competitive
-

Life on Planet Earth



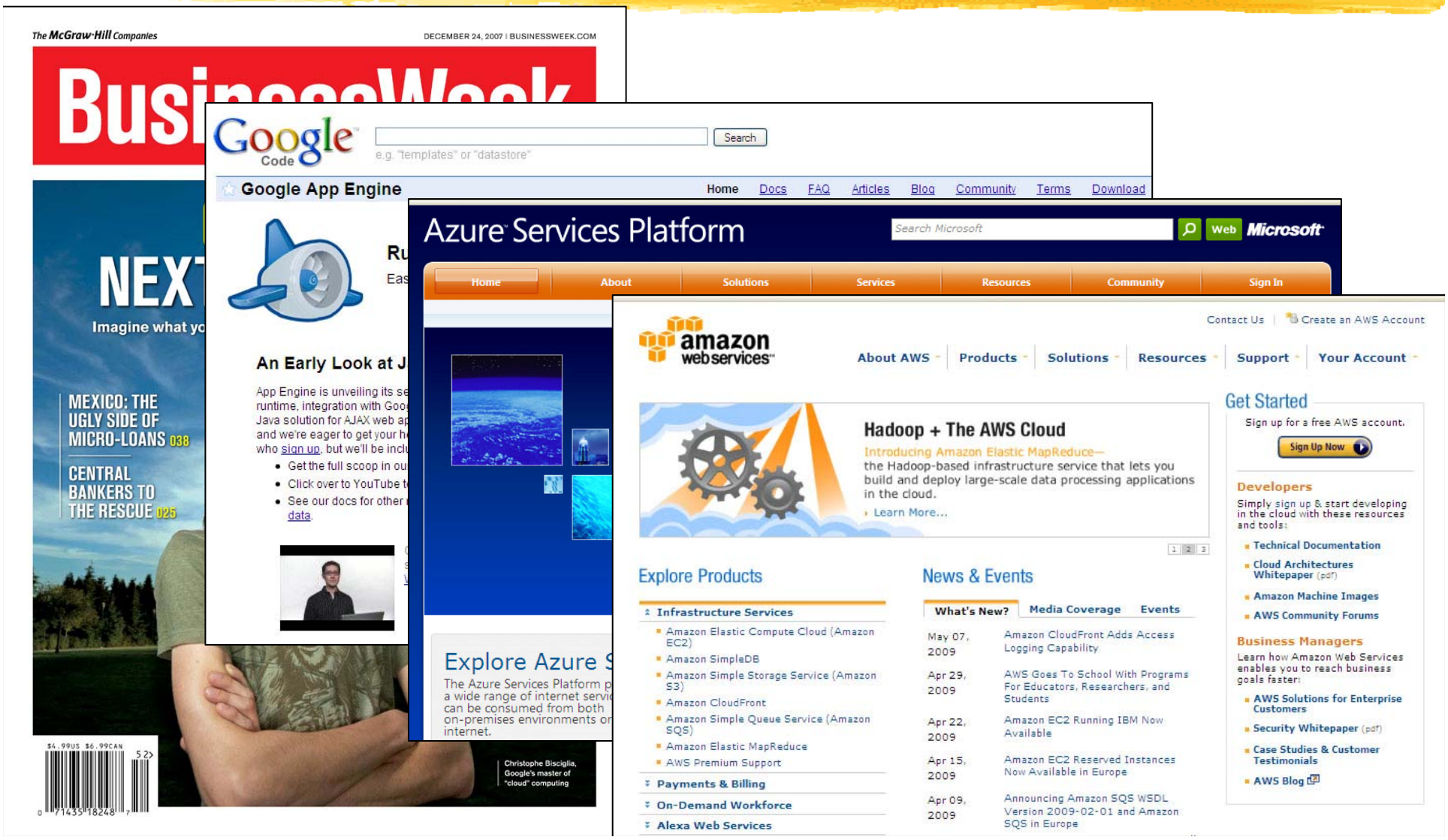
[John Delaney, University of Washington]


[John Delaney, University of Washington]



[John Delaney, University of Washington]

eScience utilizes the Cloud: Scalable computing for everyone



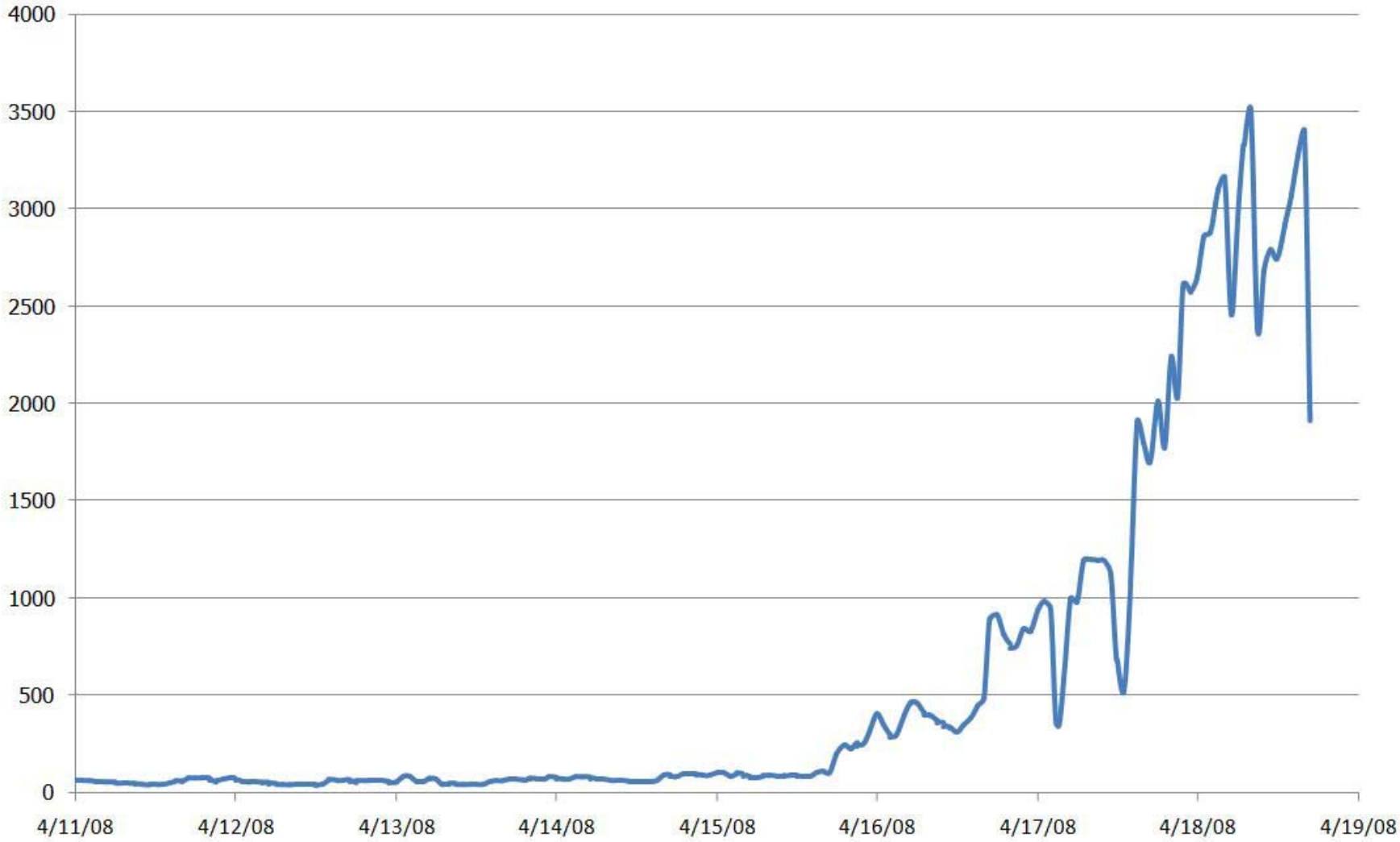
Amazon Elastic Compute Cloud (EC2)

- $0.80 per hour for
  - 8 cores of 3 GHz 64-bit Intel or AMD
  - 7 GB memory
  - 1.69 TB scratch storage
- Need it 24x7 for a year?
  - $3000

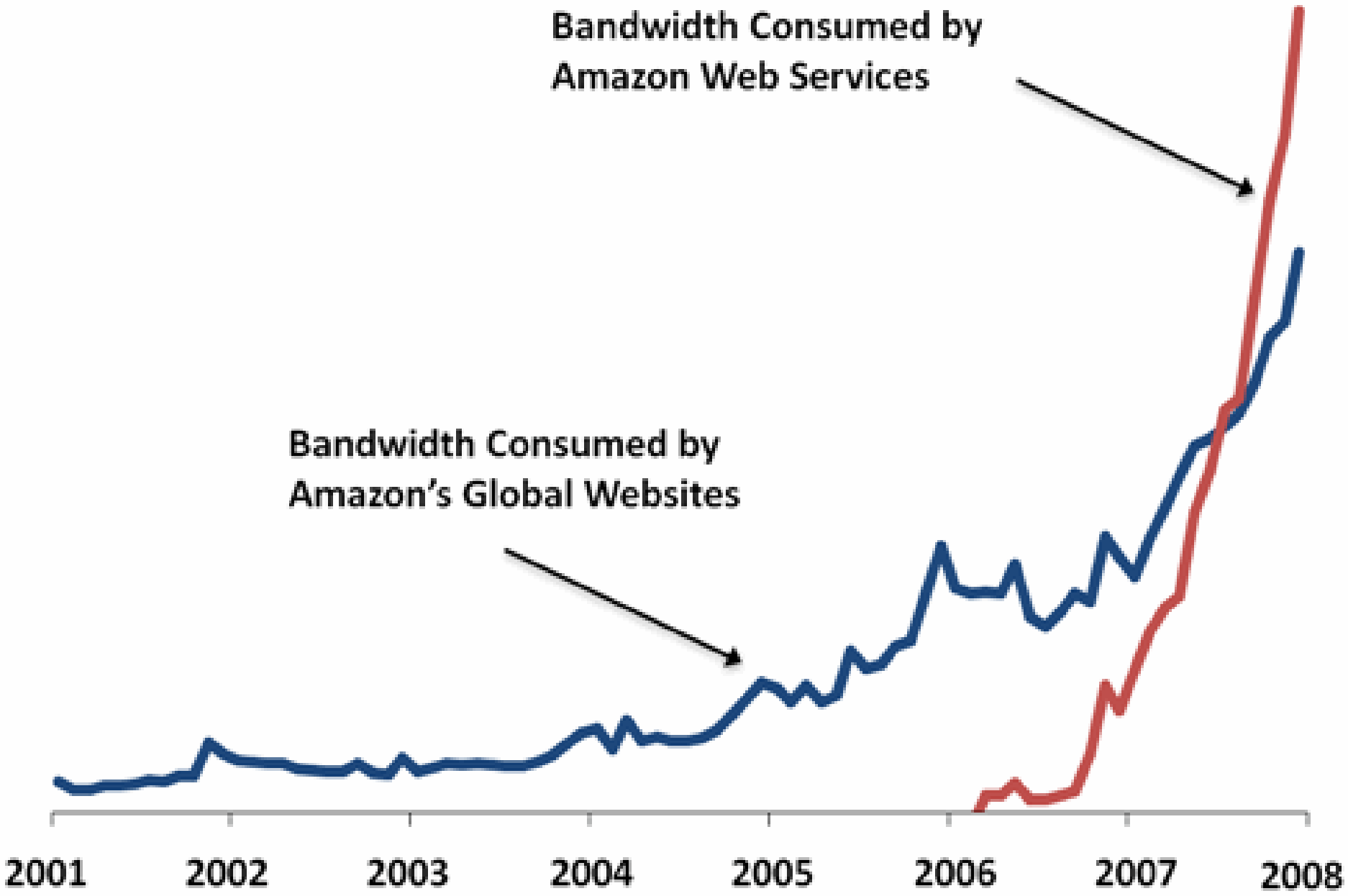
- $0.10 per hour for
  - 1 core of 1.2 GHz 32-bit Intel or AMD (1/20th the above)
  - 1.7 GB memory
  - 160 GB scratch storage
- Need it 24x7 for a year?
  - $379

- This includes
  - Purchase + replacement
  - Housing
  - Power
  - Operation
  - Reliability
  - Security
  - Instantaneous expansion and contraction
- 1000 computers for a day costs the same as one computer for 1000 days – revolutionary!

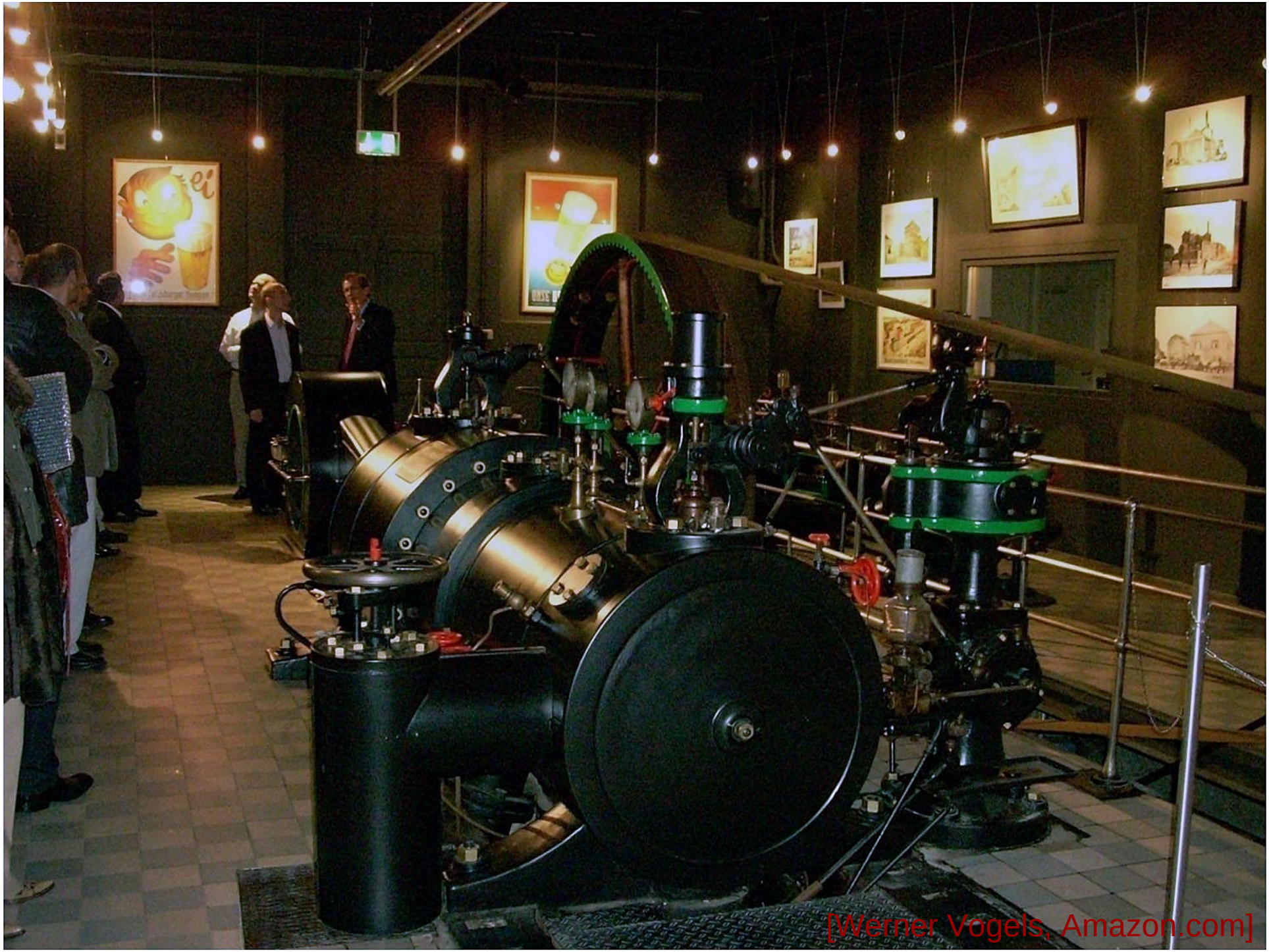
Animoto: EC2 Instance Usage



[Werner Vogels, Amazon.com]



[Werner Vogels, Amazon.com]


ei
[Werner Vogels, Amazon.com]

ICTD: Empowering the developing world

*3 billion people in the **rural developing world***
need the same information we do

- ✓ Business: new opportunities
- ✓ Finance: capital to invest
- ✓ Government: services & programs
- ✓ Health: informed, consistent care
- ✓ Education: personal advancement




[Tapan Parikh, UW and UC Berkeley]

3 billion people in the rural ***developing world***
have different limitations and capabilities

✗ Money: to buy technology

✗ Education: to use technology

✗ Infrastructure: power, connectivity

✓ Time: lots of available labor

✓ Community: lots of relations




[Tapan Parikh, UW and UC Berkeley]

CAM: Managing Information from the Grassroots

Information systems are key to scaling microfinance

- *Transaction processing*
- *Monitor members and groups*
- *Analyse performance and impact*
- *Offer more services*
- *Link to formal institutions*

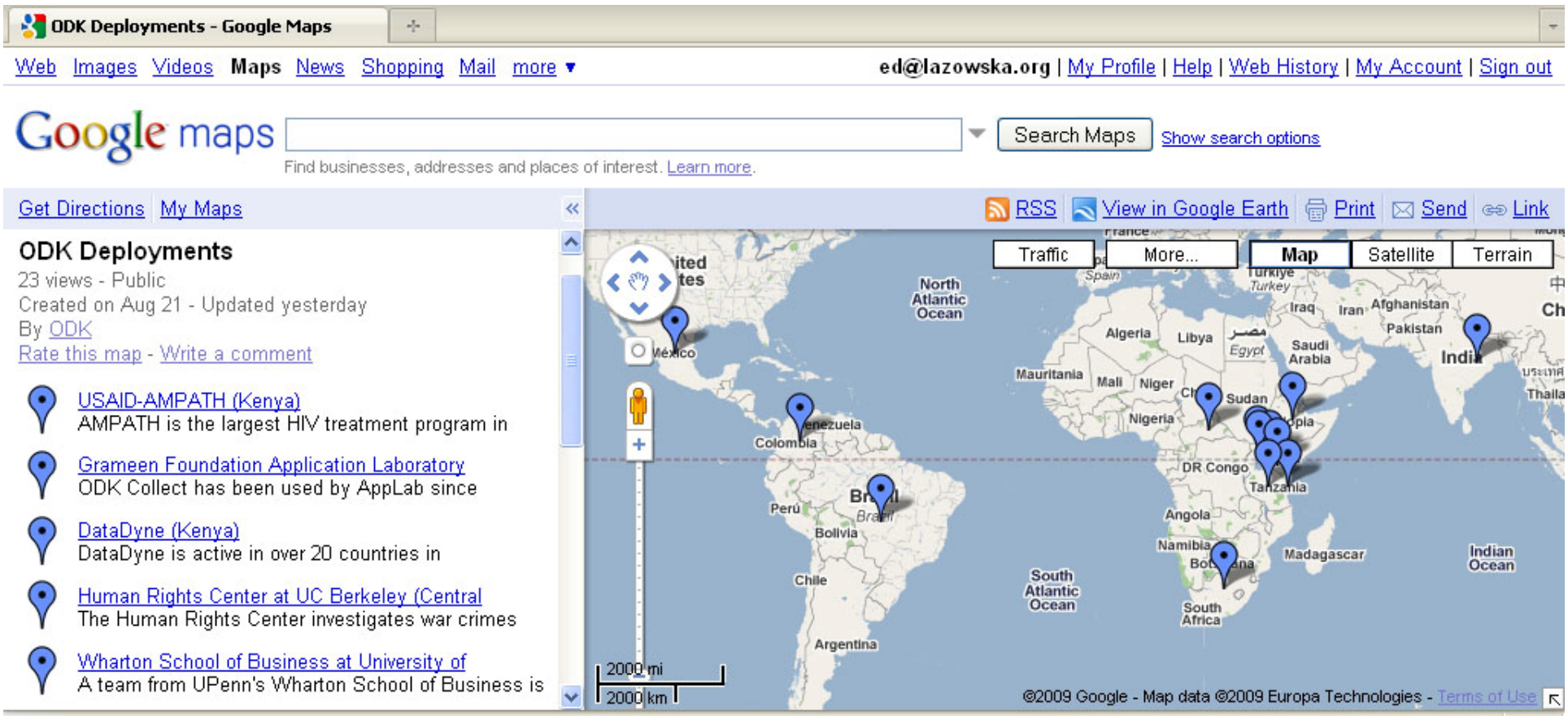
Can we design a UI to document member-level SHG transactions?

- *Accurate and efficient*
- *Accessible to a variety of users*



[Tapan Parikh, UW and UC Berkeley]


[Tapan Parikh, UW and UC Berkeley]

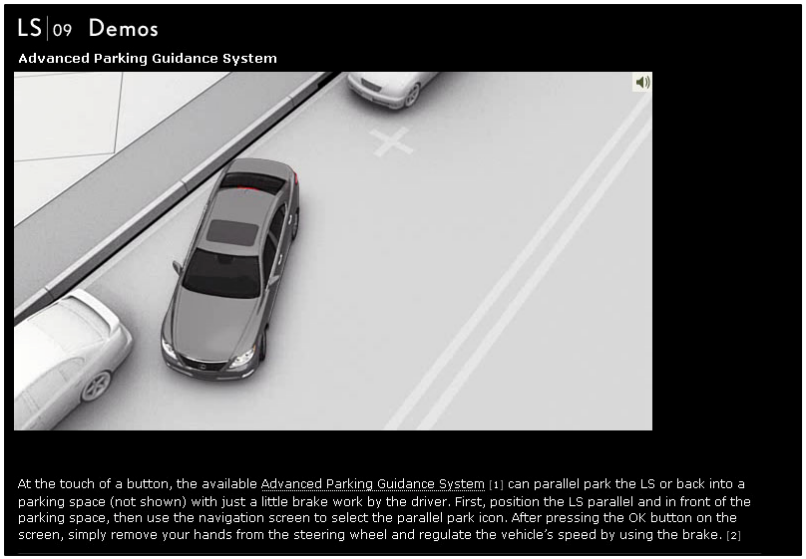


Open Data Kit

[Gaetano Borriello, UW and Google]

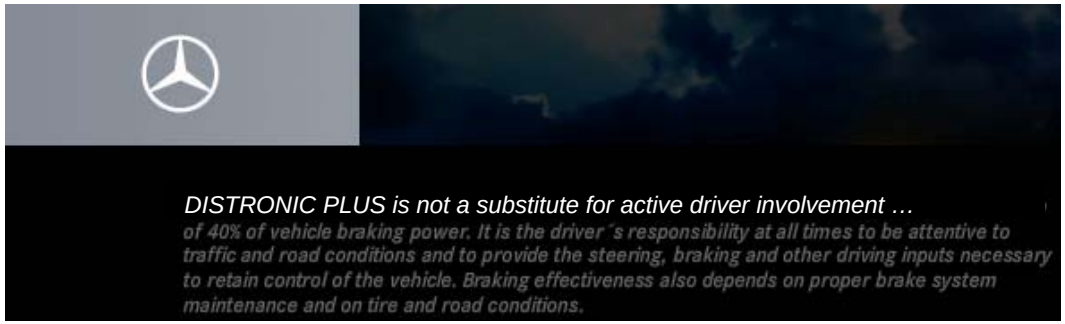
Revolutionizing transportation

← Lane departure warning



← Self-parking

← Adaptive cruise control

- 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
  - ~ $500 billion (that's *half a trillion dollars* …) in *annual* economic cost
    - 200 times greater than even an extravagant estimate of the nation's annual investment in computing research
  - 

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 disadvantages
- The economic and environmental costs of manufacturing automobiles

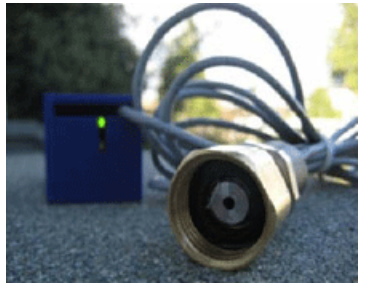
And computing research can help!

- 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

Transportation is one element of energy

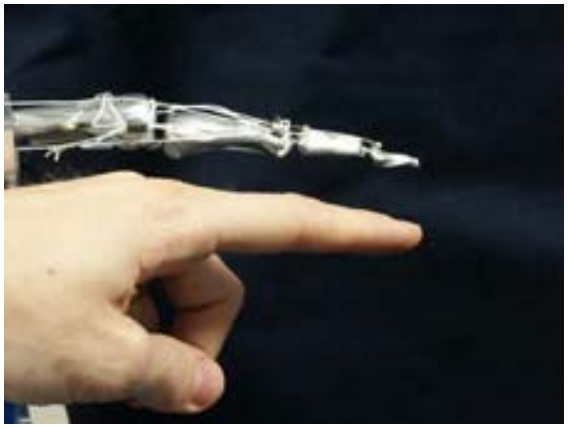
- The smart grid
  - Engineering
  - Control
  - Conservation (intelligent structures)

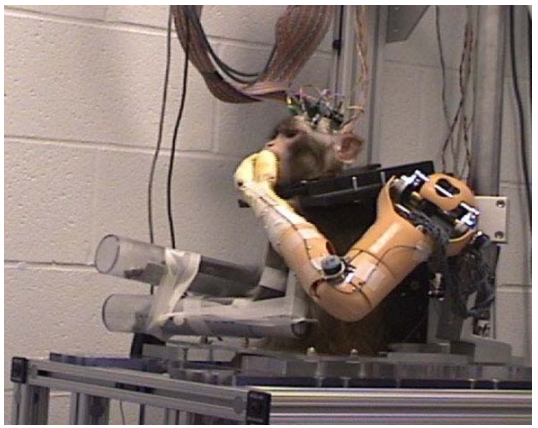
- IT as a substitute for energy-intensive goods and services
- IT as a tool for discovering and designing new energy sources
- Improved energy efficiency in computation



[Shwetak Patel, UW]

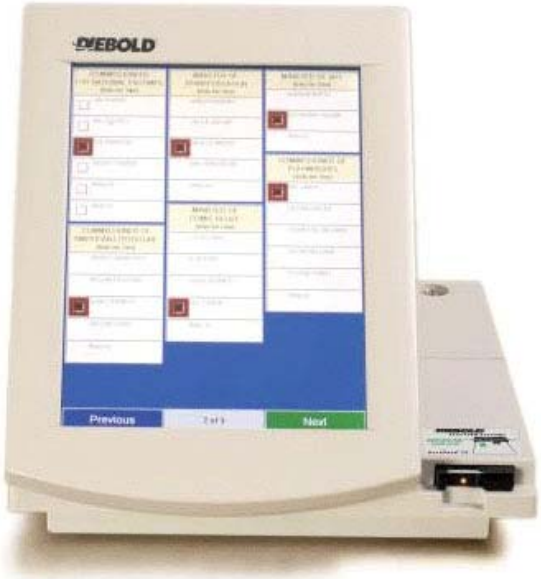
Neurobotics

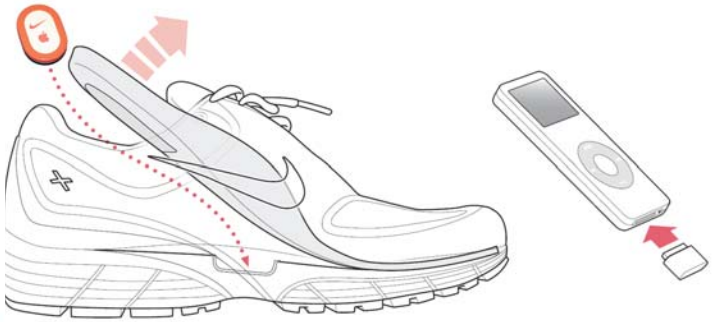




[Yoky Matsuoka and Raj Rao, UW]

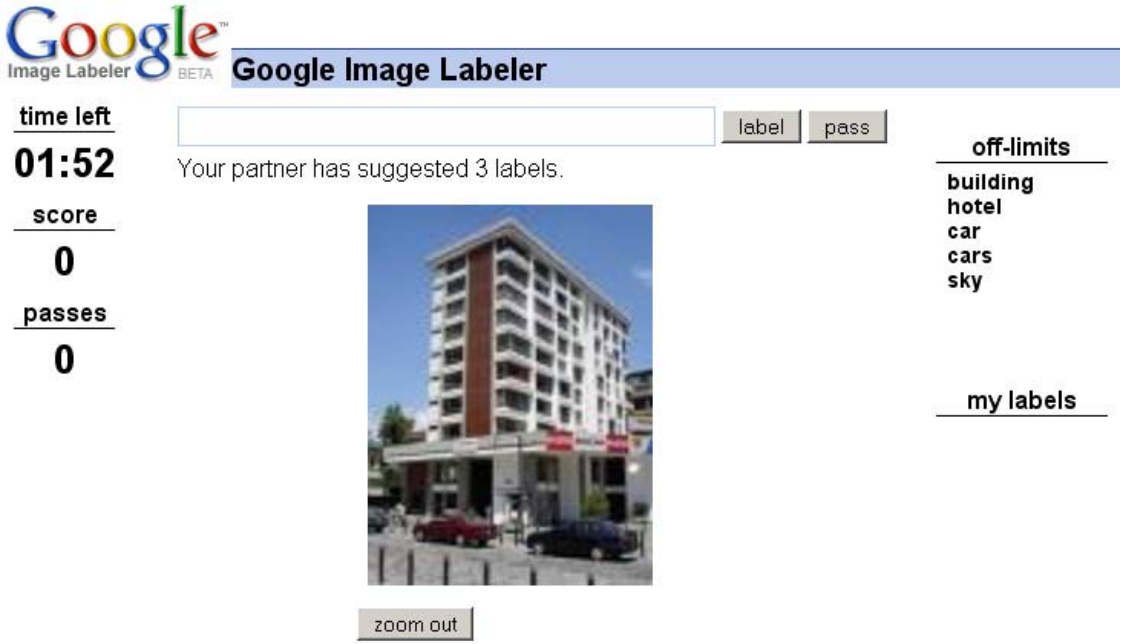
Security and privacy



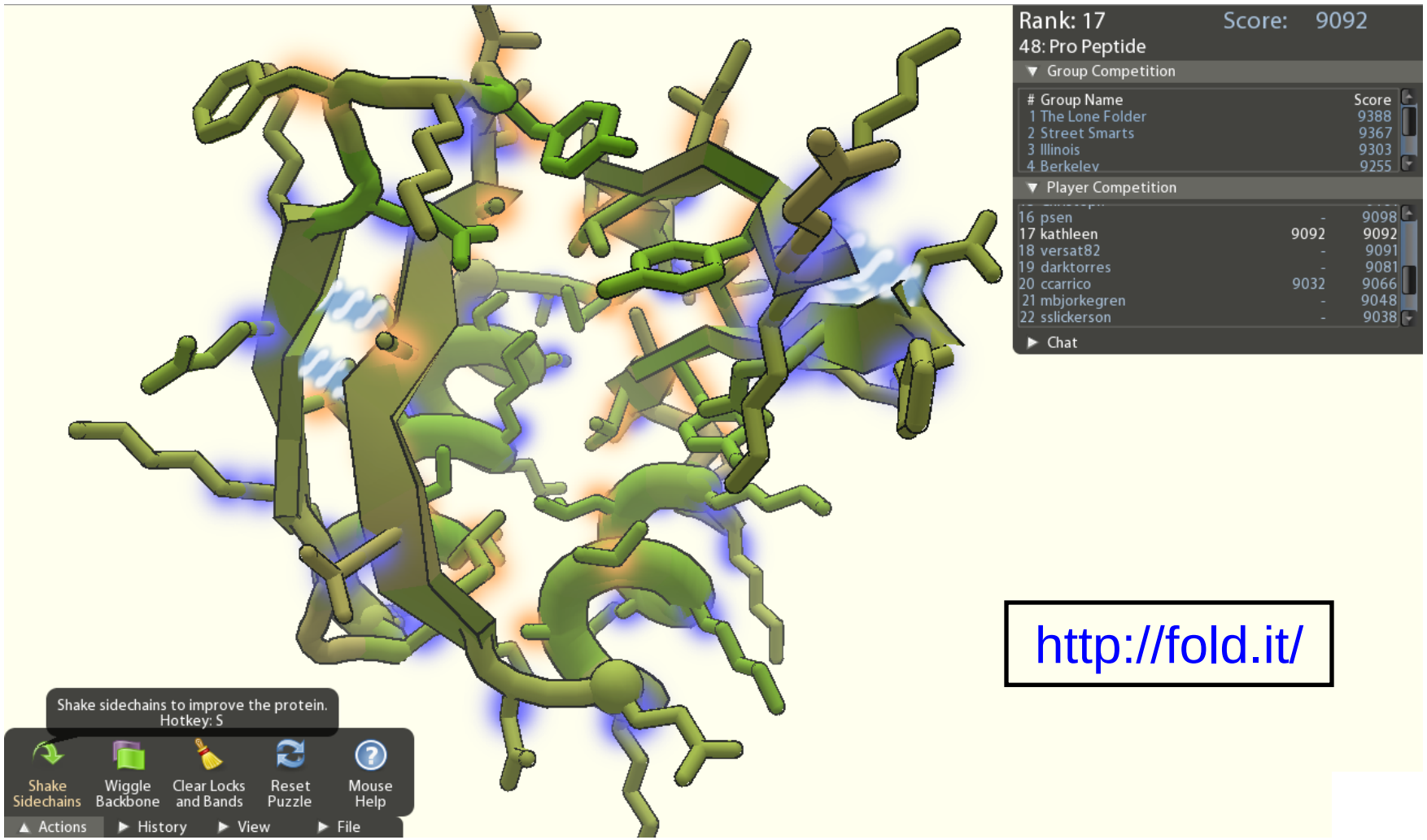


[Yoshi Kohno, UW]

Human-computer systems



[Luis von Ahn, CMU]

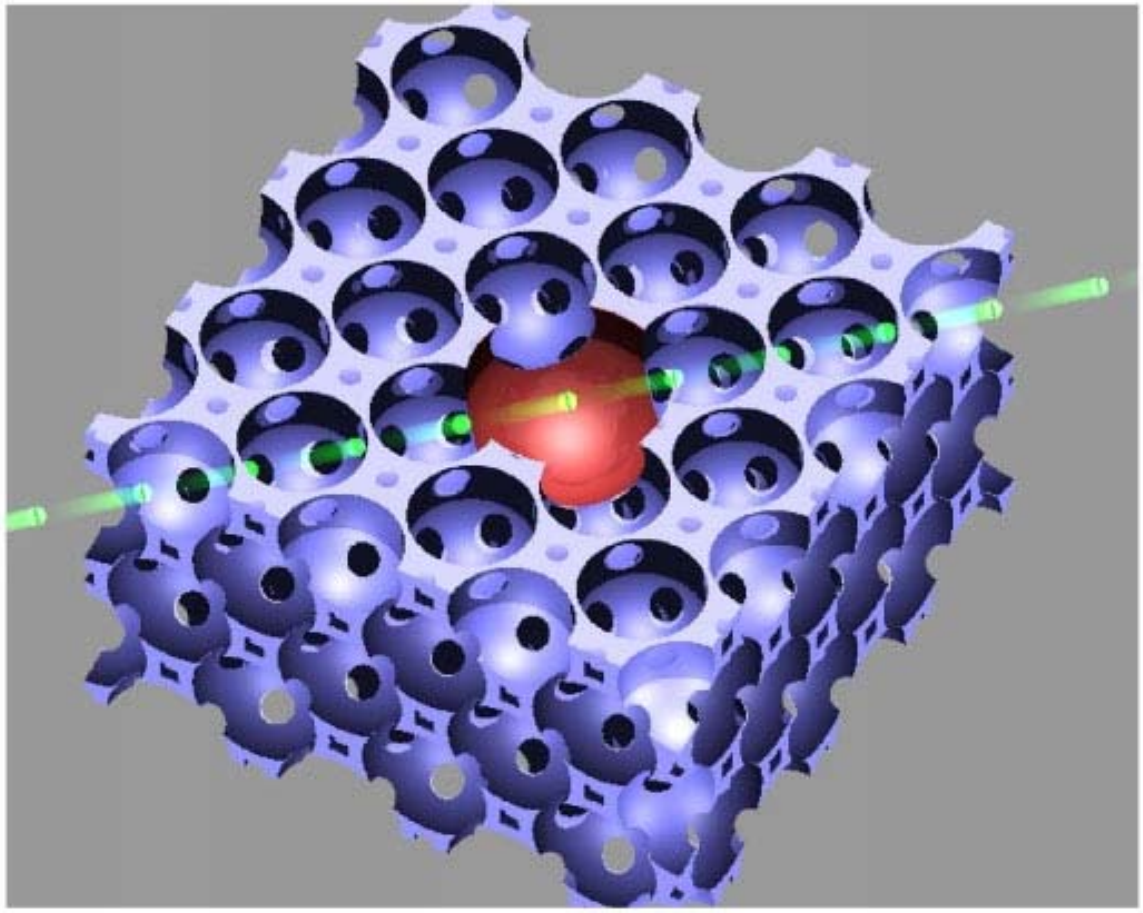


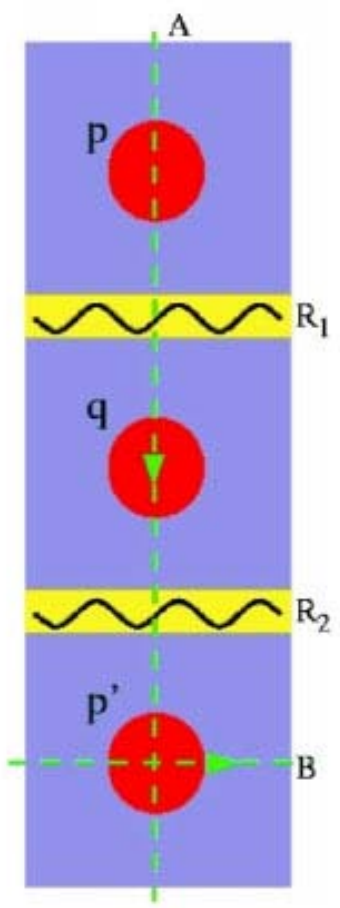
http://fold.it/

[David Baker and Zoran Popovic, UW]

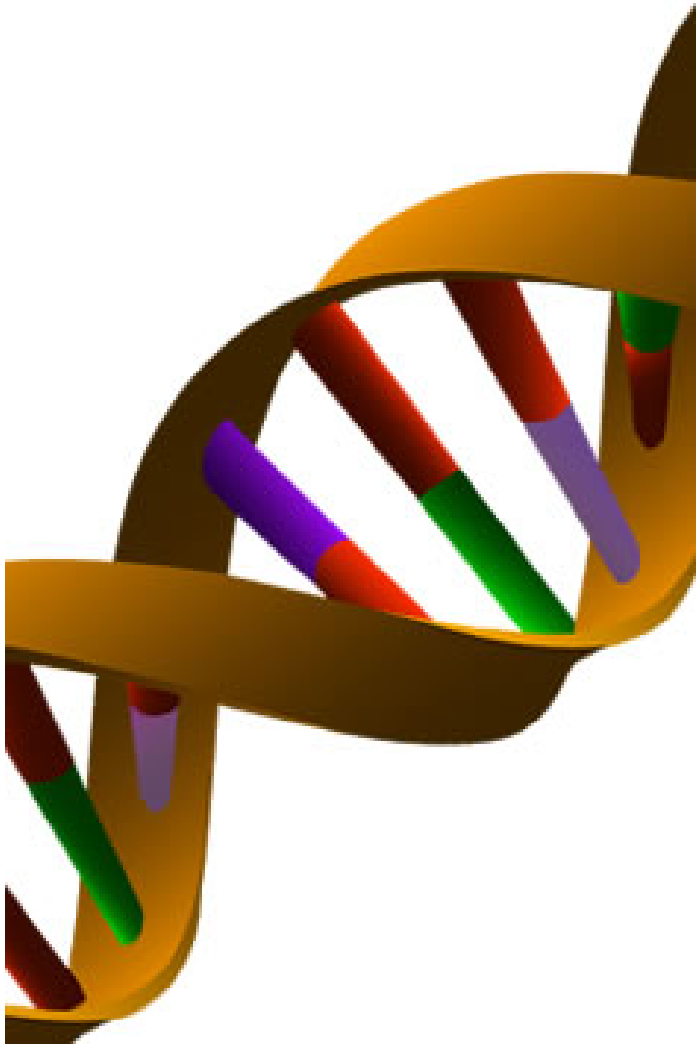
Personalized education

Quantum computing

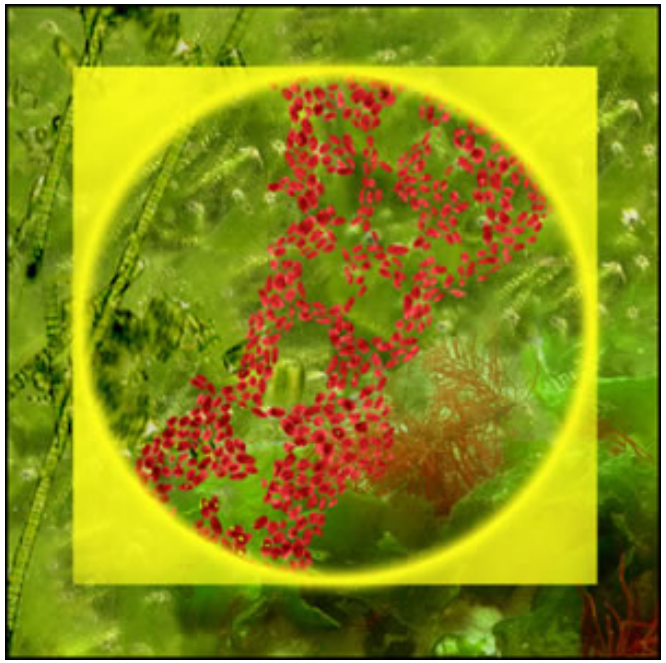


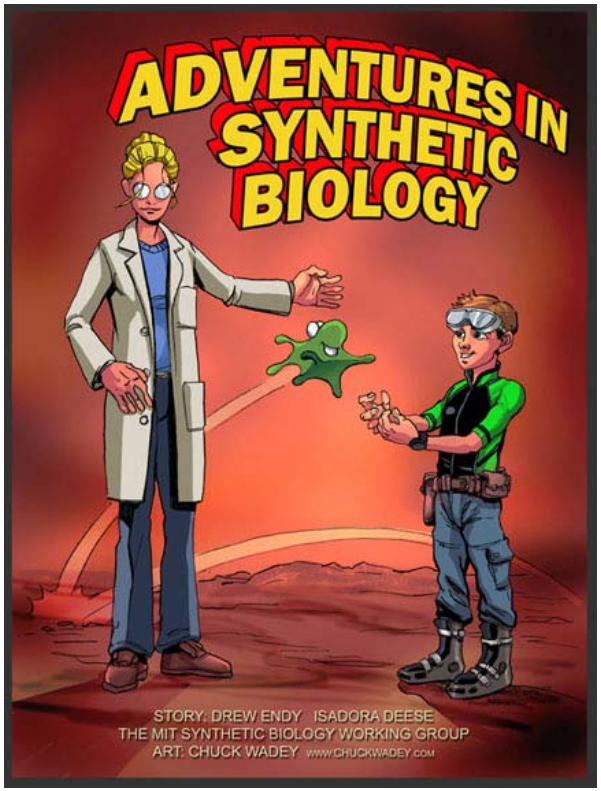


Predictive, preventive, personalized medicine



Synthetic biology / molecular engineering





Personalized health monitoring => quality of life => IT and health

Omron pedometer

Nike + iPod

Bodymedia multi-function

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

Glucowatch: measuring body chemistry

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.

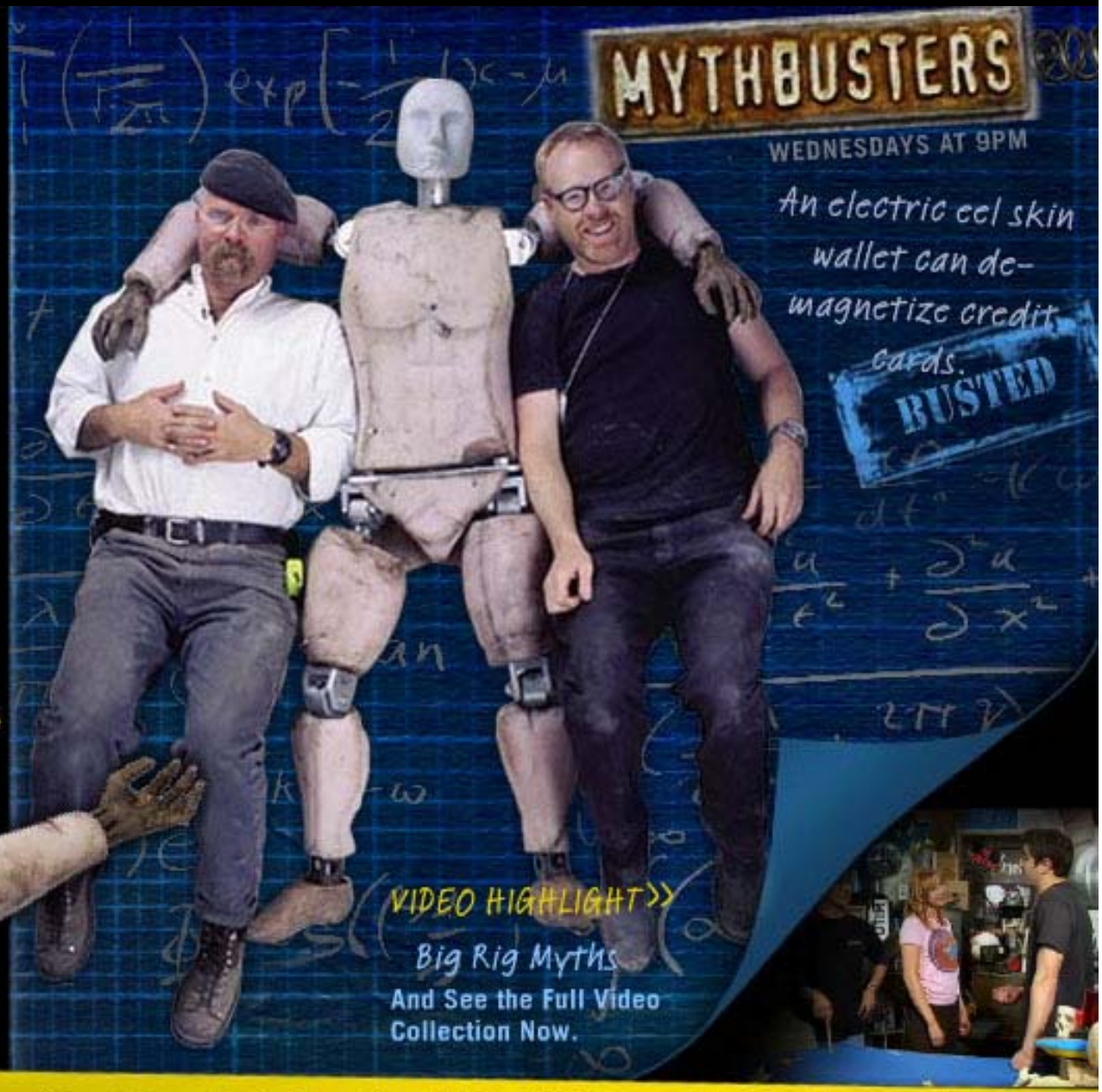
JOIN THE MESSAGE BOARD

"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

[Your part goes here]

- What are *your* compelling visions for the field?
- How can the CCC facilitate your pursuit of them?

http://www.cra.org/ccc/

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

Computing Community Consortium

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