

# Computer Science: Past, Present, and Future

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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!

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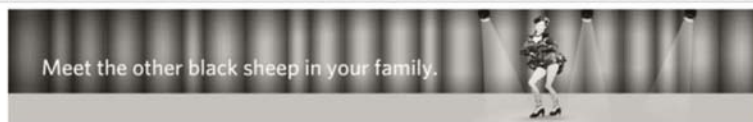


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THE COUNT

Internet, Mobile Phones Named Most Important Inventions

By PHYLLIS KORRKKI  
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.

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2. PC and laptop computers
3. Mobile phones
4. E-mail
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20. Internet social networking

THE NEW YORK TIMES

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

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### Named Most Important Inventions

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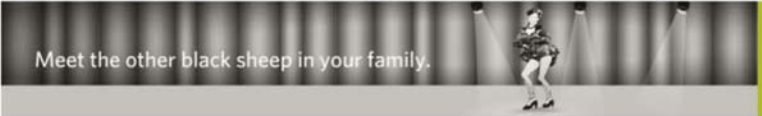
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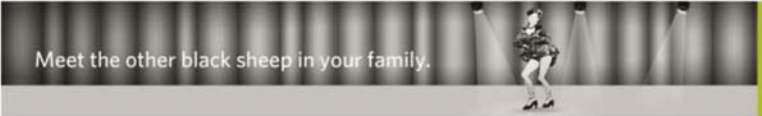
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# Landmark contributions by students



- 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

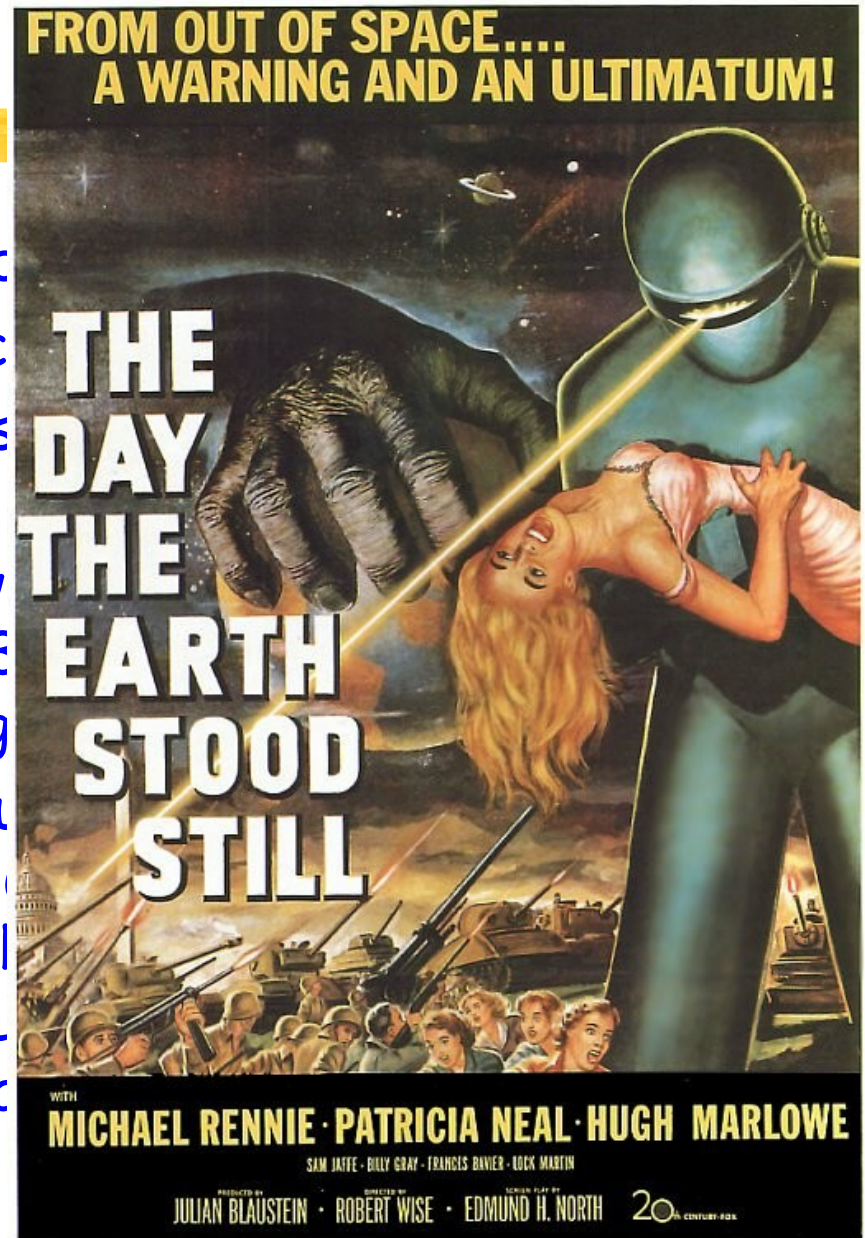
# Imagine spending a day without information technology



- 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

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

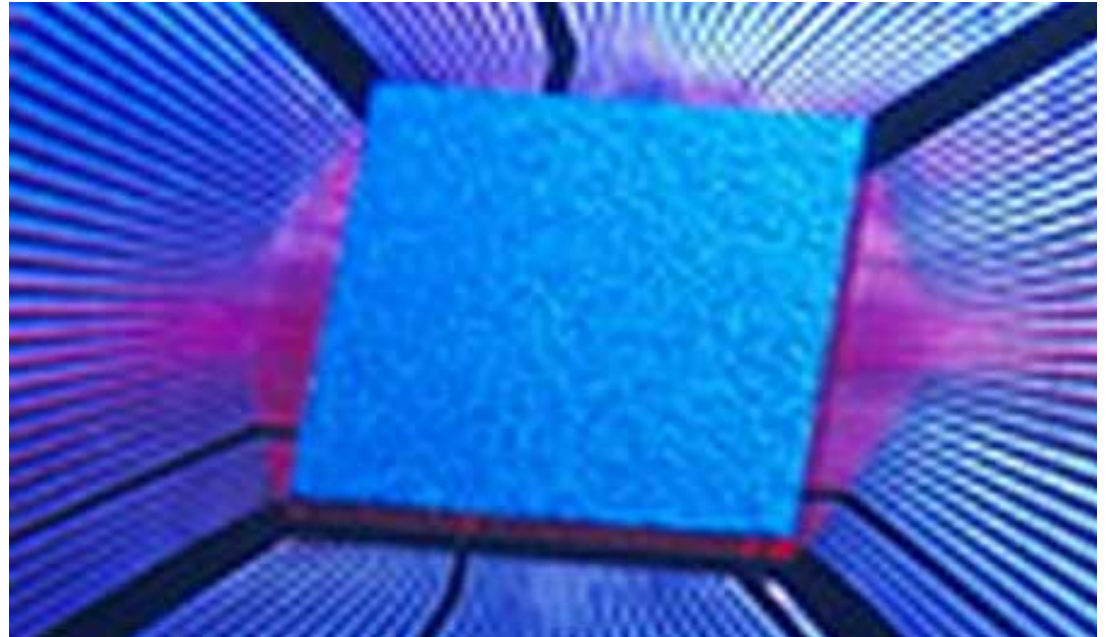
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- Ten quintillion:  $10 \cdot 10^{18}$ 
  - The number of grains of rice harvested in 2004



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

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



# The transistor

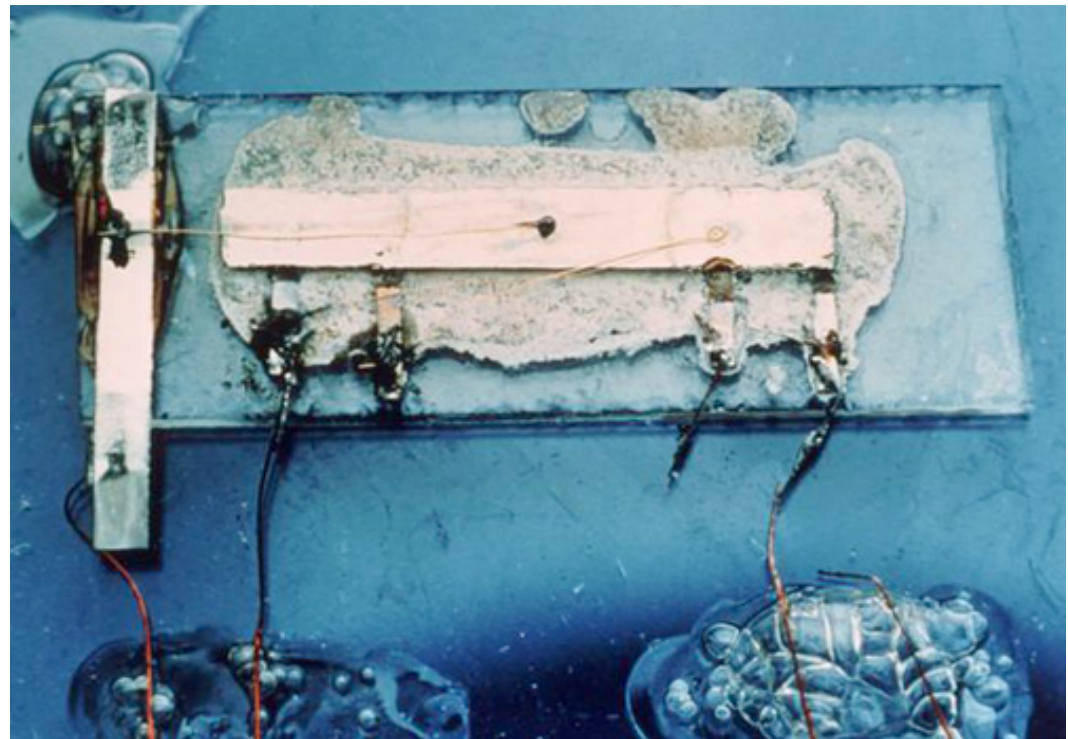
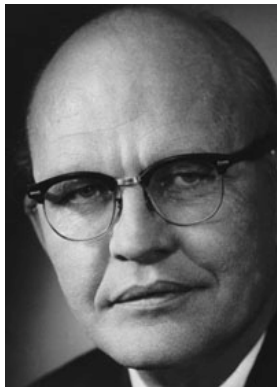
- William Shockley, Walter Brattain and John Bardeen, Bell Labs, 1947





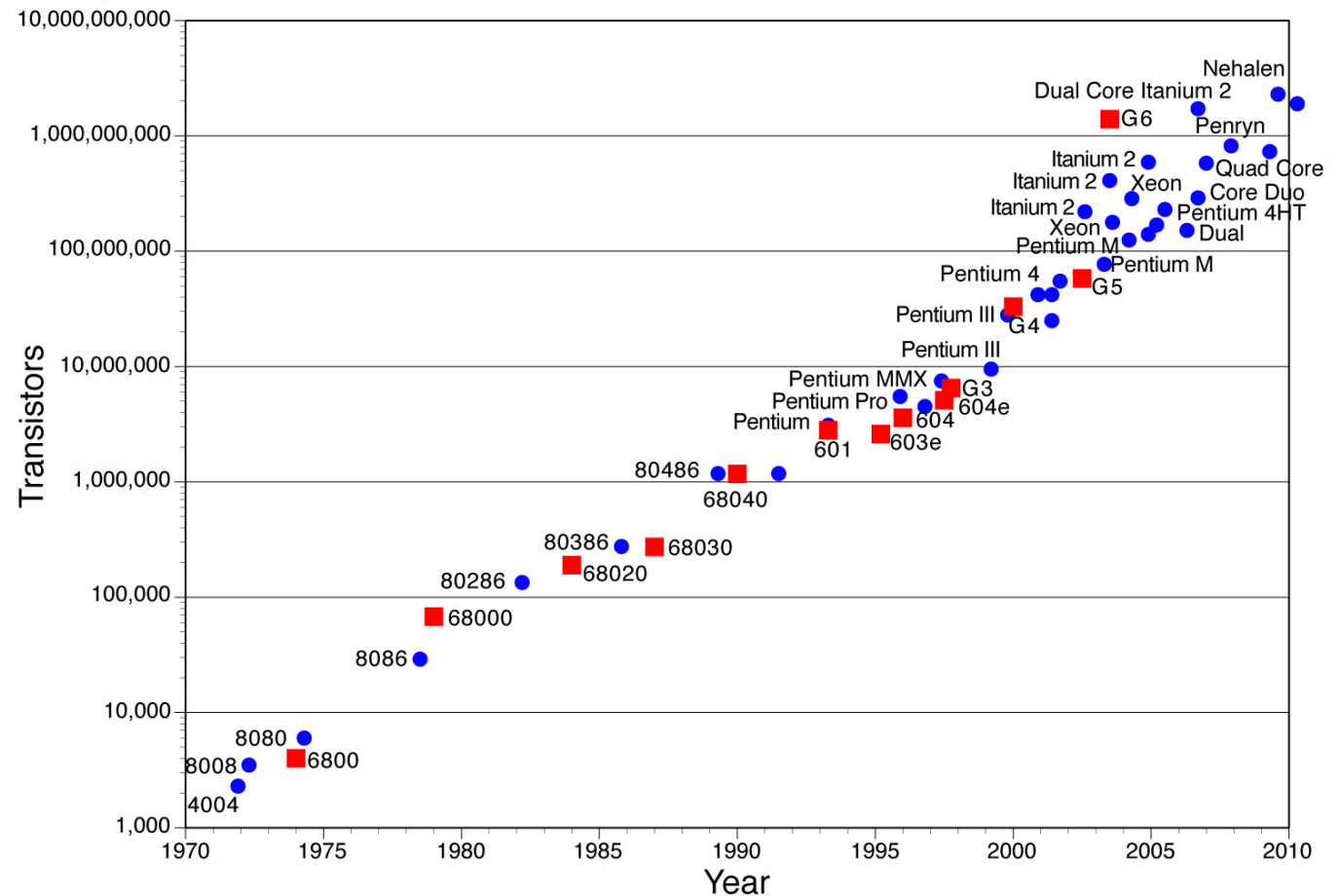
# The integrated circuit

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



# Exponential progress

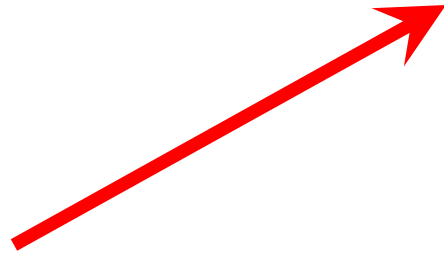
## Gordon Moore, 1965







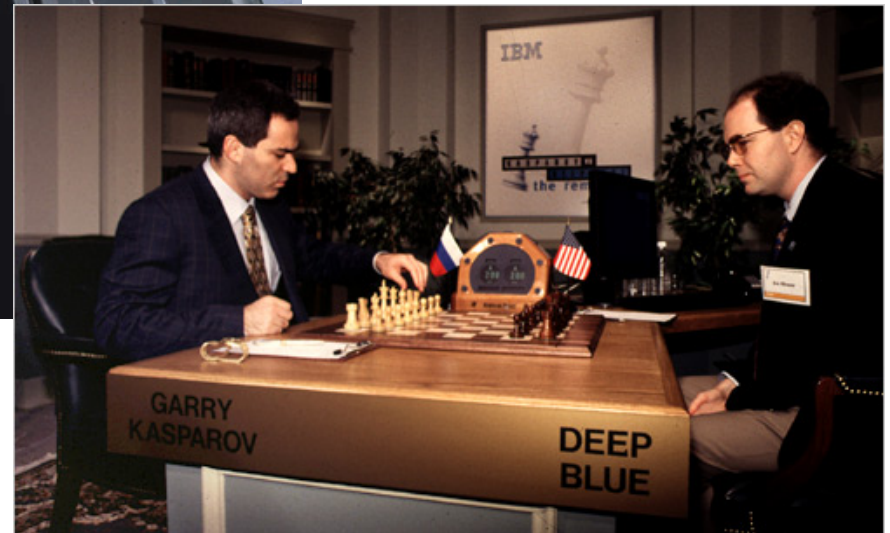


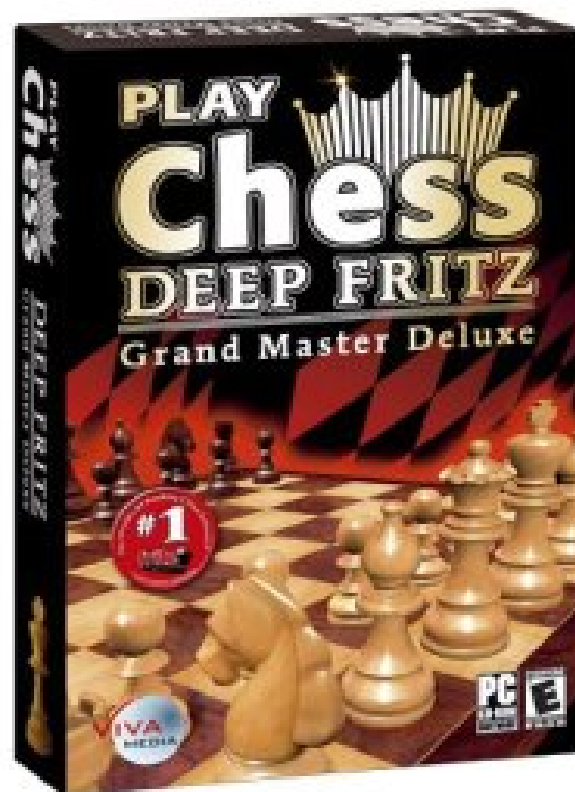


# Algorithms make remarkable progress too!



Deep Blue, 1997





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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

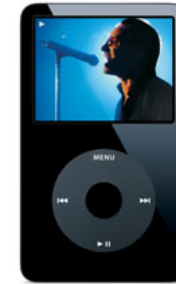


"There is no reason anyone would want a computer in their home" - Ken Olsen, founder and President of Digital Equipment Corporation, 1977

Today: More than 1 billion PCs in use ...

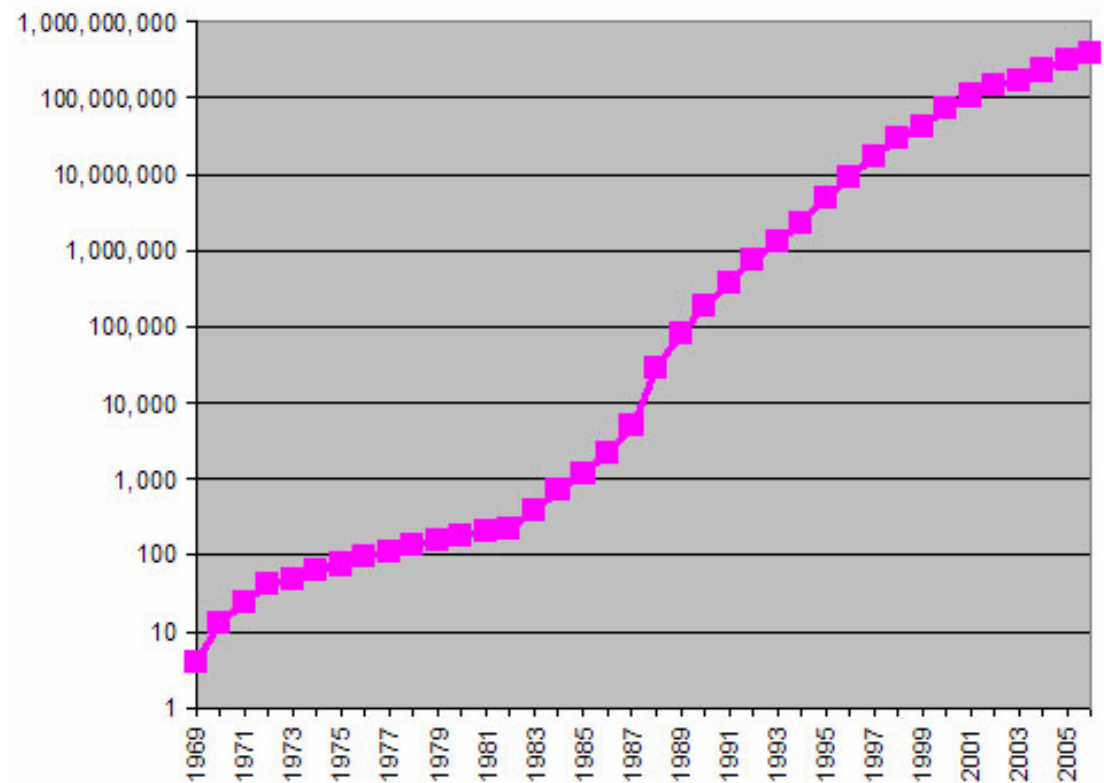


# Representing less than 2% of all processors!



# Number of Internet hosts

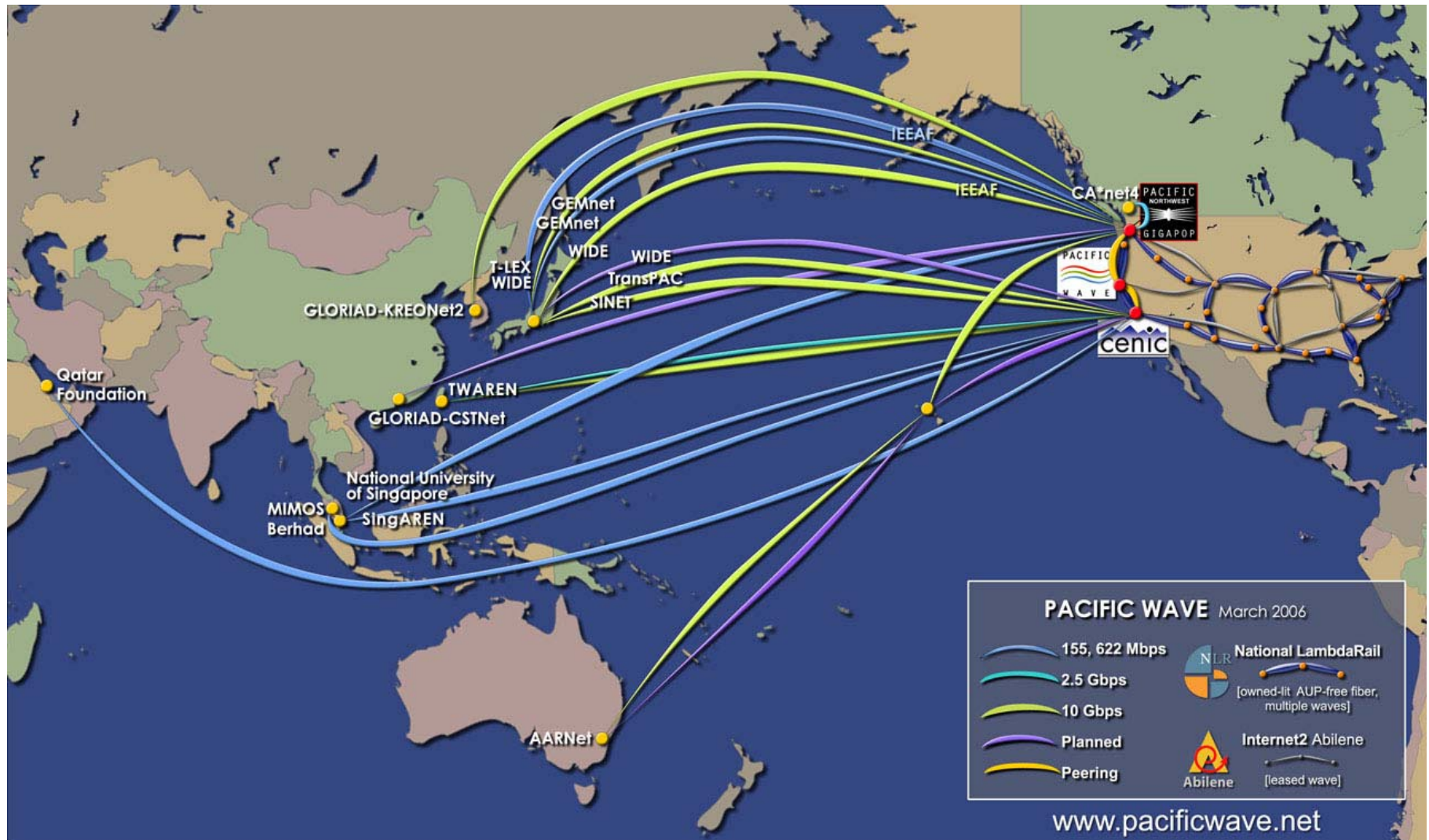
- 1970: 10
- 1975: 100
- 1980: 200
- 1985: 2,000
- 1990: 350,000
- 1995: 10,000,000
- 2000: 100,000,000
- 2005: 400,000,000



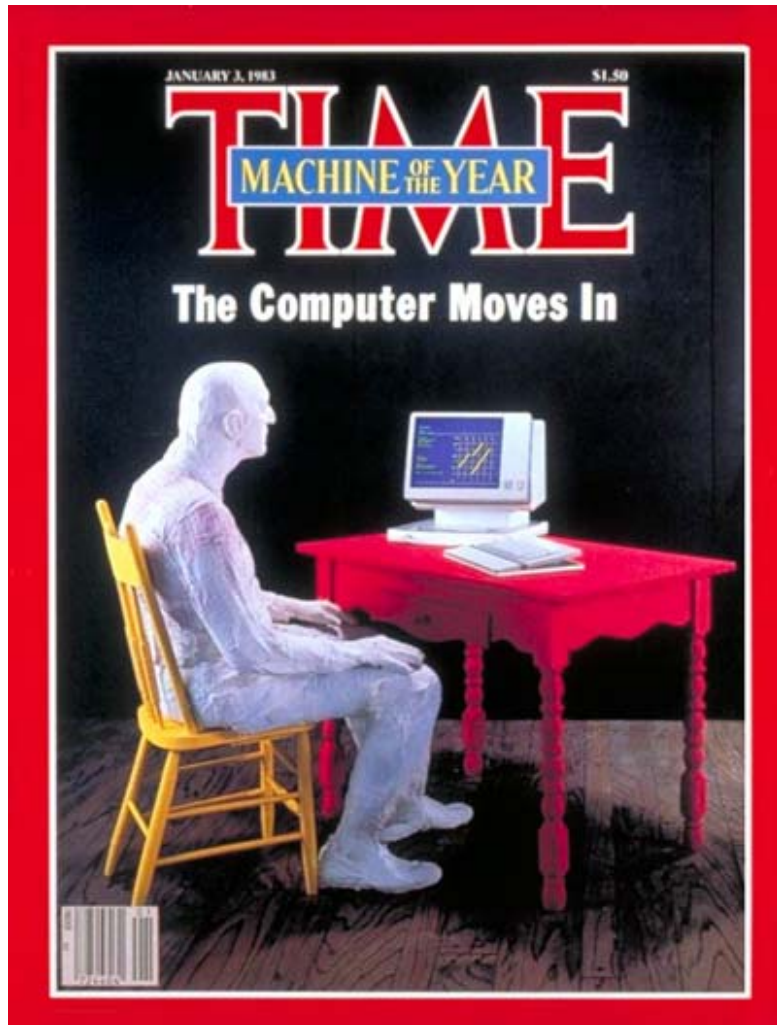
# A connected region - then



# 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."

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- 
- "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



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- “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



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

clean your gutters



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amuse your pet



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detonate your IED's



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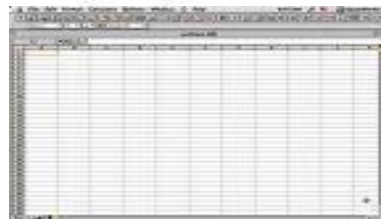
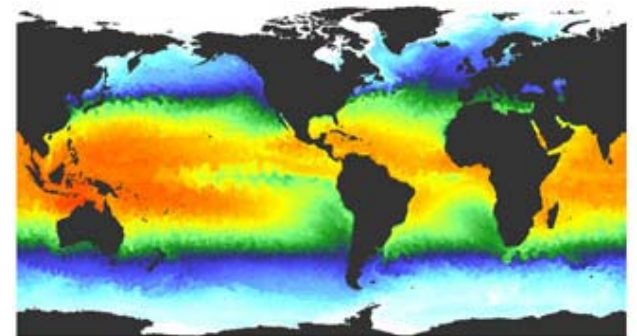
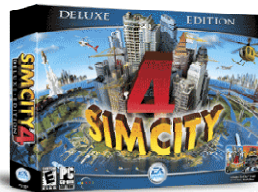
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*We support the computing research community in creating compelling research visions and the mechanisms to realize these visions.*

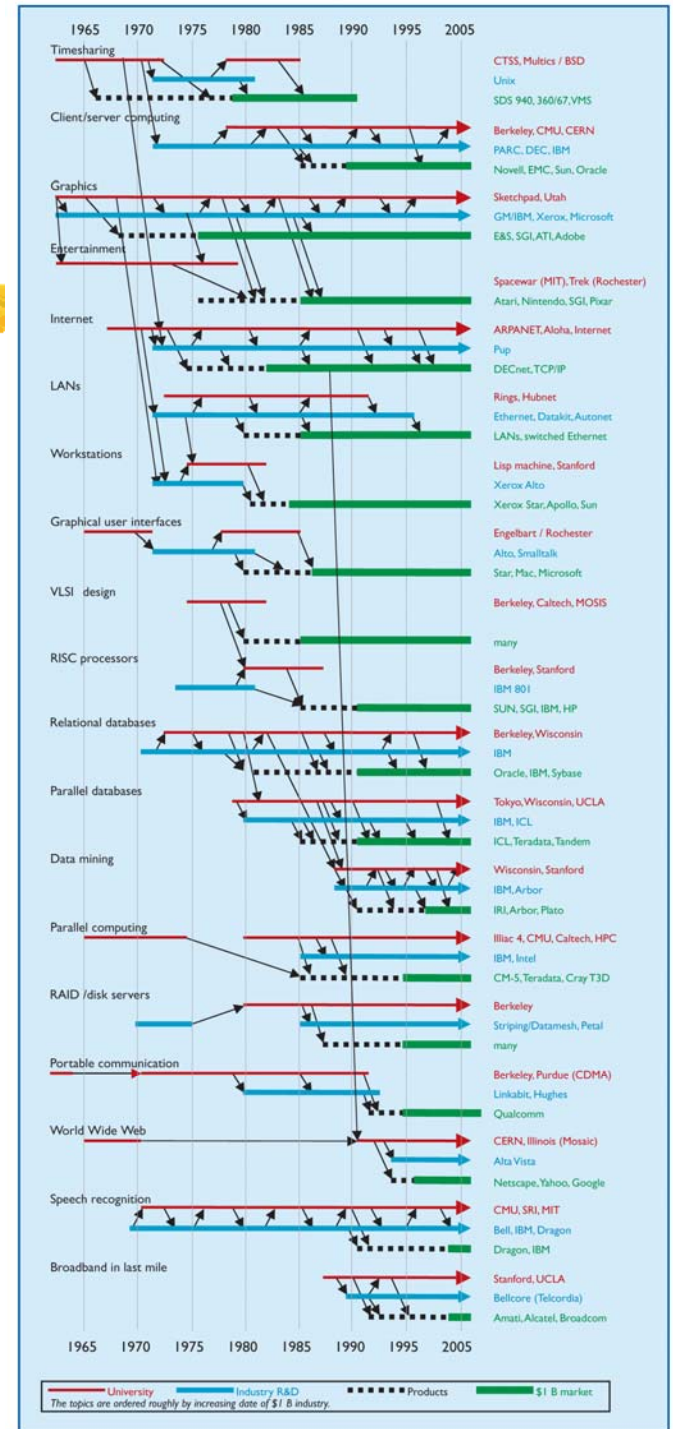
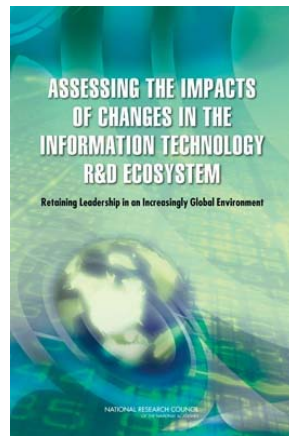
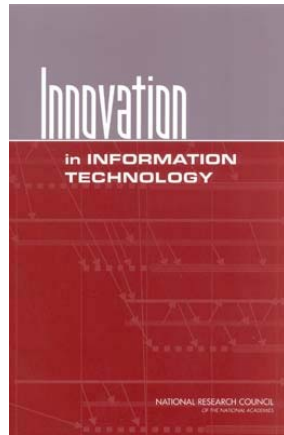
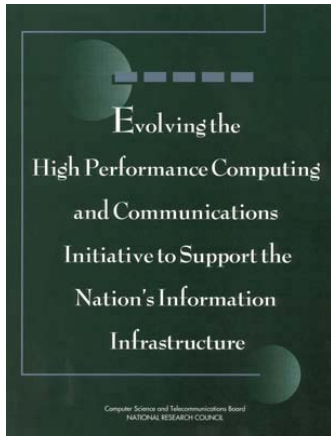


# Computing has changed the world

- 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

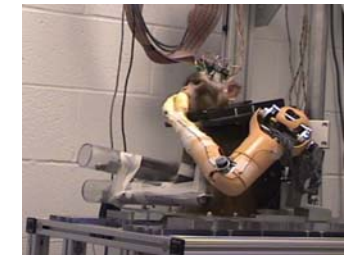
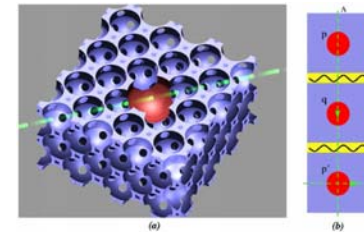
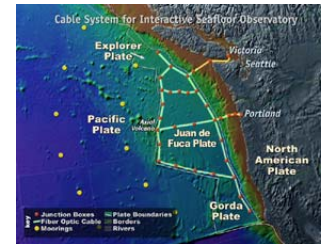
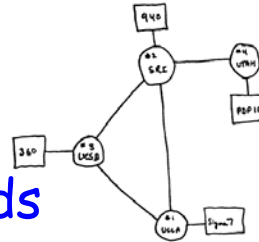


# Research has built the foundation



# 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

The screenshot displays the Computing Community Consortium (CCC) website. At the top, the CCC logo and name are visible. Below the header, a navigation bar includes 'HOME' and 'COMPUTING RESEARCH HIGHLIGHT OF THE WEEK [August 14 - 21, 2009]'. A featured article titled 'Cornell Computer Scientists Track the News Cycle' is highlighted. To the right, a 'Relevant Links' section lists 'Press Release', 'Research Papers', and 'Media Contact'. The main content area features the 'CCC BLOG' header and navigation links for 'HOME', 'ABOUT THE CCC', and 'ABOUT THIS BLOG'. A featured blog post from August 28th is titled 'Landmark Contributions by Students in Computer Science'. The post text discusses research funding agencies (DARPA, NSF, etc.) and the importance of investing in student education. It lists several individuals and their affiliations who compiled an inspiring list of student contributions. The post concludes with a solicitation for suggestions for additional student contributions and a link to 'Here's the list!'. A sidebar on the left contains a 'Subscribe to this Blog' section with an RSS icon and a 'Recent Posts' section listing various articles.

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!](#)



# March: Library of Congress Symposium

*The* LIBRARY of CONGRESS

Computing Research That Changed The World



## 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



Computing Community Consortium

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

## 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



Computing Community Consortium

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### 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



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## 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



Computing Community Consortium

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# 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 positions 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 20<sup>TH</sup> CENTURY

◆ About ◆ Timeline ◆ The Book

## 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 Engineering Achievements OF THE 20<sup>TH</sup> CENTURY

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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





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



CHALLENGES	IDEAS	NEXT STEPS	COMMITTEE
------------	-------	------------	-----------



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



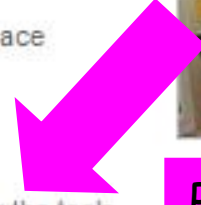
Enhance virtual reality



Advance personalized learning



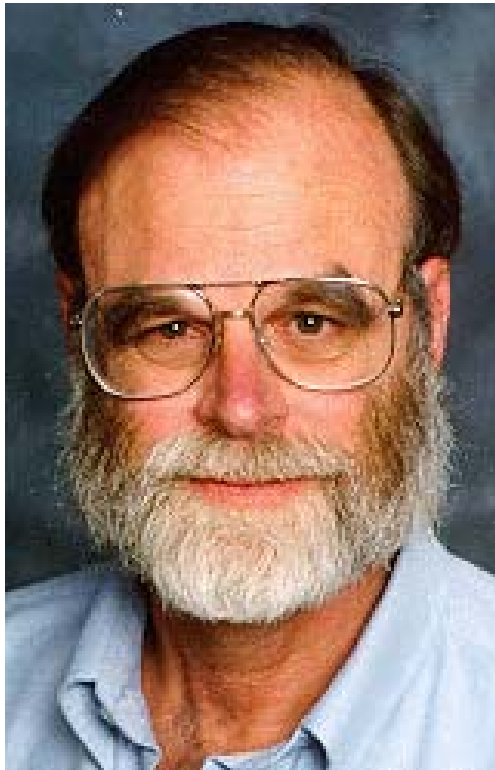
Engineer the tools of scientific discovery



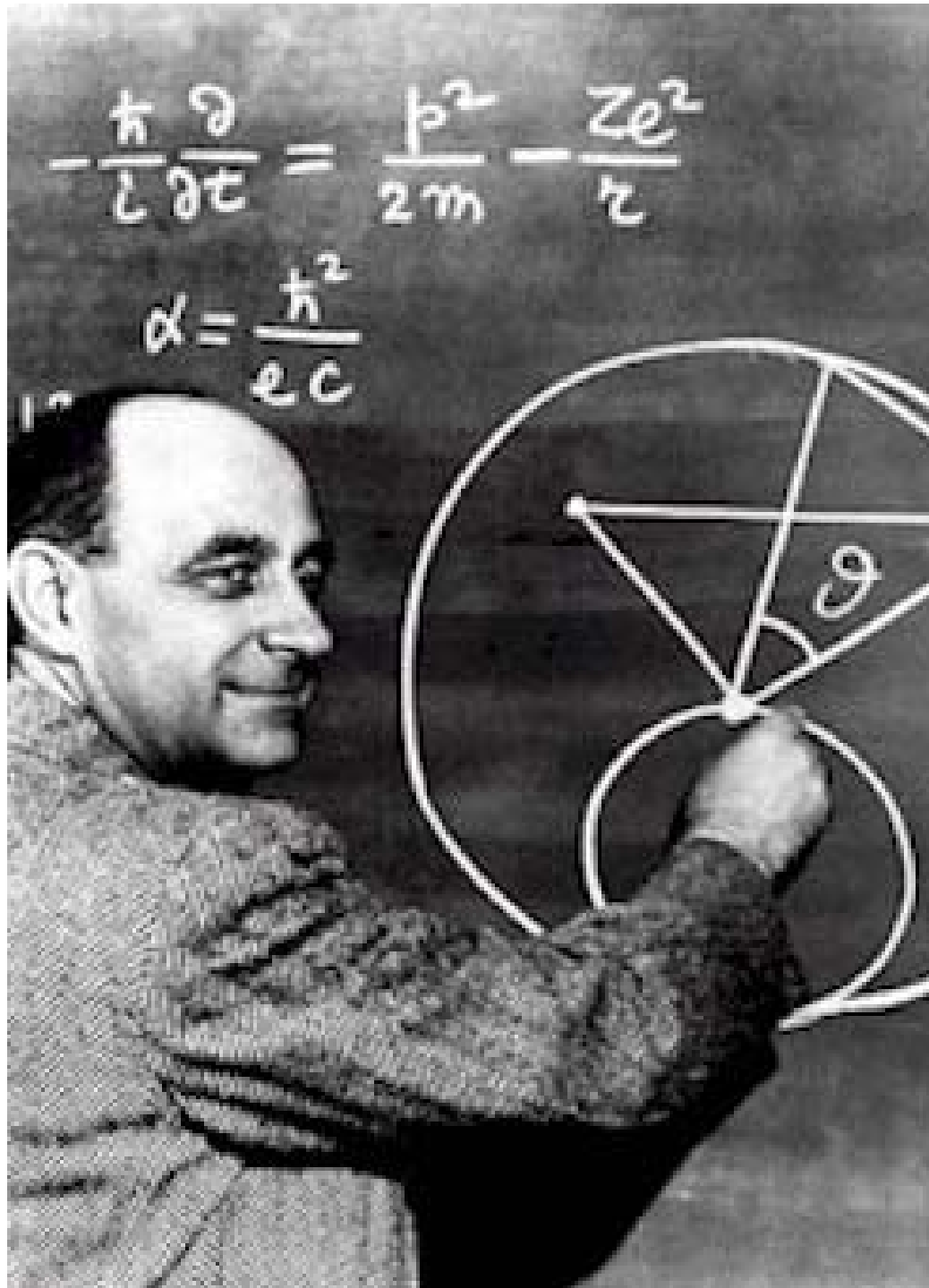
Predominant CS component

Significant CS component

# eScience: Computational science for the 21<sup>st</sup> century



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**

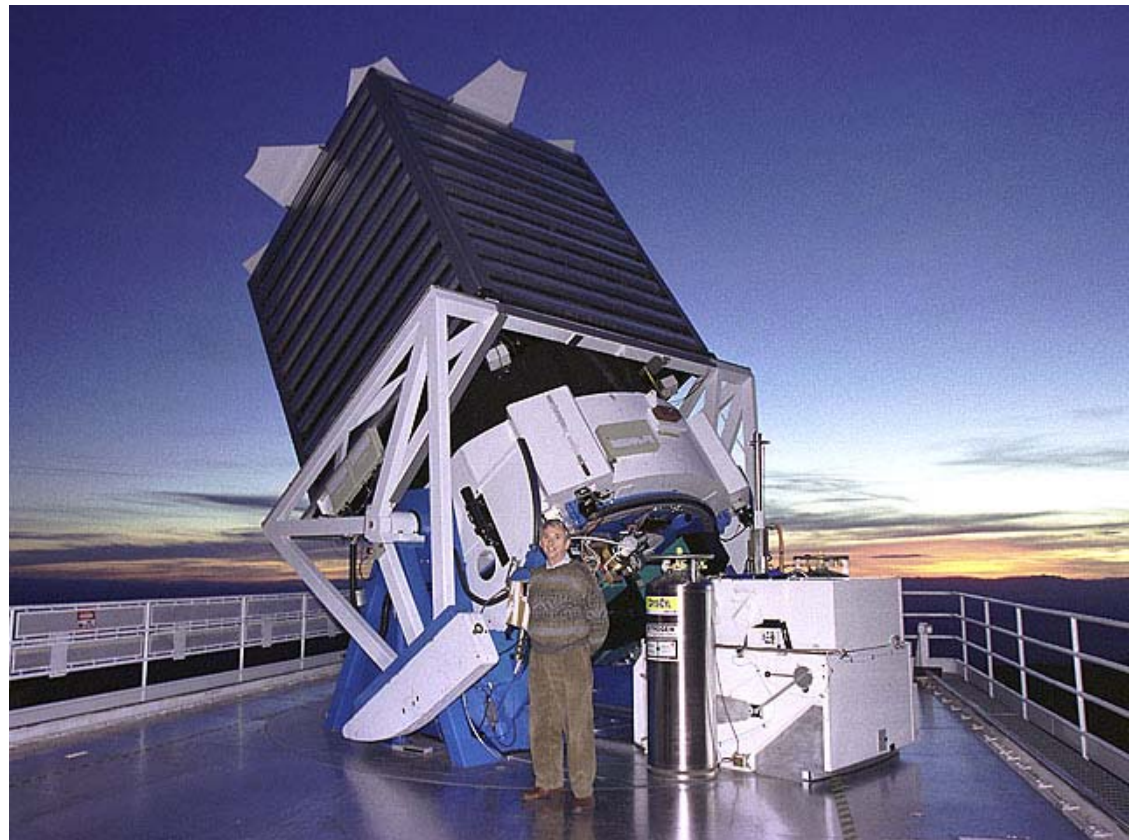


# eScience is driven by *data*

- Massive volumes of data from sensors and networks of sensors

**Apache Point telescope,  
SDSS**

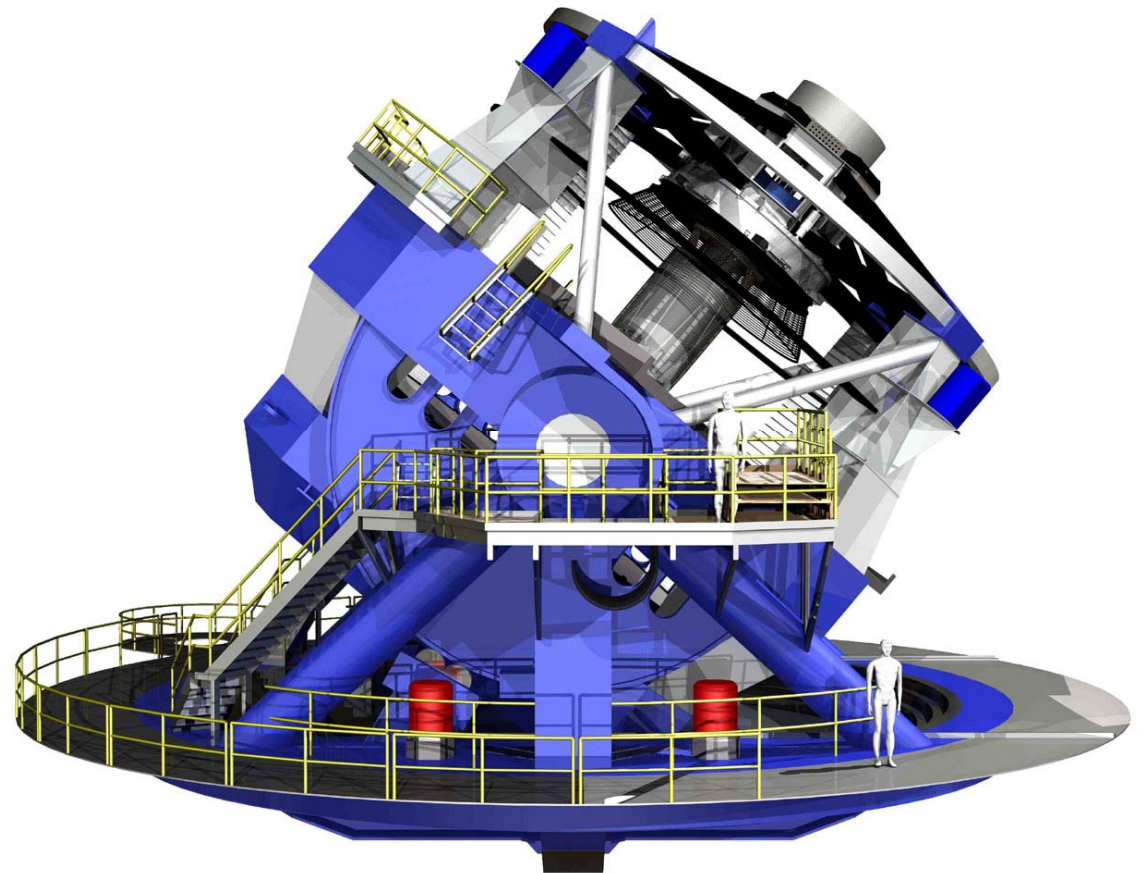
**15TB of data  
(15,000,000,000,000 bytes)**





**Large Synoptic Survey  
Telescope (LSST)**

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

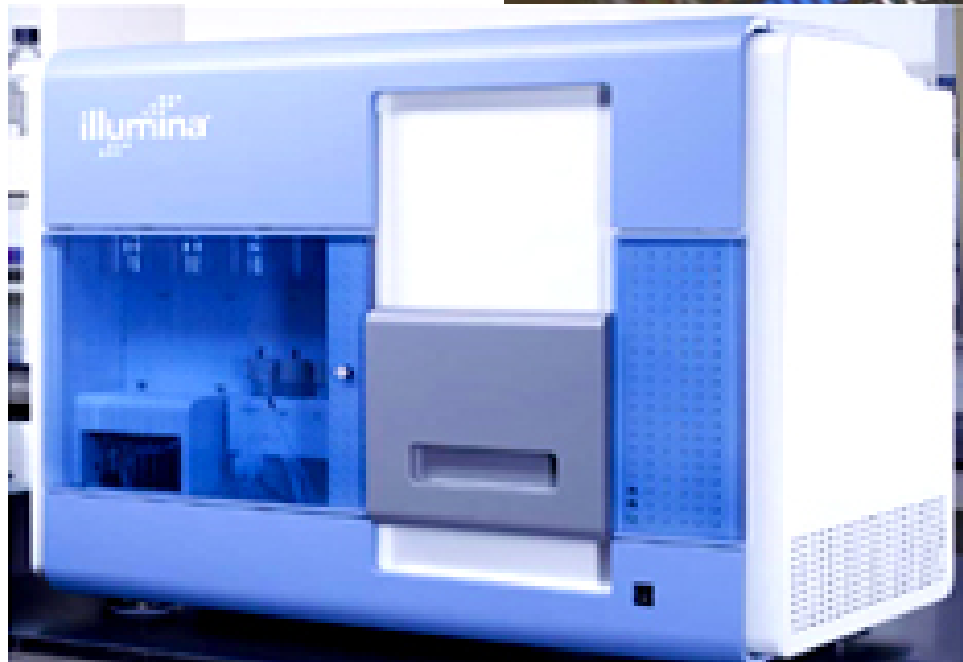




**Large Hadron Collider**

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

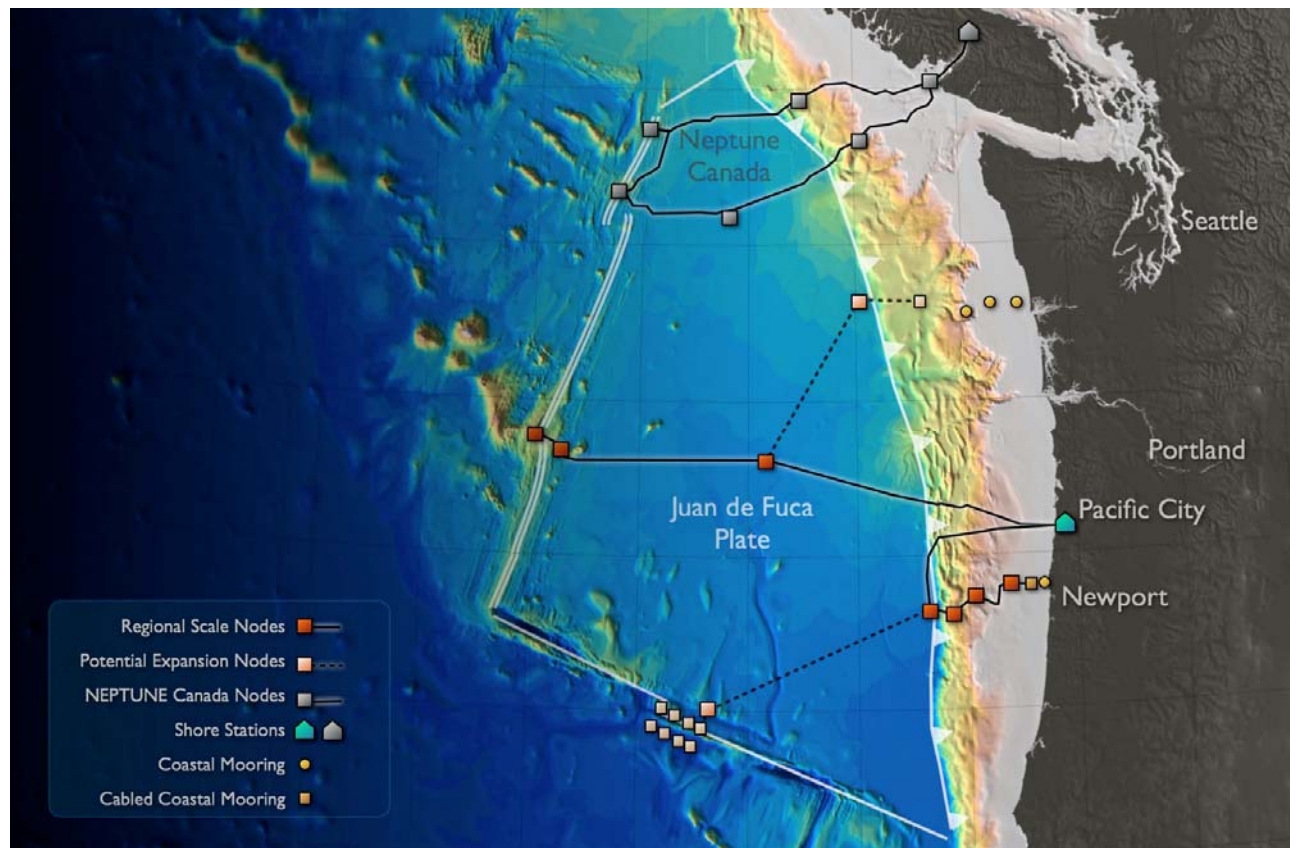




**Illumina Genome  
Analyzer  
~1TB/day**

# 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

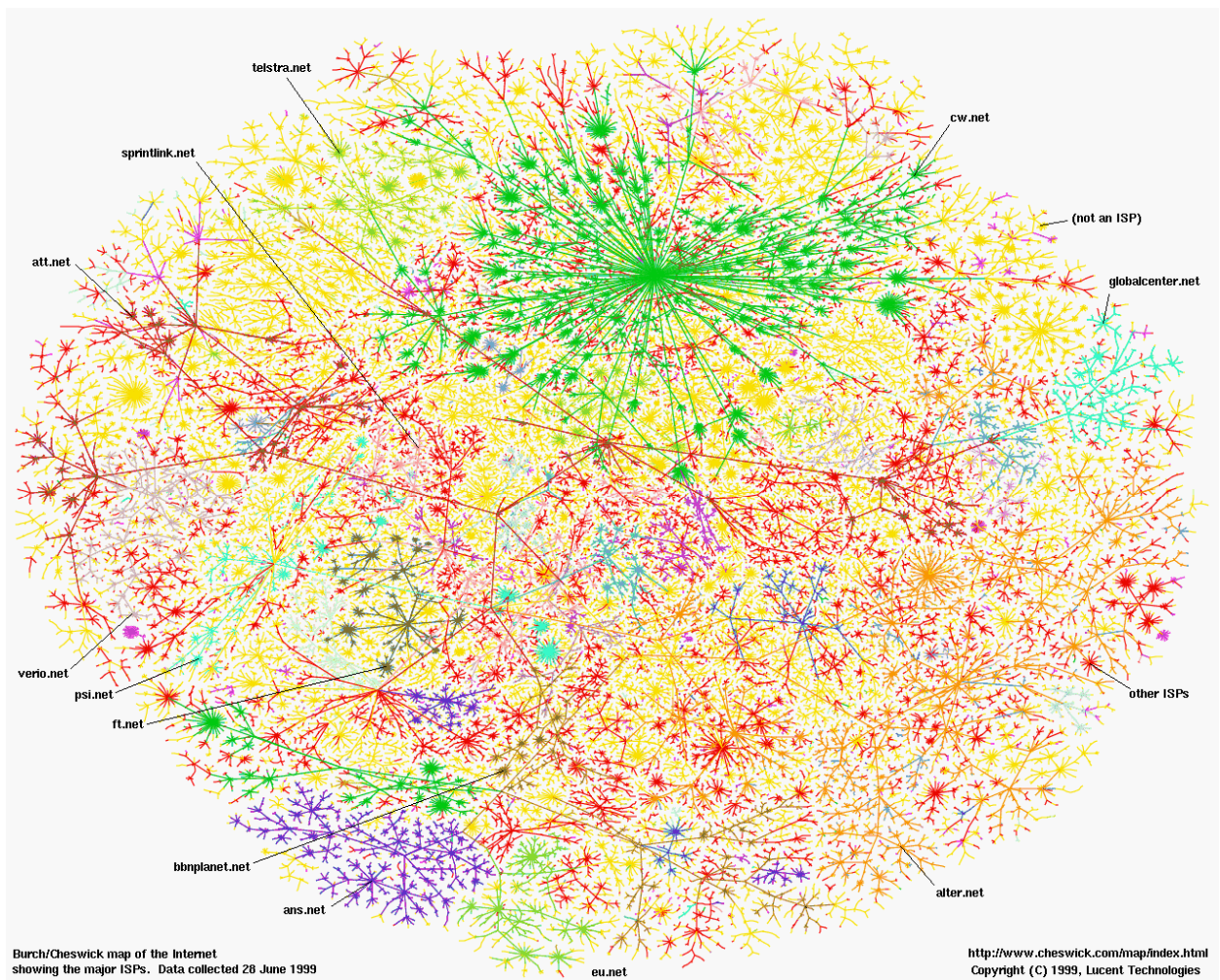




## The Web

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





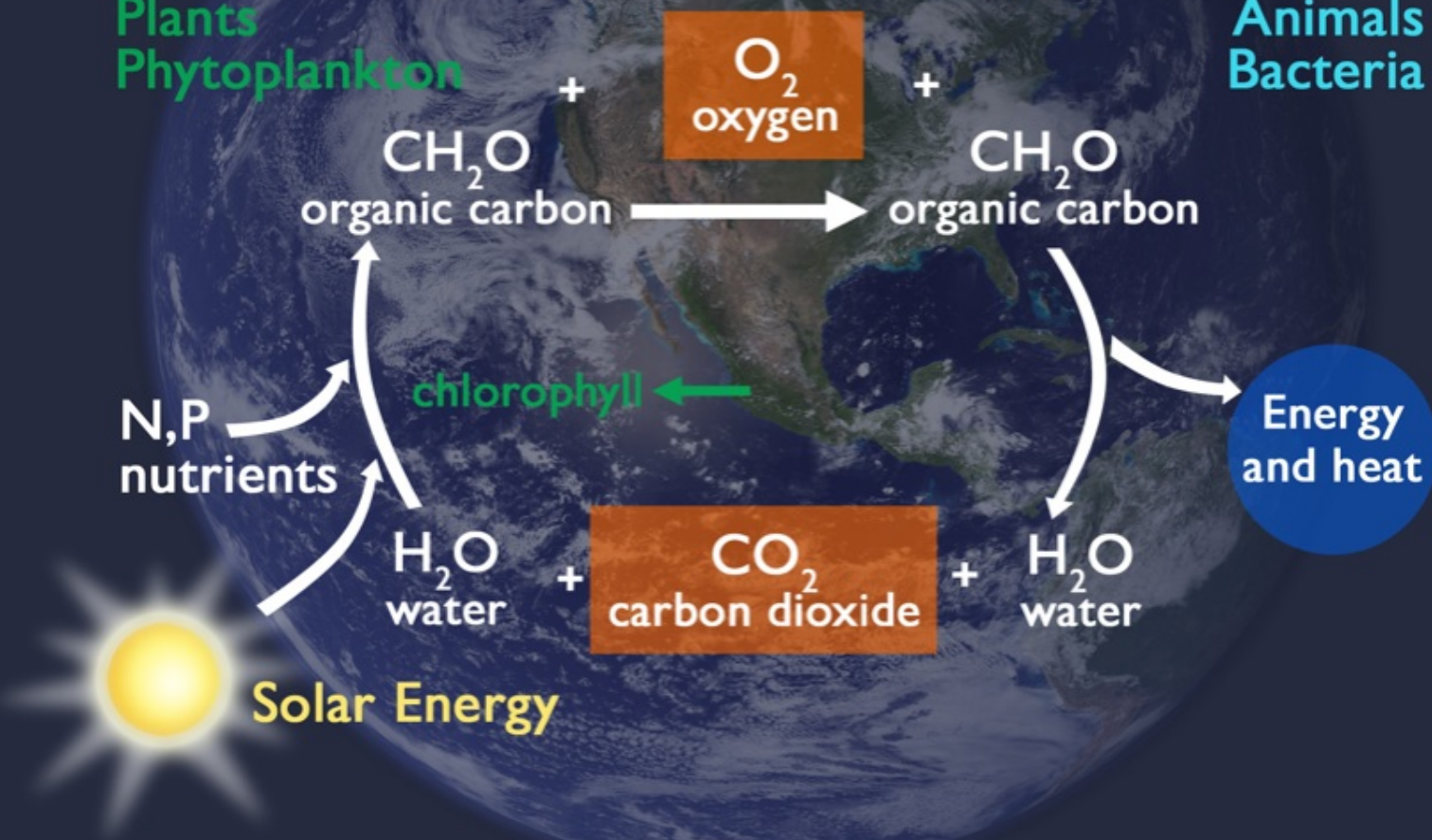
# Life on Planet Earth

## Photosynthesis

Plants  
Phytoplankton

## Respiration

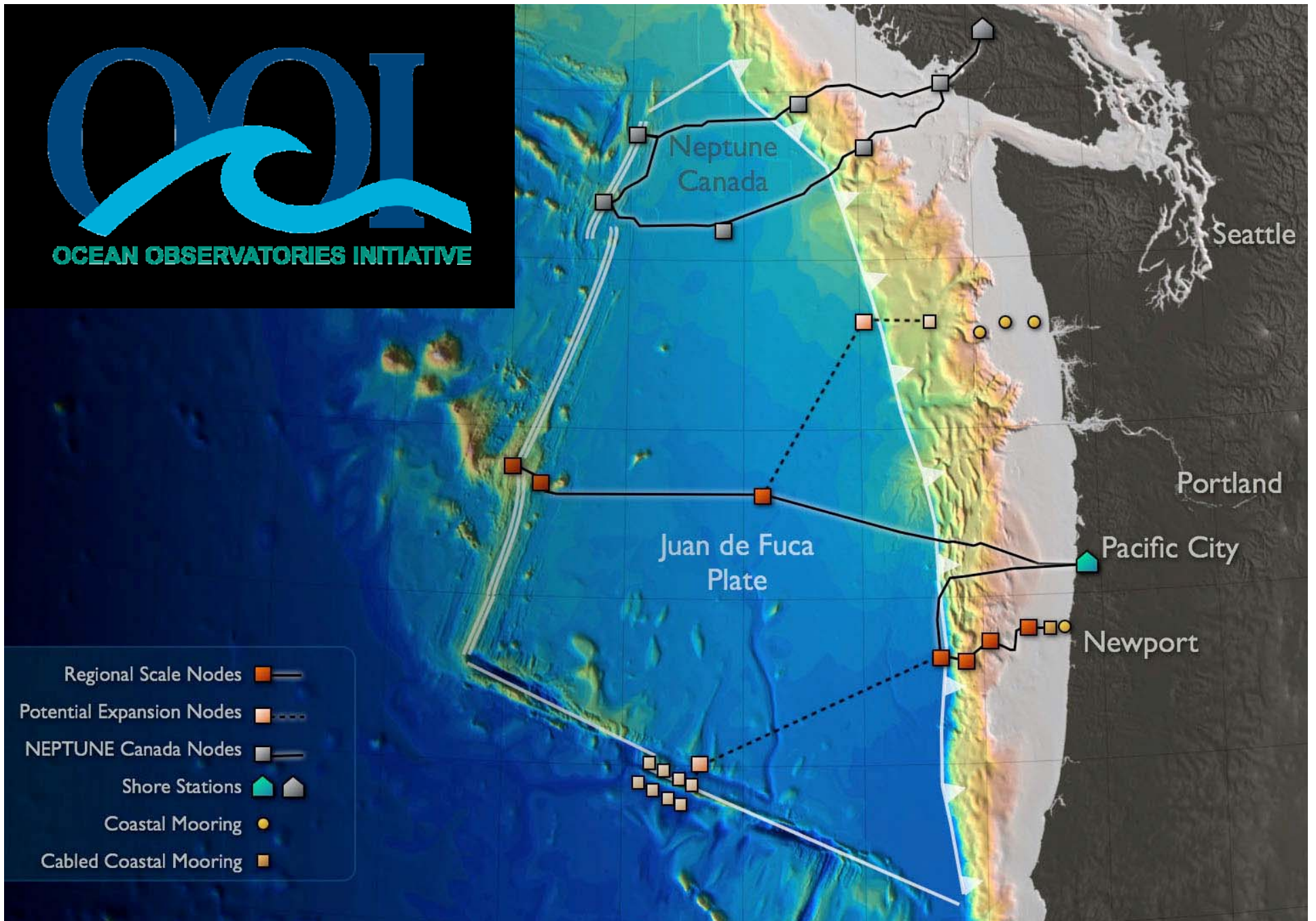
Animals  
Bacteria



[John Delaney, University of Washington]



[John Delaney, University of Washington]



[John Delaney, University of Washington]

# eScience utilizes the Cloud: Scalable computing for everyone

The collage features several overlapping elements:

- BusinessWeek Magazine:** The top left shows the cover of BusinessWeek magazine, dated December 24, 2007. The cover has a red header with the title "BusinessWeek" and a blue section with the word "NEXT" and the subtext "Imagine what you can do". Below this, there are two article teasers: "MEXICO: THE UGLY SIDE OF MICRO-LOANS 038" and "CENTRAL BANKERS TO THE RESCUE 026". At the bottom left is a barcode with the number 0 71435 18248 7. At the bottom right is a small photo of Christophe Bisciglia, Google's master of "cloud" computing.
- Google Search:** A Google search bar is positioned in the upper middle, with the text "Code" and "e.g. 'templates' or 'datastore'" below it.
- Google App Engine:** A snippet of the Google App Engine website is visible, showing a blue rocket icon and the text "An Early Look at J...".
- Azure Services Platform:** A snippet of the Azure Services Platform website is visible, showing the title "Azure Services Platform" and a search bar.
- Amazon Web Services:** A large snippet of the Amazon Web Services website is visible, showing the "amazon web services" logo, navigation tabs (Home, About, Solutions, Services, Resources, Community, Sign In), and a featured article titled "Hadoop + The AWS Cloud" which introduces Amazon Elastic MapReduce. Below this are sections for "Explore Products" (listing services like Amazon Elastic Compute Cloud, Amazon SimpleDB, Amazon Simple Storage Service, Amazon CloudFront, Amazon Simple Queue Service, Amazon Elastic MapReduce, and AWS Premium Support) and "News & Events" (listing recent news items from May 07, 2009 to Apr 09, 2009).

# 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 (1/20<sup>th</sup> the above)
  - 1.7 GB memory
  - 160 GB scratch storage
- Need it 24x7 for a year?
  - \$379

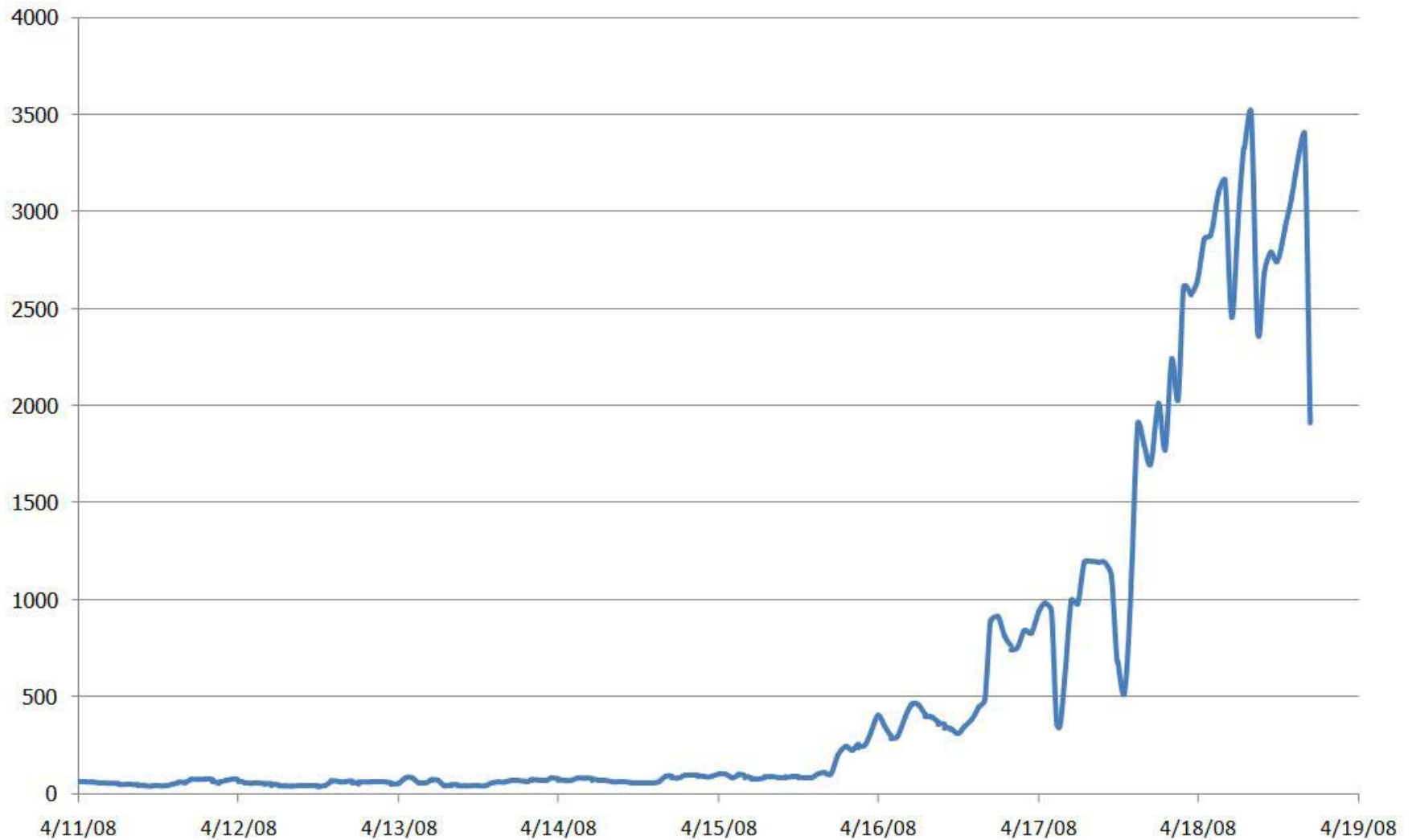


- This includes

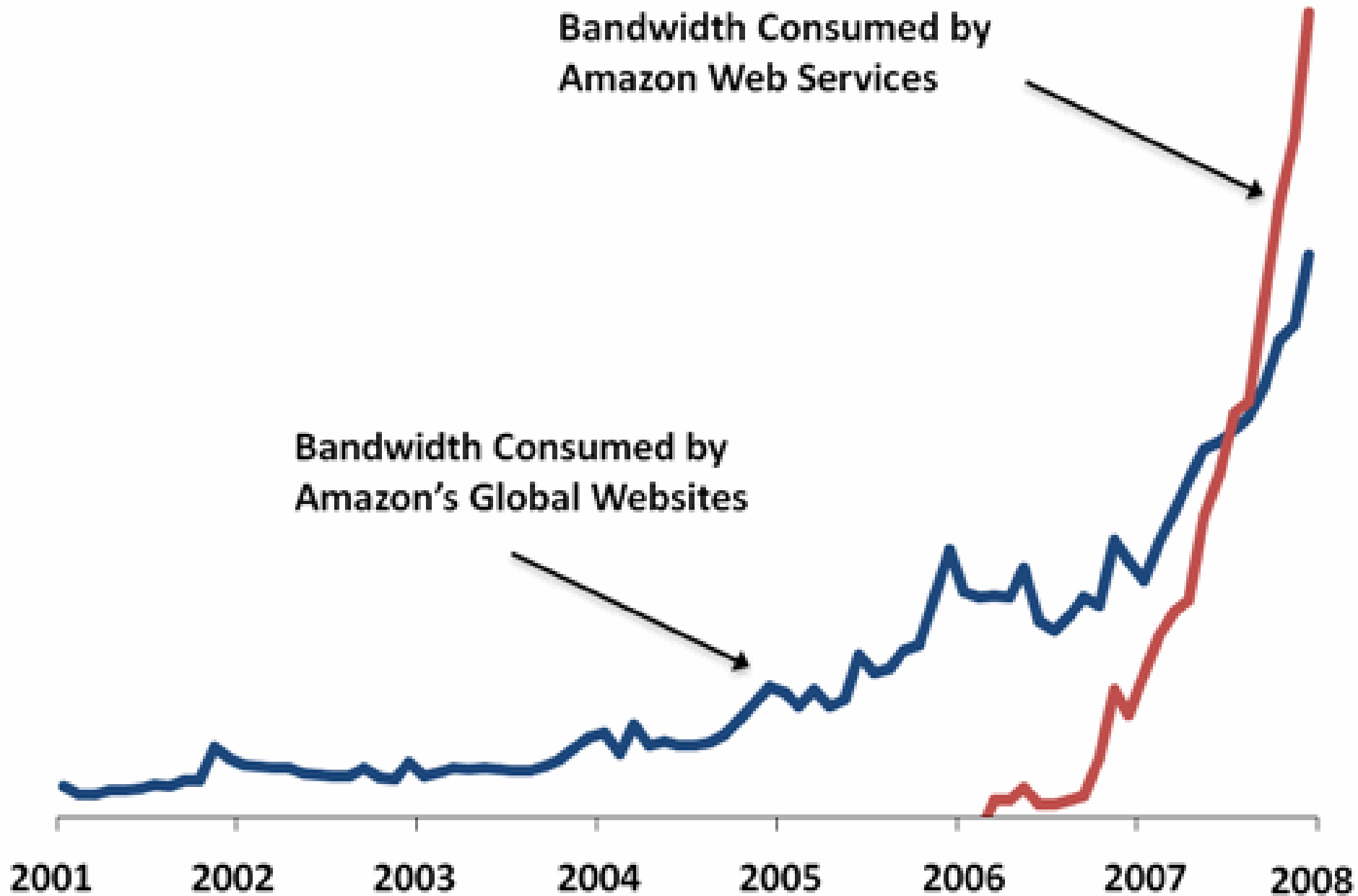
- Purchase + replacement
- Housing
- Power
- Operation
- Reliability
- Security
- Instantaneous expansion and contraction

- 1000 computers for a day costs the same as one computer for 1000 days - revolutionary!

# Animoto: EC2 Instance Usage

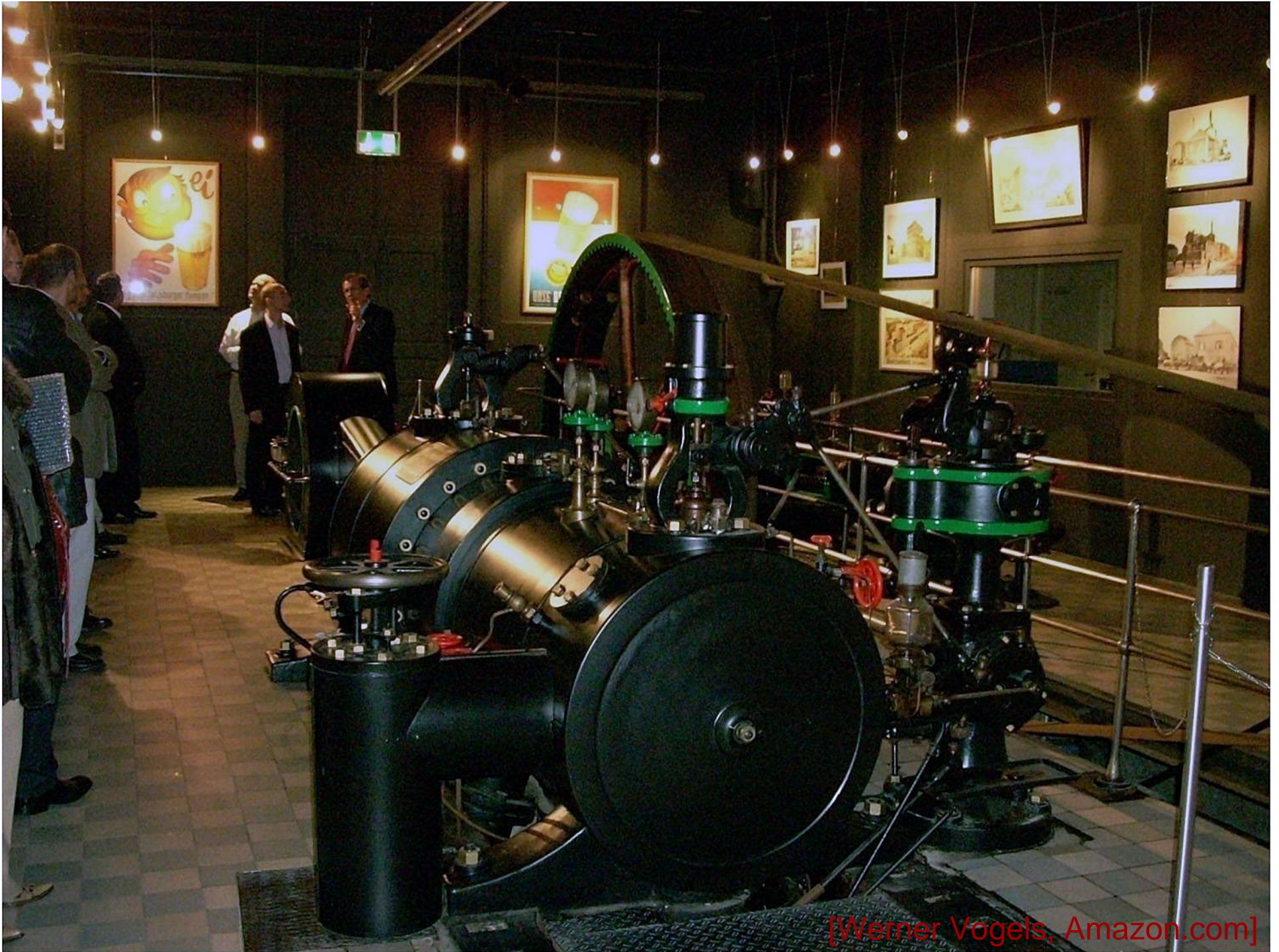


[Werner Vogels, Amazon.com]



[Werner Vogels, Amazon.com]





[Werner Vogels, Amazon.com]

# ICTD: Empowering the developing world



[Gaetano Borriello, University of Washington]

***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]

ODK Deployments - Google Maps

Web Images Videos Maps News Shopping Mail more ▾

ed@lazowska.org | My Profile | Help | Web History | My Account | Sign out

Google maps  Search Maps [Show search options](#)

Find businesses, addresses and places of interest. [Learn more.](#)

Get Directions My Maps

**ODK Deployments**  
 23 views - Public  
 Created on Aug 21 - Updated yesterday  
 By ODK  
[Rate this map](#) - [Write a comment](#)

- [USAID-AMPATH \(Kenya\)](#)  
AMPATH is the largest HIV treatment program in
- [Grameen Foundation Application Laboratory](#)  
ODK Collect has been used by AppLab since
- [DataDyne \(Kenya\)](#)  
DataDyne is active in over 20 countries in
- [Human Rights Center at UC Berkeley \(Central](#)  
The Human Rights Center investigates war crimes
- [Wharton School of Business at University of](#)  
A team from UPenn's Wharton School of Business is

©2009 Google - Map data ©2009 Europa Technologies - [Terms of Use](#)

## Open Data Kit

[Gaetano Borriello, UW and Google]

# Revolutionizing transportation







← Lane departure warning

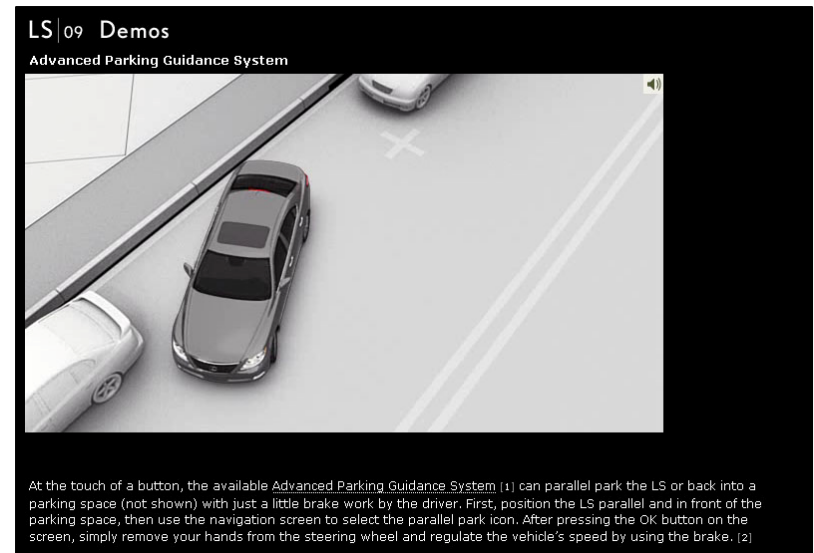
**Stay on track.**

**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.



← Adaptive cruise control



← Self-parking



- 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



*DISTRONIC PLUS is not a substitute for active driver involvement ... of 40% of vehicle braking power. 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. Braking effectiveness also depends on proper brake system maintenance and on tire and road conditions.*

# 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

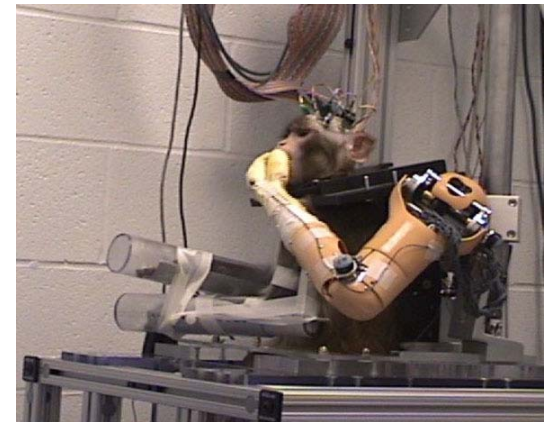
- Engineering
- Control
- Conservation (intelligent structures)



- 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

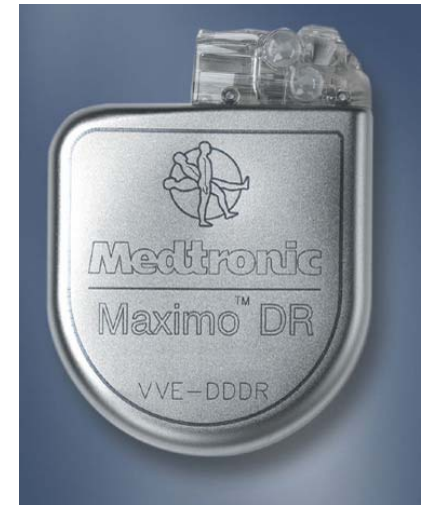


# Neurobotics



[Yoky Matsuoka and Raj Rao, UW]

# Security and privacy



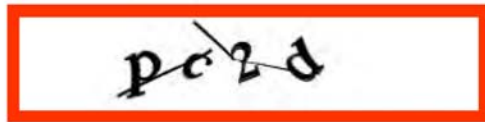
[Yoshi Kohno, UW]

# Human-computer systems

## Verify Your Registration

Enter the code shown:  [More info](#)

This helps Yahoo! prevent automated registrations.



Submit

The words above come from scanned books.  
By typing them, you help to digitize old texts.



Image Labeler BETA

## Google Image Labeler

time left

01:52

score

0

passes

0

label

pass

Your partner has suggested 3 labels.



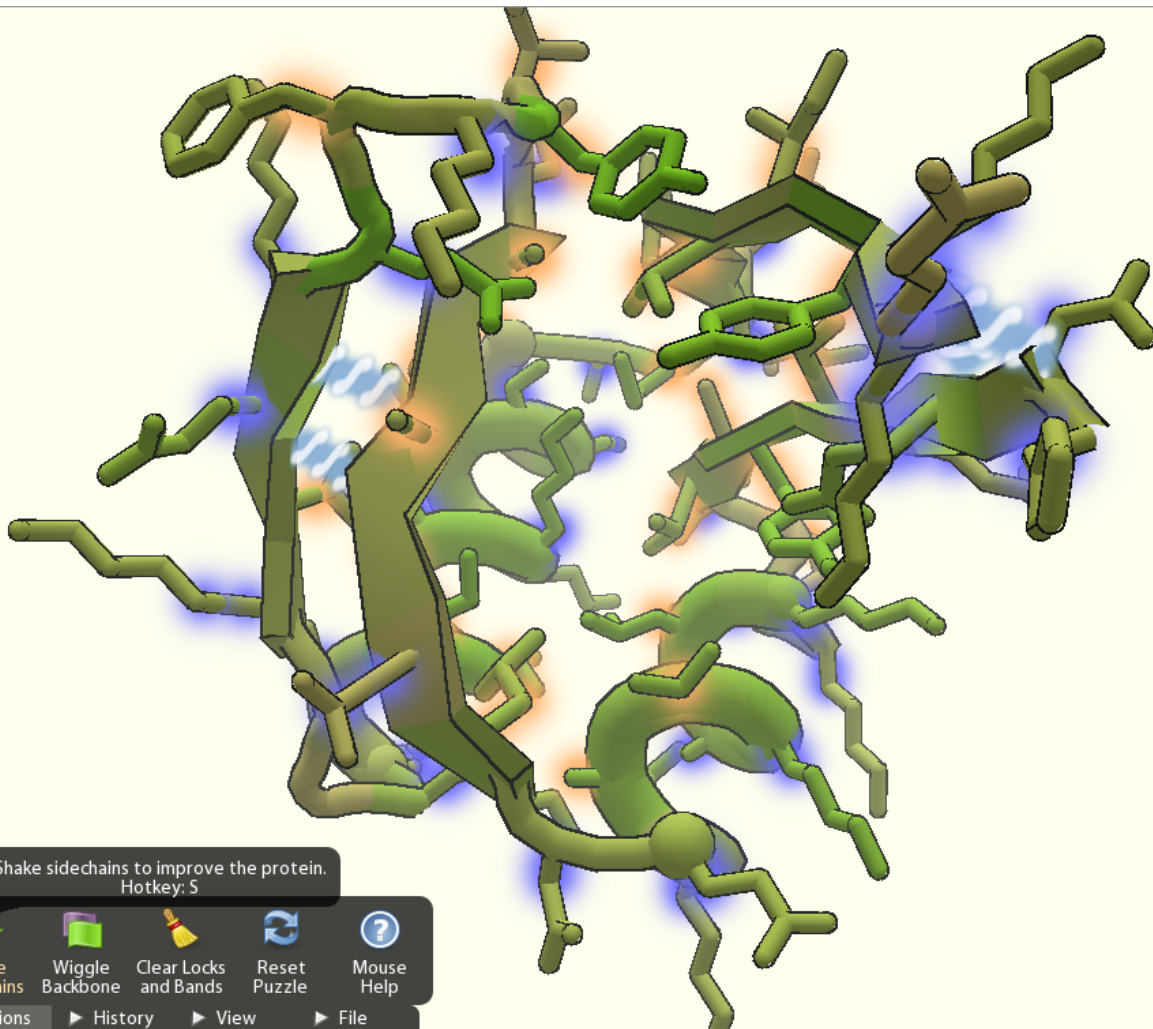
zoom out

off-limits

building  
hotel  
car  
cars  
sky

my labels





Rank: 17      Score: 9092  
 48: Pro Peptide

▼ Group Competition

#	Group Name	Score
1	The Lone Folder	9388
2	Street Smarts	9367
3	Illinois	9303
4	Berkeley	9255

▼ Player Competition

16	psen	-	9098
17	kathleen	9092	9092
18	versat82	-	9091
19	darktorres	-	9081
20	ccarrico	9032	9066
21	mbjorkegren	-	9048
22	sslickerson	-	9038

► Chat

<http://fold.it/>

Shake sidechains to improve the protein.  
Hotkey: S

Shake Sidechains	Wiggle Backbone	Clear Locks and Bands	Reset Puzzle	Mouse Help

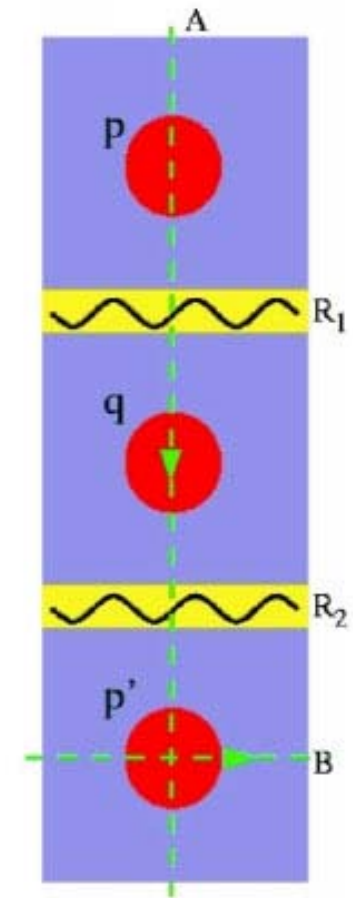
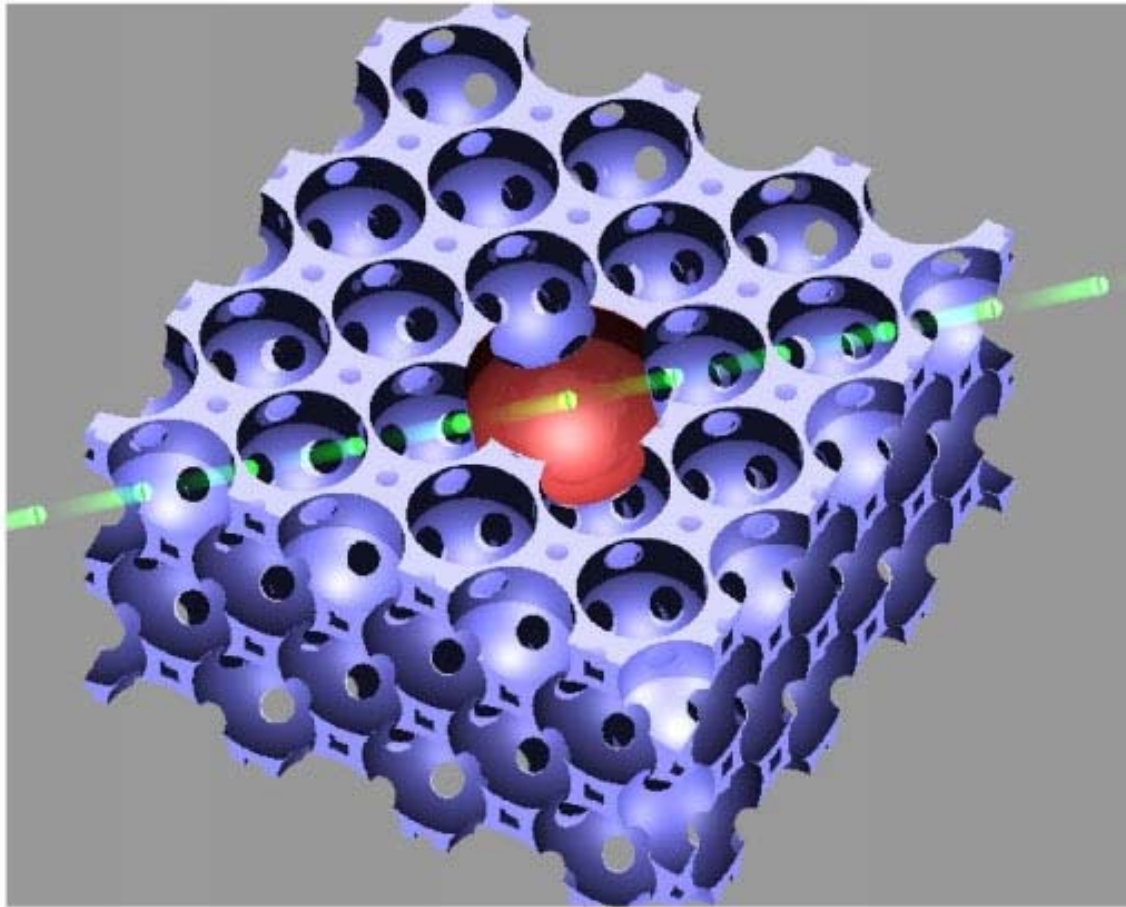
▲ Actions   ► History   ► View   ► File

[David Baker and Zoran Popovic, UW]

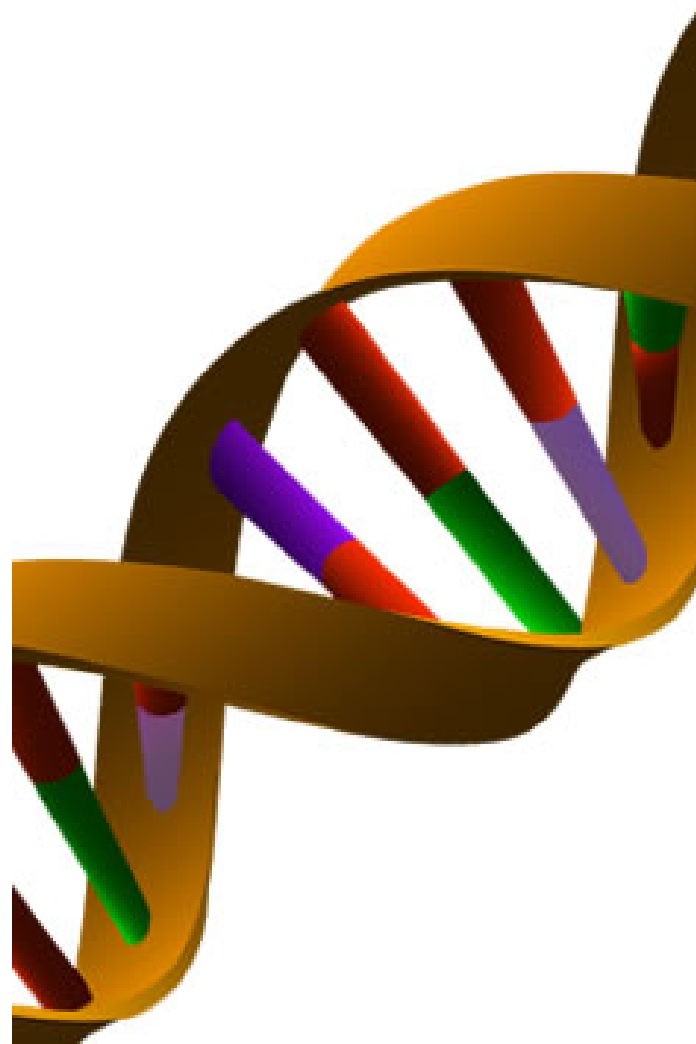
# Personalized education



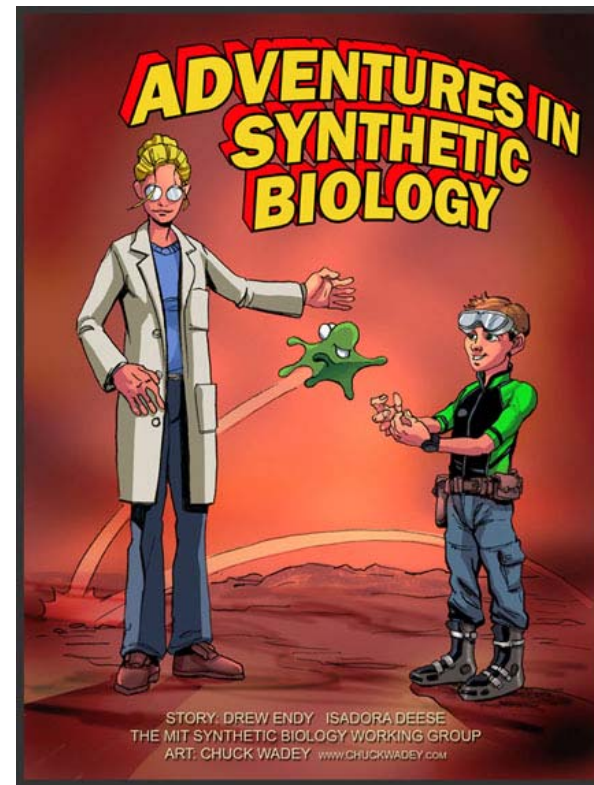
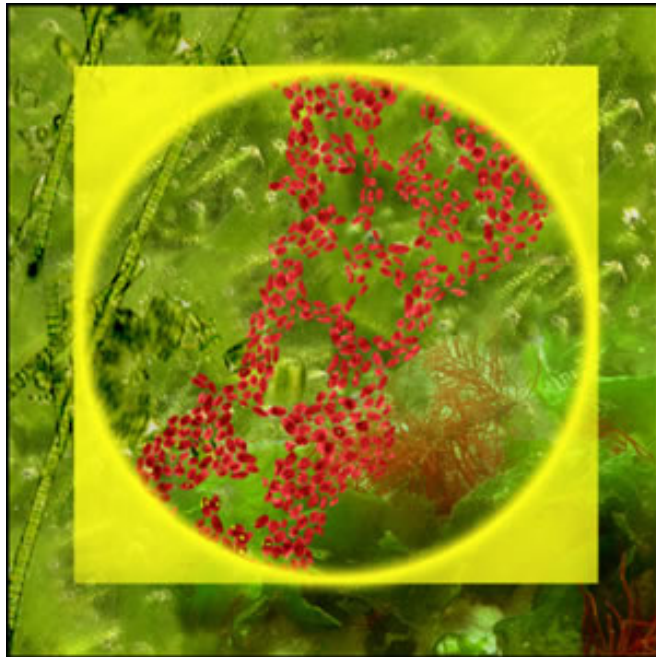
# Quantum computing



# Predictive, preventive, personalized medicine



# Synthetic biology / molecular engineering



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



Omron pedometer



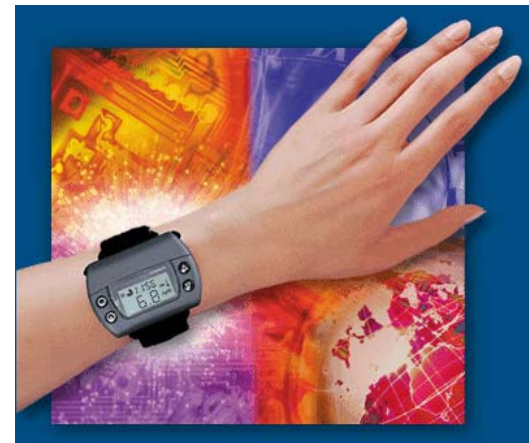
Nike + iPod



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.



**MYTHBUSTERS**  
WEDNESDAYS AT 9PM

An electric eel skin wallet can demagnetize credit cards.

**BUSTED**

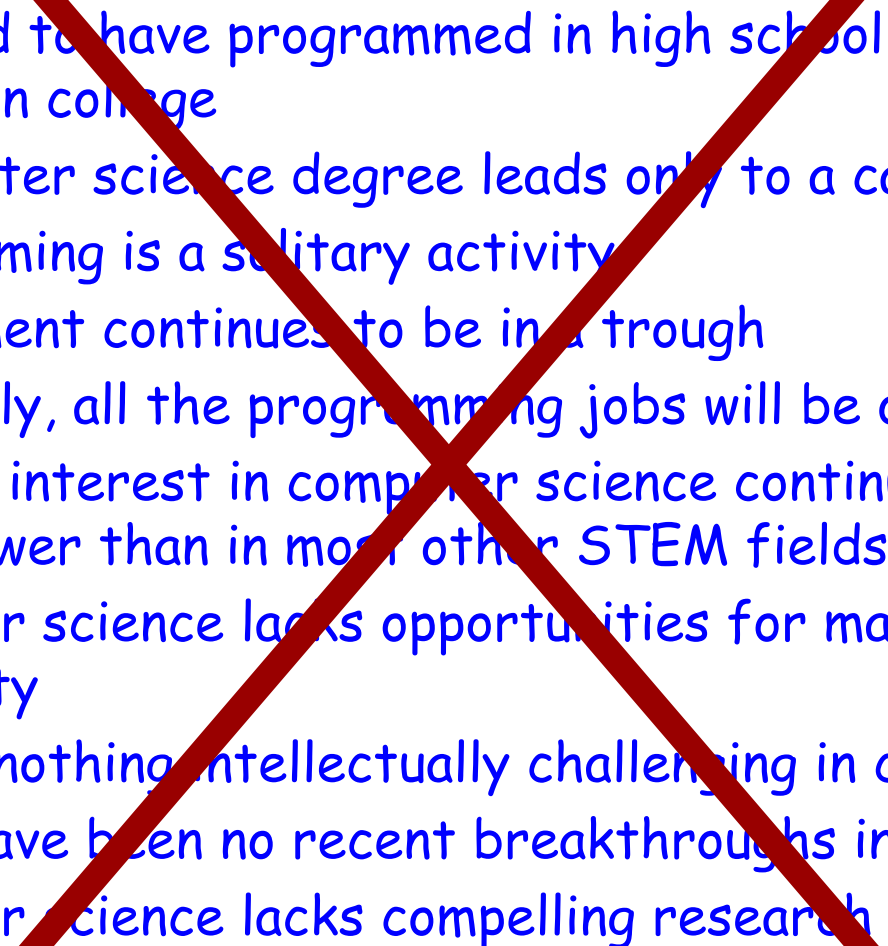
**VIDEO HIGHLIGHT >>**  
Big Rig Myths  
And See the Full Video Collection Now.



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.*

