The CCC & Health IT

Dr. Erwin Gianchandani
Director, Computing Community Consortium
Computing Research Association
National Institutes of Health
October 21, 2011
Objective

- Overview of the Computing Community Consortium (CCC)
- Our view of health information technology
- How can we be of help to you?
What is the CCC?
What is the CCC?

- Established in 2006 through a multi-year cooperative agreement between the National Science Foundation and the Computing Research Association (CRA)

- Provides a voice for the national computing research community

- Facilitates the development of a bold, multi-themed vision for the field - and communicates this vision to stakeholders
A broad-based Council

Leadership:
- Ed Lazowska, U of Washington (Chair)
- Susan Graham, UC-Berkeley (Vice-Chair)
- Erwin Gianchandani, CRA (Director)

Terms ending 2014:
- Deborah Crawford, Drexel
- Gregory Hager, Johns Hopkins
- John Mitchell, Stanford
- Bob Sproull, Oracle (ret.)
- Josep Torrellas, UIUC

Terms ending 2013:
- Randy Bryant, CMU
- Lance Fortnow, Northwestern
- Eric Horvitz, Microsoft Research
- Hank Korth, Lehigh
- Beth Mynatt, Georgia Tech
- Fred Schneider, Cornell
- Margo Seltzer, Harvard

Terms ending 2012:
- Stephanie Forrest, U of New Mexico
- Chris Johnson, U of Utah
- Anita Jones, U of Virginia
- Frans Kaashoek, MIT
- Ran Libeskind-Hadas, Harvey Mudd
- Robin Murphy, Texas A&M

Rotated off:
- Bill Feiereisen, Intel (2011)
- Dave Kaeli, Northeastern (2011)
- Dick Karp, UC-Berkeley (2010)
- John King, U of Michigan (2011)
- Peter Lee, Microsoft Research (2009)
- Karen Sutherland, Augsburg U (2009)
- Dave Waltz, Columbia (2010)

Meets three times a year, including an annual summer meeting in Washington, DC

http://cra.org/ccc
A multitude of activities

- Community-initiated visioning:
  - Workshops that bring researchers together to discuss the frontiers of computing
  - Challenges & Visions tracks at conferences

- Outreach to the White House and Federal agencies:
  - Outputs of visioning activities
  - Short reports to inform policy makers
  - Task Forces -- Health IT, Computational Sustainability, and Big Data

http://cra.org/ccc
4 meetings during summer 2008
Roadmap published May 2009
Extensive discussions between visioning leaders & agencies

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

National Robotics Initiative is announced

Henrik Chistensen
Georgia Tech

http://cra.org/ccc
## Visioning: Progress to date

<table>
<thead>
<tr>
<th>Community visioning activities</th>
<th>Participants</th>
<th>Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Networking science &amp; engineering</td>
<td>109</td>
<td>44</td>
</tr>
<tr>
<td>Cyber-physical systems</td>
<td>100</td>
<td>47</td>
</tr>
<tr>
<td>Robotics</td>
<td>141</td>
<td>79</td>
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<tr>
<td>&quot;Big Data&quot; Computing</td>
<td>81</td>
<td>46</td>
</tr>
<tr>
<td>Theoretical computer science</td>
<td>39</td>
<td>26</td>
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<tr>
<td>Global development (ICT4D)</td>
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<td>37</td>
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<tr>
<td>Learning technologies</td>
<td>55</td>
<td>30</td>
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<tr>
<td>Health information technology</td>
<td>121</td>
<td>102</td>
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<tr>
<td>Cross-layer reliability</td>
<td>121</td>
<td>45</td>
</tr>
<tr>
<td>Free &amp; open source software</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td>Advancing computer architecture</td>
<td>In progress</td>
<td></td>
</tr>
<tr>
<td>Interactive technologies</td>
<td>In progress</td>
<td></td>
</tr>
<tr>
<td>Sustainability &amp; IT</td>
<td>In progress</td>
<td></td>
</tr>
</tbody>
</table>
A multitude of activities

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- Public relations efforts:
  - Library of Congress symposia
  - Research “Highlight of the Week”
  - CCC Blog [http://cccblog.org/]
Outreach: CCC Blog

"Improving Brain-Computer Interfaces"
October 17th, 2011 by Erwin Gianchandani | Edit this entry | 0 Comments and 3 Reactions

A Science Nation story published today describes a public-private partnership funded in part by the National Science Foundation (NSF) that is attempting to link mind and machine to ultimately improve the living conditions of those with "locked-in syndrome" — a malady in which people with normal cognitive brain activity suffer severe paralysis, often from injuries or an illness such as Lou Gehrig's disease.

From the Science Nation article (see a video after the jump):

Read more: "Improving Brain-Computer Interfaces"

Posted in big science, research horizons, research news | 0 Comments and 3 Reactions

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Enter your email address:  [ ] Go

SUBSCRIBE to the CCC Blog Feed

LATEST TWEET
"Improving Brain-Computer Interfaces" http://t.co/SqiqERgA
Follow CCC on twitter here.

RECENT POSTS
- "Improving Brain-Computer Interfaces"
- Administration Seeking Input on National Bioeconomy Blueprint
- First Person: "One of My Most Exciting Internship Experiences"
- Announcing the 2011 Computing Innovation Fellows
- Susan Graham to Receive Ken Kennedy Award

MOST READ POSTS
- "Improving Brain-Computer Interfaces" (22)
- Administration Seeking Input on National Bioeconomy Blueprint (15)
- Announcing the 2011 Computing Innovation Fellows (4)

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A multitude of activities

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- Nurturing the next generation of leaders:
  - Computing Innovation Fellows Project
  - “Landmark Contributions by Students”
  - Leadership in Science Policy Institute

http://cra.org/ccc
Next generation: CIFellows Project

- Established in 2009 with NSF/CISE funding
- Provides recent CS Ph.D.s one- to two-year postdoctoral positions
- Goal has been to retain new Ph.D.s in research & teaching during difficult economic times
- 60 CIFellows funded in 2009
  - 19 left the program after year I
  - 39 have now found tenure-track faculty or industrial research positions
- 47 funded in 2010
- 20 funded in 2011
- A research project in and of itself...
A multitude of activities

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Our view of health IT
The PCAST report

- “Go well beyond the current national program to adopt electronic health records”
- “Make possible comprehensive lifelong multi-source health records for individuals”
- “Enable both professionals and the public to obtain and act on health knowledge from diverse and varied sources as part of an interoperable health IT ecosystem”
- “Provide appropriate information, tools, and assistive technologies that empower individuals to take charge of their own health and reduce costs.”
“Although information collection, processing, communication, and management are at the heart of health care delivery, and considerable evidence links the use of clinical information/communications technologies to improvements in the quality, safety, and patient-centeredness of care, the health care sector remains woefully underinvested in these technologies…”

Computer science as a discipline does not subsume health/biomedical informatics, although computer scientists can and do make major contributions to that field. Health/biomedical informatics is more than medical computer science… In the context of this report, specialists in health/biomedical informatics can serve a bridging function between the computer science community and the world of biomedicine...

The Learning Healthcare System is... one in which progress in science, informatics, and care culture align to generate new knowledge as an ongoing, natural by-product of the care experience, and seamlessly refine and deliver best practices for continuous improvement in health and health care.
## The challenge of healthcare

### Exhibit ES-1. Overall Ranking

<table>
<thead>
<tr>
<th>Country Rankings</th>
<th>AUS</th>
<th>CAN</th>
<th>GER</th>
<th>NETH</th>
<th>NZ</th>
<th>UK</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00-2.33</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>7</td>
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<td>2.34-4.66</td>
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<td>7</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>6</td>
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<tr>
<td>4.67-7.00</td>
<td>6.5</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>6.5</td>
</tr>
</tbody>
</table>

**OVERALL RANKING (2010)**

| Quality Care | 2 | 7 | 6 | 3 | 5 | 1 | 4 |
| Effective Care | 4 | 5 | 7 | 2 | 1 | 3 | 6 |
| Safe Care | 2 | 5 | 3 | 6 | 1 | 7 | 4 |
| Coordinated Care | 6 | 7 | 2 | 1 | 3 | 4 | 5 |
| Patient-Centered Care | 6 | 3.5 | 3.5 | 2 | 5 | 1 | 7 |
| Access | 6 | 7 | 2 | 1 | 3 | 4 | 5 |
| Cost-Related Problem | 2 | 6 | 5 | 3 | 4 | 1 | 7 |
| Timeliness of Care | 4 | 5 | 3 | 1 | 6 | 2 | 7 |
| Efficiency | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Long, Healthy, Productive Lives | 3,357 | 3,895 | 3,588 | 3,837* | 2,454 | 2,992 | 7,290 |

*Note: * Estimate. Expenditures shown in $US PPP (purchasing power parity).

Source: The Commonwealth Fund.

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Between $600 million and $850 million in waste and fraud in the U.S.

Over two million patients harmed each year by hospital-acquired infections
  - Over 100,000 of these individuals die

Over one million patients suffer disabling complications during surgery
  - 100,000 of these are fatal
  - Half are thought to be avoidable
"Discovery & Innovation in HIT"

- Multi-agency workshop with 100+ computer scientists, systems engineers, social scientists, care practitioners
  - Oct. 2009 in San Francisco
  - Produced a report summarizing key research questions, directions
- NSF/CISE initiated Smart Health & Wellbeing in FY 2011

- From data to knowledge to action -- enabling evidence-based healthcare
- Empowering people -- providers and consumers -- improves healthcare quality
- Computer-based augmentation of human learning, reasoning, decision-making, and physical motion significantly enhances human capabilities
- Healthcare is a complex, large-scale, adaptive distributed evolving system
- The Importance of Collaborative Government Investment

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Healthcare is changing

- Acute to chronic care
  - 75% of healthcare expenditures due to chronic disease
  - Top 50% of patients account for 97% of total cost

- Disease-centered to patient-centered
  - Patients become active participants in their care

- Hospitals to homes
  - More healthcare at home, in communities; family members act as caregivers

- Treatment to wellness
  - Behaviors impact over 50% of one’s health status - but only 4% of healthcare expenses are spent on managing one’s activities
  - Medical services impact 10% of health status - but total 88% of expenses
  - Among heart disease patients, 75% claimed healthy behaviors - but 30% were honest

- Quantity to quality
  - Business of healthcare delivery is increasingly complex

Continuous treatment of chronic conditions

Individuals manage their own health

Individuals take responsibility of their health
Powerful technologies emerging...

- Sophisticated imaging, sensing, monitoring and communication technologies
- Massive amounts of multi-media electronic data about individuals, disease, treatments
- Increasingly powerful data analysis methods
- Robust robotic and speech technologies
- Advancing understanding of human behavior, cognition, and incentives
But healthcare is different

- Multi-modal data, e.g., quantitative metrics, continuous readings, human reports
- Data are incomplete and may be contradictory
- Poorly defined noise models
  - Sampling bias towards the sick
  - Poorly characterized individual and population variations
- Complex social dynamics
- Leads to integration and specialization
Integration is essential

- Information over long periods of time must be uniformly accessible

- Must combine data from multiple sources, multiple scales, and multiple representations

- Need common understanding of terminology and actions
Specialization is important

- Access to information must be contextual and use-driven
  - Privacy in context
  - Use-driven relevance

- Ease and clarity of understanding

- Skills of caregiver and patient matter
The research opportunities

- “Data to Knowledge to Action” (Decisions)
  - Data availability, summarization, and visualization
  - Information discovery, predictive modeling, and decision-making

- Smart sensing, telemetry, and actuation for patient monitoring and care

- Deployment systems
Research opportunities: Big Data

- Patient records
  - Automated abstraction
  - Interactive contextual views
  - Automated documentation and communication
  - Person’s own record

- Care-giving tools for non-specialists
  - Online personalized recommendations
  - Social networking for questions and concerns
  - Mobile interactive tools for community health workers
Research opportunities: Information Extraction

- Machine learning for clinical care
  - Use large patient data sets to develop recommendations, alerts, and warnings for diagnosis, drugs, disease management, etc.
  - Analyze genomic, epidemiologic, and clinical data to create wellness plans and therapies

- Predictive models
  - Assess the effects of a new therapy on outcomes and costs
  - Identify drug-related adverse effects and to whom
  - Model relationships among biologic, environmental, and behavioral processes at multiple scales

- Cognitive assistance
  - For decision making under uncertainty and time pressure
  - Self-documenting environments, e.g. for care
  - Automated fault detection

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Research opportunities: Monitoring and care

- Closed loop
  - Sensing and dosing for fine-grained drug delivery
  - Non-invasive monitoring of physiological phenomena
  - Implanted devices to monitor internal structure and function
  - Robotic home care assistance

- Diagnosis and surgery
  - Machine vision for histological and radiological imaging
  - Distributed surgical teams and collaborations
  - Robotic surgical assistance
  - Automated vision-guided precision microsurgery

- Patient-in-the-loop
  - Telemetric and remote social monitoring and assistance for the chronically ill
  - Assistive software agents for independent living for the cognitively impaired
  - Devices and behavioral models to persuade and coach healthier living
  - Privacy-preserving architectures for selective sharing of personal health data
Research opportunities:

Deployment platforms

- Patient-centered - model information processes from hospital to home
- Disease-centered - diabetes from childhood to adult, Alzheimer’s progression and evaluation
- Tool-centered - robotics
- Modeling and simulation
- A hospital, a home, or an individual as a testbed
- Competitions for solutions

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An interdisciplinary approach

- Problem solutions require diverse disciplinary components
  - Experts in one domain are novices in others
    - CS experts understand human-computer interfaces, data collection and analysis, assistive technologies, etc.
    - Healthcare experts understand disease, interventions, a variety of healthcare processes, etc.
  - Many computer scientists are eager to do health-related research
    - Opportunity to ground their research in important applications
    - Socially relevant problems
    - New intellectually interesting challenges unique to healthcare
    - 150 applications to NSF’s FY 2011 Smart Health & Wellbeing solicitation
  - Systems engineers, social and behavioral scientists, economists
  - *Some hesitate to apply to NSF, others hesitate to apply to NIH, etc.*
How can we help?
How can we help?

- Based in downtown DC
- Committee of 20 leading computing researchers can tap into the field
- Workshops? White papers?
- Other offices at NIH?

Please contact me:

erwin@cra.org or 202-266-2936

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

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Computing Research Association

Arizona State University – CSE
Auburn University – CS
Ball State University – CS
Boston College – CS
Boston University – CS
Bowdoin College – CS
Bowling Green State University – CS
Bradley University – CS
Brandeis University – CS
Brigham Young University - CS
Brown University – CS
Bryn Mawr College – MCS
Bucknell University – CS
California Institute of Technology – CS
California Polytechnic State University – CS
California State University, Chico – CS
Carnegie Mellon University – CS
Case Western Reserve University – ECECS
City University of New York, Graduate Center – CS
Clemson University – CS
Collège Université – CS
College of William & Mary – CS
Colorado School of Mines – MCS
Colorado State University – CS
Columbia University – CS
Cornell University – CS
Cornell University – ECE
Dartmouth College – CS
DePaul University – CS
Drexel University – CS
Drexel University – IST
Duke University – CS
Emory University – MCS
Florida Atlantic University – CSE
Florida Institute of Technology – CS
Florida International University – CS
Florida State University – CS
Florida State University – IT
Florida Tech – MCS
Gonzaga University – CS
Georgia Institute of Technology – CS
Georgia Institute of Technology – CSE
Georgia Southern University – IT
Georgia Tech – CS
Georgia State University – CS
Georgia State University – CSE
Georgia Tech – CS
Grinnell College – MCS
Harvard University – CS
Harvey Mudd College – CS
Hofstra University – CSE
Illinois Institute of Technology – CS
Illinois State University – ACS
Indiana University – CS
Indiana University – I
Iowa State University – CS
Iowa State University – ECE
Johns Hopkins University – CS
Johns Hopkins University – SJ
Kansas State University – CSE
Kent State University - CS
LaFayette College – CS
Lehigh University – CS
Long Island University – CS
Louisiana State University – CS
 Loyola University, Chicago – CS
Massachusetts Institute of Technology – ECECS
Miami University – CS
McMaster University – CE&S
Michigan State University – CSE
Michigan Technological University – CS
Mississippi State University – CSE
Montana State University – CS
Montclair State University – CS
National University of Singapore – CS
Naval Postgraduate School – CS
New Jersey Institute of Technology – CCS
New Mexico State University – CS
New York University – CS
North Carolina State University – CS
Northern Illinois University – ECE
Northeastern University – CS
Northwestern University – ECE
Ohio State University – CS
Ohio Tech – ECECS
Ohio University – ECE
Old Dominion University – CS
Oregon Health & Science University – CSE
Oregon State University – ECECS
Pace University – CSIS
Pennsylvania State University – CSE
Pennsylvania State University – IST
Polytechnic University – CSE
Pomona College – CS
Portland State University – CS
Princeton University – CS
Purdue University – CS
Purdue University – ECE
Reussler Polytechnic Institute – CS
Rice University – CS
Rochester Institute of Technology – CS
Roosevelt University – CS
Rutgers University, Busch Campus – CS
Saint Louis University – MCS
Santa Clara University – CE
Simon Fraser University – CS
Singapore Management University – IS
Southern Illinois University, Carbondale – CS
Southern Methodist University – CSE
Southern Polytechnic State University – CSE
Stanford University – CS
State University of New York, Albany – CS
State University of New York, Binghamton – CS
State University of New York, Stony Brook – CS
Stevens Institute of Technology – CS
Swarthmore College – CS
Syracuse University – CS
Temple University – CS
Texas A&M University – CS
Texas Tech University – CS
Trent University at Chicago – CS
Tufts University – CS
Tulane University – ECECS
Union College – CS
University at Buffalo – CSE
University at Buffalo – IS
University of Alabama, Birmingham – CSE
University of Alabama, Tuscaloosa – CSE
University of Alberta – CSE
University of Arizona – CS
University of Arkansas – CS
University of Arkansas at Little Rock – I
University of California – CS
University of California, Berkeley – ECECS
University of California, Berkeley – IMS
University of California, Davis – CS
University of California, Irvine – ICS
University of California, Los Angeles – CS
University of California, Riverside – CSE
University of California, San Diego – CS
University of California, Santa Barbara – CSE
University of California, Santa Cruz – CE
University of California, Santa Cruz – CS
University of Central Florida – CS
University of Chicago – CSE
University of Cincinnati – ECECS
University of Colorado, Boulder – CSE
University of Delaware – CSE
University of Denver – MCS
University of Florida – CSE
University of Georgia – CS
University of Hawaii – ICS
University of Houston – CS
University of Idaho – CS
University of Illinois, Chicago – CSE
University of Illinois, Urbana Champaign – CS
University of Illinois, Urbana Champaign – ECE
University of Iowa – CS
University of Kansas – CS
University of Kentucky – CS
University of Kansas – CS
University of Maine – CS
University of Maryland – CS
University of Maryland, Baltimore Co - CSE
University of Maryland, Baltimore Co – IS
University of Massachusetts, Amherst – CS
University of Massachusetts, Boston – CS
University of Michigan – ECECS
University of Michigan – I
University of Michigan, Dearborn – CSE
University of Minnesota – CSE
University of Minnesota, Duluth – CS
University of Missouri – CSE
University of Missouri, Columbia – CSE
University of Missouri, Rolla – CS
University of Montana – CS
University of Montana – CSE
University of Nebraska at Omaha – CS/IST
University of Nebraska, Lincoln – CSE
University of Nevada, Las Vegas – CS
University of Nevada, Reno – CSE
University of New Brunswick – CSE
University of New Hampshire – CSE
University of New Mexico – CS
University of New Mexico – ECE
University of North Carolina at Chapel Hill – CSE
University of North Carolina, Charlotte – IT
University of North Dakota – CS
University of North Texas – CS
University of Notre Dame – CSE
University of Oklahoma – CSE
University of Oregon – CSE
University of Pennsylvania – CSE
University of Pittsburgh – CSE
University of Pittsburgh – IS
University of Poquet Sound – MCS
University of Rochester – CS
University of South Alabama – CSE
University of South Carolina – CS
University of South Florida – CSE
University of Southern California – CS
University of Southern California – ECE
University of Tennessee, Knoxville – CS
University of Texas, Arlington – CSE
University of Texas, Austin – CS
University of Texas, Dallas – CS
University of Texas, El Paso – CS
University of Toronto – CS
University of Tulsa – MCS
University of Utah – CS
University of Washington, Bothell – CS
University of Washington, Tacoma – CS
University of Waterloo – CS
University of Wisconsin, Madison – CS
University of Wisconsin, Milwaukee – EECS
University of Wyoming – CS
Utah State University – CS
Vanderbilt University – ECECS
Virginia Commonwealth University – CS
Virginia Tech – CS
Wake Forest University – CS
Washington State University – ECECS
Washington University in St Louis – CS
Wayne State University – CS
West Virginia University – CSE
Western Michigan University – CS
Williams College – CS
Worcester Polytechnic Institute – CS
Wright State University – CSE
Yale University – CS
York University – CS
Sun Microsystems (Sponsoring Member)
Microsoft Corporation (Sponsoring Member)
IBM Research (Sponsoring Member)
Accenture Technology Labs
Argonne National Laboratory
Awaay
CA Labs
Computer Science Research Institute,
Sandia National Labs
Fraunhofer Center for Experimental Software Engineering
Fujitsu Laboratories of America
Google
Hewlett-Packard Company
TDA Center for Computing Sciences
InTEL Corporation
Lawrence Berkeley National Laboratory
Los Alamos National Laboratory
Lucent Technologies, Bell Labs
McNEC Research
Mitsubishi Electric Research Labs
National Center for Atmospheric Research
NSCA
NIE Laboratory Americas
NTT DoCoMo USA Labs
Pacific Northwest National Laboratory
Panasonic Information & Networking Technologies Lab
Rich Innovations
Sand Diego Supercomputer Center
SAP Labs
SRI International
Telecordia Technologies

http://cra.org/ccc
Mission and activities

- Strengthen research and education in the computing fields
  - Working to influence policy that impacts computing research
  - Encouraging the development of human resources
- Contributing to the cohesiveness of the professional community
- Collect and disseminate information about the importance and state of computing research

Table 1. PhD Production by Type of Department and Rank

<table>
<thead>
<tr>
<th>Department, Rank</th>
<th>PhDs</th>
<th>Avg. per PhDs</th>
<th>PhDs Next Year</th>
<th>Avg. per Dept.</th>
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<tr>
<td>US CS 1-12</td>
<td>215</td>
<td>17.9</td>
<td>241</td>
<td>20.1</td>
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<tr>
<td>US CS 13-24</td>
<td>645</td>
<td>9.6</td>
<td>962</td>
<td>11.3</td>
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<tr>
<td>US CS 25-36</td>
<td>806</td>
<td>10.0</td>
<td>1,596</td>
<td>11.3</td>
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<tr>
<td>US CS Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US CS Total</td>
<td>1,501</td>
<td>10.0</td>
<td>1,596</td>
<td>11.3</td>
</tr>
</tbody>
</table>

http://cra.org/ccc
“Transition Team” white papers

- Sensed and seized an opportunity to influence Federal science policy through the Presidential transition team

- 19 papers produced in late 2008 & early 2009
  - 30 separate authors

- Many highly influential:
  - Re-envisioning DARPA - Peter Lee, Randy Katz
  - Infrastructure for eScience & eLearning/Unleashing Waves of Innovation - Ed Lazowska, Peter Lee, Chip Elliott, and Lary Smarr
  - Security is Not a Commodity - Stefan Savage, Fred Schneider
  - Synthetic Biology - Drew Endy
  - Big Data Computing - Randy Bryant, Randy Katz, Ed Lazowska
  - The Ocean Observatories Initiative - John Delaney, John Orcutt, Robert Weller
  - Cyber-Physical Systems - Janos Sztipanovits, Jack Stankovic
Next generation: CIF “cross-flow”

Academic institutions [ranks 1-12]
MIT Stanford Berkeley
Cornell CMU CalTech UIUC
Princeton UT Austin Harvard
U Wisconsin U Wash

Academic [ranks 13-24]
Brown Yale UCLA
Maryland NYU U Mass Rice
USC U Michigan UCSD
Columbia U Penn

Industrial research labs
IBM PARC
Intel HP
Adobe Systems

Academic [ranks 25-36]

Academic [other ranks]
Next generation: Postdocs in CS

Numbers of New Ph.D.s Hired

- Industry
- PostDocs
- Tenure-track faculty
- Teaching faculty
- Research faculty
- Other

http://cra.org/ccc
Next generation: Postdocs in CS II

Numbers of New Ph.D.s Hired

- PostDocs
- Tenure-track faculty
- Teaching faculty
- Research faculty

http://cra.org/ccc
Total CS degrees granted

Number of Degrees

http://cra.org/ccc
* Just about every field is becoming an information field

* “NIT is arguably unique among all fields of science and engineering in the breadth of its impact … Recent technological and societal trends place the further advancement and application of NIT squarely at the center of our Nation’s ability to achieve essentially all of our priorities and to address essentially all of our challenges … All indicators - all historical data, and all projections - argue that NIT is the dominant factor in America’s science and technology employment.

-- PCAST report, December 2010
The shift toward interdisciplinary

Driving forward the “application” domain...

...and driving forward the field of computing.

- Artificial Intelligence/Robotics
- Hardware/Architecture
- Numerical Analysis/Scientific
- Programming Languages/Compilers
- Operating Systems/Networks
- Software Engineering
- Theory & Algorithms
- Graphics/Human Interfaces
- Database/Information Systems
- Other/Unknown

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