The Computing Community Consortium

Dr. Erwin Gianchandani
Director, Computing Community Consortium
Computing Research Association

NIH Biomedical Information Science & Technology Initiative (BISTI)
April 7, 2011
Overview

- The Computing Research Association
- What is the CCC?
- Possible synergistic directions?
The Computing Research Association
Over 220 department/lab members

- Johns Hopkins University - CS
- Johns Hopkins University - StS
- Juniata College - IT & CS
- Kansas State University - CS
- Kent State University - CS
- Lafayette College - CS
- Lehigh University - CS
- Long Island University - IC
- Louisiana State University - CS
- Loyola University, Chicago - CS
- Massachusetts Institute of Technology - EEC
- Miami University - CS
- McMaster University - CEGS
- Michigan State University - CSE
- Michigan Technological University - CS
- Mississippi State University - CS
- Montana State University - CS
- Montclair State University - CS
- National University of Singapore - CS/IS
- Naval Postgraduate School - CS
- New Jersey Institute of Technology - CCSE
- New Mexico State University - CS
- New York University - CS
- North Carolina State University - CS
- Northeastern University - CS
- Northwestern University - ECE
- Nova Southeastern University - CS
- Ohio University - EECS
- Old Dominion University - CS
- Oregon Health & Science University - CSE
- Oregon State University - CS
- Pace University - CSE
- Pennsylvania State University - CS
- Penn State Harrisburg - CS
- Polytechnic University - CS
- Pomona College - MC
- Portland State University - CS
- Princeton University - CS
- Purdue University - CS
- Purdue University - ECE
- Rensselaer Polytechnic Institute - CS
- Rice University - CS
- Rochester Institute of Technology - CS
- Rollins College - CS
- Rutgers University, Busch Campus - CS
- Saint Louis University - MC
- Santa Clara University - CE
- Simon Fraser University - CS
- Singapore Management University - IS
- Southern Illinois University, Carbondale - CS
- Southern Methodist University - CS
- 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 - IS
- Temple University - CS
- Texas A&M University - CS
- Texas State University - CS
- Texas Tech University - CS
- Tufts University - CS
- Tulane University - EEC
- Union College - CS
- University at Buffalo - CS
- University of Alabama, Birmingham - CS
- University of Alabama, Tuscaloosa - CS
- University of Alberta - CS
- University of Arizona - CS
- University of Arkansas - CSCE
- University of Arizona at Little Rock - I
- University of Cali - CS
- University of California, Berkeley - EEECS
- University of California, Berkeley - IME
- University of California, Davis - CS
- University of California, Irvine - CS
- University of California, Los Angeles - CS
- University of California, Riverside - CSE
- University of California, San Diego - CSE
- University of California, Santa Barbara - CS
- University of California, Santa Cruz - CE
- University of Central Florida - CS
- University of Chicago - CS
- University of Cincinnati - ECECS
- University of Colorado at Boulder - CS
- University of Delaware - CS
- University of Denver - CS
- University of Denver - CSE
- University of Georgia - CS
- University of Hawaii - IC
- University of Houston - CS
- University of Houston - ECE
- University of Idaho - CS
- University of Illinois, Chicago - CS
- University of Illinois, Urbana-Champaign - CS
- University of Kansas - ECECS
- University of Kentucky - CS
- University of Louisville - CACS
- University of Maryland - CE
- University of Maryland, Baltimore Co - CS
- University of Massachusetts, Amherst - CS
- University of Massachusetts, Boston - CS
- University of Michigan - ECECS
- University of Michigan, Dearborn - CS
- University of Minnesota - CSE
- University of Minnesota - St Paul - CS
- University of Mississippi - CS
- University of Montana - CS
- University of Montreal - CS
- University of Nebraska at Omaha - CS/IST
- University of Nebraska, Lincoln - CS
- University of Nevada, Las Vegas - CS
- University of Nevada, Reno - CSE
- University of New Brunswick - CS
- University of New Hampshire - CS
- University of New Mexico - CS
- University of North Carolina at Chapel Hill - CS
- University of North Carolina at Chapel Hill - SILS
- University of North Carolina, Charlotte - IT
- University of North Dakota - CS
- University of North Texas - CS
- University of Notre Dame - CSE
- University of Oklahoma - CS
- University of Pennsylvania - CSE
- University of Pittsburgh - CS
- University of Puget Sound - MC
- University of Rochester - CS
- University of South Alabama - CSE
- University of South Carolina - CSE
- University of Tennessee, Knoxville - CS
- University of Texas at Austin - CS
- University of Texas at Dallas - CS
- University of Texas, El Paso - CS
- University of Toronto - CS
- University of Utah - CS
- University of Virginia - CS
- University of Washington - CSE
- University of Wisconsin - ECE
- Virginia Commonwealth University - CS
- Virginia Tech - CS
- Wake Forest University - CS
- Washington State University - EEECS
- Washington University - 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 (Supporting Member)

- Accenture Technology Labs
- Argonne National Laboratory
- Avaya
- CA Labs
- Computer Science Research Institute, Sandy National Labs
- Fraunhofer Center for-risk Management
- Fujitsu Laboratories of America
- Google
- Hewlett-Packard Company
- InDA Center for Computing Sciences
- Intel Corporation
- Lawrence Berkeley National Laboratory
- Los Alamos National Laboratory
- Lucent Technologies, Bell Labs
- McAfee Research
- Mitsubishi Electric Research Labs
- National Center for Atmospheric Research
- NCSA
- NEC Laboratories America
- NTT DoCoMo USA Labs
- Pacific Northwest National Laboratory
- Panasonic Information & Telecommunications Technologies Lab
- Ricoh Innovations
- San Diego Supercomputer Center
- SAP Labs
- SRI International
- Telcordia Technologies
Core 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
Mission + 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
Mission + 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
Mission + 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
Mission + 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
The Computing Community Consortium
NSF leaders and computing research leaders had similar deep concerns about computing:

- Failure to articulate and coalesce around exciting research visions in computer science that could galvanize the public, policymakers, researchers, and students
- Need to groom the future leadership of the field
- Decrease in student interest
 Increased focus by NSF leaders and computing research leaders in academia & industry

 A Computing Community Consortium solicitation & proposal

 “[NSF] will support the CCC as a community proxy responsible for facilitating the conceptualization and design of promising infrastructure-intensive projects…”

 “The purpose of the CCC is to provide a voice for the national computing research community. The CCC will facilitate the development of a bold, multi-themed vision for computing research and education... [communicating] that vision to ... major stakeholders.”
...And NSF asked CRA to create it

- 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
The CCC -- a broad-based Council

Leadership:
- Ed Lazowska, Chair
- Susan Graham, Vice-Chair
- Erwin Gianchandani, Director
- Andrew Bernat, CRA Executive Director

Terms ending 2014
- Deborah Crawford
- Gregory Hager
- John Mitchell
- Bob Sproull
- Josep Torrellas

Terms ending 2013
- Randy Bryant
- Lance Fortnow
- Hank Korth
- Eric Horvitz
- Beth Mynatt
- Fred Schneider
- Margo Seltzer

Terms ending 2012
- Stephanie Forrest
- Chris Johnson
- Anita Jones
- Frans Kaashoek
- Ran Libeskind-Hadas
- Robin Murphy

Rotated off
- Greg Andrews, 2009
- Bill Feiereisen, 2011
- Dave Kaeli, 2011
- Dick Karp, 2010
- John King, 2011
- Peter Lee, 2009
- Andrew McCallum, 2010
- Karen Sutherland, 2009
- Dave Waltz, 2010

Meets three times a year, including once in DC
Funded at $2M/year for three years
Communicating about computing...

...to the community, to the public, etc.
Communicating about computing...

Presentations

The Computing Community Consortium: Stimulating Bigger Thinking

Ed Lazowska
Bill & Melinda Gates Chair in Computer Science & Engineering
University of Washington
Chair, Computing Community Consortium
Tapia Conference Career Workshop
April 2009
http://www.cra.org/ccc/

...to the community, to the public, etc.
Communicating about computing...

...to the community, to the public, etc.
Communicating about computing...

Presentations
Articles
CCC Blog

...to the community, to the public, etc.
Communicating about computing...

- Presentations
- Articles
- CCC Blog
- Computing Research “Highlight of the Week”

...to the community, to the public, etc.
Outreach to Federal agencies

“Transition Team” white papers
“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, Larry Smarr
  - Security is not a commodity -- Stefan Savage, Fred Schneider
  - Synthetic biology -- Drew Endy, Ed Lazowska
  - 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
Outreach to Federal agencies

“Transition Team” white papers

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 G.I. 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 excellence and elearning in Higher Education (Word version) (Unattributed PDF)
(Ed Lazowska, University of Washington, Peter Lee, Carnegie Mellon University, Chip Elliot, 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)

*Internet 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)
Outreach to Federal agencies

- “Transition Team” white papers
- Library of Congress Symposium
Outreach to Federal agencies

- “Transition Team” white papers
- Library of Congress Symposium
- “Landmark Contributions by Students in Computer Science”
Leadership development
Leadership development

Computing Innovation Fellows (CIFellows)

The Computing Innovation Fellows Project

The 2009 Computing Innovation Fellows have been selected!

View the press release with the names of the 2009 Fellows and their Mentors.

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.

The Computing Community Consortium (CCC) and the Computing Research Association (CRA), with funding from the National Science Foundation, announce a program for new PhD graduates to obtain one-to-two year postdoctoral positions.
Established in 2009 with NSF/CISE funding
Provides recent Ph.D.s in computer science (and allied fields) post-doctoral positions
Positions span one to two years
Goal is to retain new Ph.D.s in research & teaching during difficult economic times
60 CIFellows funded in 2009
  19 are leaving by the end of year I, most with permanent positions, many with tenure-track faculty appointments
  41 are continuing for a second year
Additional 47 CIFellows funded in 2010
Leadership development

Computing Innovation Fellows (CIFellows)

The 2009 Computing Innovation Fellows have been selected!

View the press release with the names of the 2009 Fellows and their Mentors.

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.

The Computing Community Consortium (CCC) and the Computing Research Association (CRA), with funding from the National Science Foundation, announce a program for new PhD graduates to obtain one-to-two year postdoctoral positions.
Leadership development

Computing Innovation Fellows (CIFellows)
Leadership in Science Policy Institute
Visioning for the future
Visioning for the future

Research visions sessions at conferences...

Call for Visionary Conference Tracks

The Computing Community Consortium (CCC) is sponsoring an initiative to bring special "Challenges and Visions" tracks to leading computer science research conferences. The goal of this initiative is to help conferences reach out beyond the usual research papers that present completed work and to seek out papers that present ideas and visions that can stimulate the research community to pursue new directions.

Conferences may request CCC sponsorship of such tracks along with a CCC grant that provides for prize money for the top 3 papers (first prize $1000, second prize $750, and third prize $500, to be awarded as travel grants). (See below for details about selecting and awarding these prizes.)

Papers in a "Challenges and Visions" track should be open-ended, possibly "outrageous" or "wacky", and present new problems, new application domains, or new methodologies that are likely to stimulate significant new research. The CCC is seeking papers (roughly 4 pages in length) so that the ideas can be referenced after the conference is over.

After the conference, the CCC will post links to the track papers on its Challenges and Visions web page and help disseminate these ideas broadly in the computer science research community.

Requests for CCC sponsorship should include information on the conference and a proposed list of program committee members for the track. We provide below a prototype call for papers and suggestions regarding the review process. Proposals should be sent to Devi Anandachar, the CCC Director, at devi@csrg.org.
...And lots of “visioning activities”

<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>
</tr>
<tr>
<td>“Big data” computing</td>
<td>81</td>
<td>46</td>
</tr>
<tr>
<td>Theoretical computer science</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>Global development (ICT4D)</td>
<td>56</td>
<td>37</td>
</tr>
<tr>
<td>Learning technologies</td>
<td>55</td>
<td>30</td>
</tr>
<tr>
<td>Health information technology</td>
<td>121</td>
<td>102</td>
</tr>
<tr>
<td>Cross-layer reliability</td>
<td>121</td>
<td>45</td>
</tr>
<tr>
<td>Free and open source software</td>
<td>42</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 + IT</td>
<td>In progress</td>
<td></td>
</tr>
</tbody>
</table>

Open RFP for community-driven visioning

Thursday, April 7, 2011
…And lots of “visioning activities”

<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>
</tr>
<tr>
<td>“Big data” computing</td>
<td>81</td>
<td>46</td>
</tr>
<tr>
<td>Theoretical computer science</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>Global development (ICT4D)</td>
<td>56</td>
<td>37</td>
</tr>
<tr>
<td>Learning technologies</td>
<td>55</td>
<td>30</td>
</tr>
<tr>
<td>Health information technology</td>
<td>121</td>
<td>102</td>
</tr>
<tr>
<td>Cross-layer reliability</td>
<td>121</td>
<td>45</td>
</tr>
<tr>
<td>Free and open source software</td>
<td>42</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 + IT</td>
<td>In progress</td>
<td></td>
</tr>
</tbody>
</table>

Open RFP for community-driven visioning

Yahoo!
NSF, ONC, NLM, NIST, AHRQ
Canada GRAND, ACM CHI

Thursday, April 7, 2011
...And lots of “visioning activities”

<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>
</tr>
<tr>
<td>“Big data” computing</td>
<td>81</td>
<td>46</td>
</tr>
<tr>
<td>Theoretical computer science</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>Global development (ICT4D)</td>
<td>56</td>
<td>37</td>
</tr>
<tr>
<td>Learning technologies</td>
<td>55</td>
<td>30</td>
</tr>
<tr>
<td>Health information technology</td>
<td>121</td>
<td>102</td>
</tr>
<tr>
<td>Cross-layer reliability</td>
<td>121</td>
<td>45</td>
</tr>
<tr>
<td>Free and open source software</td>
<td>42</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 + IT</td>
<td>In progress</td>
<td></td>
</tr>
</tbody>
</table>

Open RFP for community-driven visioning

Yahoo!  
NSF, ONC, NLM, NIST, AHRQ  
Canada GRAND, ACM CHI  

Thursday, April 7, 2011
Robotics as an example

A Roadmap for US Robotics
From Internet to Robotics

Organized by
Georgia Institute of Technology
University of Southern California
Johns Hopkins University
University of Pennsylvania
University of California, Berkeley
Rensselaer Polytechnic Institute
University of Massachusetts, Amherst
University of Utah
Carnegie Mellon University
Tech Collaborative

Sponsors

4 meetings during summer 2008

Roadmap published May 2009

Extensive discussions between visioning activity leaders & agencies

Henrik Christensen
Georgia Tech
Robotics as an example

A Roadmap for US Robotics
From Internet to Robotics

4 meetings during summer 2008
Roadmap published May 2009
Extensive discussions between visioning activity leaders & agencies

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

Henrik Christensen
Georgia Tech
Robotics as an example

4 meetings during summer 2008

Roadmap published May 2009

Extensive discussions between visioning activity leaders & agencies

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

 Agencies begin rolling out robotics initiatives, beginning with RTD2

Henrik Christensen
Georgia Tech
Robotics as an example

Trying to replicate success with learning technologies, through discussions with ED and NSF leaders
Health information technology

Following ARRA, NSF asked CCC to organize workshop

Computer scientists, systems engineers, social scientists, care practitioners

Produced a report summarizing key research questions and directions

- 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
**Sustainability + IT**

- NSF/CISE recently asked CCC to run a workshop on sustainability
- Computer scientists, systems engineers, social scientists, sustainability scientists
- Produced a report summarizing key research questions and directions

<table>
<thead>
<tr>
<th>Key Research Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining sustainability</td>
</tr>
<tr>
<td>Routine uses of CISE for sustainability</td>
</tr>
<tr>
<td>CISE research to further sustainability</td>
</tr>
<tr>
<td>&quot;Big data&quot;</td>
</tr>
<tr>
<td>Modeling &amp; simulation</td>
</tr>
<tr>
<td>Optimization</td>
</tr>
<tr>
<td>Intelligent systems</td>
</tr>
<tr>
<td>Cyber-physical systems</td>
</tr>
<tr>
<td>Human-centered &amp; social computing</td>
</tr>
<tr>
<td>Privacy &amp; security</td>
</tr>
<tr>
<td>Systems engineering &amp; systems integration</td>
</tr>
<tr>
<td>Green IT</td>
</tr>
<tr>
<td>The power of applied problems</td>
</tr>
<tr>
<td>Collaboration &amp; interdisciplinary research</td>
</tr>
<tr>
<td>Education &amp; workforce development</td>
</tr>
<tr>
<td>The importance of collaborative Federal investment</td>
</tr>
</tbody>
</table>
Data analytics

- Overview
- eScience
- Healthcare
- Energy
- Education technology
- New Transportation
- Intelligence
- New Biology
- Robotics & emergency response
Data analytics

Systems biology: As the NAS report stated, “Improved measurement technologies and mathematical and computational tools have led to the emergence of a new approach to [address] biological questions termed ‘systems biology’ [that] strives to [integrate heterogeneous experimental data sets] and achieve predictive modeling [of biological systems].” Rather than pursuing the decades-old reductionist approach, interrogating individual components and reactions underlying a given system, systems biology attempts to integrate various biological structures and create predictive models representing systems-level functions and behaviors.

For example, in 2007, systems biologists published a genome-scale reconstruction of the human metabolic network. This reconstruction catalogs all known gene, protein, and reaction relationships underlying human metabolism – the vital cellular process that is attributed to many human diseases – in a highly quantitative, structured, and chemically consistent manner. In other words, the reconstruction assimilates all existing experimental knowledge about the system, and enables a quantitative analysis of the “flows” through the network – much like a map of a highway system overlaid with quantitative data about traffic volumes. Nearly 1,500 genes spanning 2,000 proteins and 3,300 reactions were incorporated from nearly 1,600 different papers. The resultant model represents the set of all hypotheses about the network that have been reported in the literature to date and, in turn, can be used to predict which genes are essential or inessential, and which ones are involved in mechanisms of chronic diseases like cancer and arthritis. Ultimately, such a model enables us to better understand the manifestation of human diseases and identify ideal drug targets to combat these illnesses.

Computational biology: Whereas systems biology takes an integrative, systems-based approach, computational biology applies data mining, machine learning, graphics/visualization, and related computational techniques to specific biological questions. For instance, clustering algorithms have been applied to gene expression data to associate genes with similar functions. High-throughput gene expression assays are enabling us to measure the expression levels of thousands of genes simultaneously, across different conditions and over time. These assays result in incredibly large data sets: the expression of each gene requires multiple “probes,” meaning that there are often 20 or more data elements per gene, and a routine experiment involving human cells measures 54,000 human gene transcripts concurrently. By clustering these data, we are able to make sense of the data and gain insight into gene function; genes that respond similarly to different stimuli are more likely to have related functions. Likewise, “compendium analyses” are used to study the mechanisms underlying drug function, by comparing the gene expression profiles of unknown drugs with databases of profiles of known drugs. Drugs with similar mechanisms are likely to have correlative gene expression footprints.
Nearly 2500 years ago, Hippocrates kicked off a revolution in healthcare by calling for the careful collection and recording of evidence about patients and their illnesses. This call—which first introduced the goal of sharing data among physicians to provide the best care possible for patients—established a foundation for the evolution of modern healthcare. Although 25 centuries have passed since Hippocrates’ call, we have not yet attained the dream of true evidence-based healthcare. Large quantities of data about wellness and illness continue to be dropped on the floor, rather than collected and harnessed to optimize the provision of care. We are simply not yet doing the best that we can.

We now stand at the brink of a potential revolution in data-centric healthcare, enabled by advances in computer science. Such a revolution promises to enhance the quality of healthcare while cutting costs, and, more generally, enabling physicians to do the very best that is possible with realistically bounded healthcare resources. Doing the best that can be done with available resources aligns with the core promise that all physicians make when they solemnly raise their hand and recite the Hippocratic Oath upon receipt of their medical degree.

Enabling this vision of true evidence-based healthcare will require critical investments for translating key methods and insights into working systems, as well as for advances in core computer science research and engineering to address key conceptual bottlenecks and opportunities.

Collecting and analyzing data collected on health and illness promises to enhance the quality and efficacy of healthcare, and to enhance the quality and longevity of life. The collection and analysis of data can provide new insights about wellness and illness that can be operationalized. Data-centric methods allow us to transform data into predictive models. Predictive models can be used to generate forecasts with well-characterized accuracies about the future—or diagnoses about states of a patient that we cannot inspect directly. Such forecasts or diagnoses can be harnessed within procedures that generate recommendations for actions in the world, and decisions about when it is best to collect more information about a situation before acting, considering the costs and time delays associated with collecting more information to enhance a decision.

The pipeline of data to prediction to action can be used to automate or provide decision support for accurate triage and diagnosis, to generate well-calibrated predictions about health outcomes,
The value of the CCC

How necessary is it to have within the U.S. computing research community an organization designated to perform one or more of the following activities?

- Small, nimble organization
- Unique components to the mission
- Provides a “leadership voice” for the community

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bring the community together to discuss, prioritize, and envision future research needs</td>
<td>0% 20% 40% 60% 80% 100%</td>
</tr>
<tr>
<td>Communicate these priorities and needs to the broader national community</td>
<td>0% 20% 40% 60% 80% 100%</td>
</tr>
<tr>
<td>Develop visions and thinking for computing research that will galvanize the public, policymakers, researchers, and/or students</td>
<td>0% 20% 40% 60% 80% 100%</td>
</tr>
<tr>
<td>Turn the priorities and visions developed within the community into funded research programs and/or instruments</td>
<td>0% 20% 40% 60% 80% 100%</td>
</tr>
<tr>
<td>Generate excitement within and about computing research that attracts students of both genders and all ethnic groups into computing research careers</td>
<td>0% 20% 40% 60% 80% 100%</td>
</tr>
<tr>
<td>Serve as a widely accepted catalyst and voice for the computing research community</td>
<td>0% 20% 40% 60% 80% 100%</td>
</tr>
<tr>
<td>Inculcate values of leadership and service in the computing research community by example, inclusion, and mentoring</td>
<td>0% 20% 40% 60% 80% 100%</td>
</tr>
</tbody>
</table>

--SRI International
Synergistic steps forward?

Number of places where computing can help with NIH mission and activities
- Modeling & simulation
- Robotics and cyber-physical systems
- "Big data"/data analytics

Ways to get more computer scientists involved?
- Workshops that bring CS folks together with domain scientists?
- Getting the word out about NIH RFPs relevant for computer scientists?
Questions?

✉ E-mail: erwin@cra.org
📞 Phone: (202) 266-2936
🌐 Online: www.cra.org/ccc