**Computing Community Consortium**
**Quarterly Activities Report**
**1APR09 - 30JUN09**

The activities summarized in this report are categorized by the five CCC goals.

## Goal: Bring the computing research community together to discuss, prioritize and envision our future research needs and thrusts.

## Activities: Visioning workshops, talks and articles, CCC blog, CCC website, Computing research highlight, visionary talks, NetSE

### Visioning workshops funded through the RFP process

**Robotics**

1. A report of the roadmap to the congressional robotics caucus was presented on May 21st to an audience of 120. The 4 page summary (complete details on the CCC website):
   OVERVIEW: Robotics as a key economic enabler

   Over the past 50 years, robots have been primarily used to provide increased accuracy and throughput for particular, repetitive tasks, such as welding, painting, and machining, in hazardous, high volume manufacturing environments. Automating such dirty, dull, and dangerous functions has mostly involved implementing customized solutions with relatively specific, near term value. Although a sizeable "industrial" robotics industry has developed as a result, the applications for such first generation robotics solutions have proven to be relatively narrow and largely restricted to static, indoor environments, due to limitations in the enabling technology.

   Within the past five years, however, tremendous advancements in robotics technology have enabled a new generation of applications in fields as diverse as agile manufacturing, logistics, medicine, healthcare, and other commercial and consumer market segments. Further, it is becoming increasingly evident that these early, next generation products are a harbinger of numerous, large scale, global, robotics technology markets likely to develop in the coming decade. Owing to the inexorable aging of our population, the emergence of such a next generation, "robotech" industry will eventually affect the lives of every American and have enormous economic, social, and political impact on the future of our nation.

   Unfortunately, the United States lags behind other countries in recognizing the importance of robotics technology. While the European Union, Japan, Korea, and the

rest of the world have made significant R&D investments in robotics technology, the U.S. investment, outside unmanned systems for defense purposes, remains practically non-existent. Unless this situation can be addressed in the near future, the United States runs the risk of abdicating our ability to globally compete in these emerging markets and putting the nation at risk of having to rely on the rest of the world to provide a critical technology that our population will become increasingly dependent upon. Robotech clearly represents one of the few technologies capable in the near term of building new companies and creating new jobs and in the long run of addressing an issue of critical national importance.

To articulate the need for the United States to establish a national robotech initiative, over 140 individuals from companies, laboratories, and universities from across the country joined forces to produce a definitive report that (1) identifies the future impact of robotics technology on the economic, social, and security needs of the nation, (2) outlines the various scientific and technological challenges, and (3) documents a technological roadmap to address those challenges. This effort was sponsored by the Computing Community Consortium (CCC) and led by 12 world-class researchers from the leading robotics academic institutions in the United States. The project included three application oriented workshops that focused on efforts across the manufacturing, healthcare/medical, and services robotics markets; plus one on blue-sky research that addressed a number of enabling technologies that must be the focus of sustained research and application development in order for the U.S. to remain a leader in robotics technology and commercial development.

What follows is a summary of the major findings across all of the workshops, the opportunities and challenges specific to each of the three targeted markets, and recommended actions that must be taken if the United States is to remain globally competitive in robotics technology. Detailed reports from each of the four workshops are also available.

## ROADMAP RESULTS: SUMMARY OF MAJOR FINDINGS

- Robotics technology holds the potential to transform the future of the country and is likely to become as ubiquitous over the next few decades as computing technology is today
- The key driver effecting the long term future of robotics technology is our aging population both in terms of its potential to address the gap created by an aging work force as well as the opportunity to meet the healthcare needs of this aging population
- Led by Japan, Korea, and the European Union, the rest of the world has recognized the irrefutable need to advance robotics technology and have made research investment commitments totaling over $1 billion; the U.S. investment in

robotics technology, outside unmanned systems for defense purposes, remains practically non-existing.

- Robotics technology has sufficiently advanced, however, to enable an increasing number of "human augmentation" solutions and applications in a wide range of areas that are pragmatic, affordable, and provide real value
- As such, robotics technology offers a rare opportunity to invest in an area providing the very real potential to create new jobs, increase productivity, and increase worker safety in the short run, and to address the fundamental issues associated with economic growth in an era significant ageing of the general population and securing services for such a population
- Each workshop identified both near and long term applications of robotics technology, established 5, 10, and 15 year goals for the critical capabilities required to enable such applications, and identified the underlying technologies needed to enable these critical capabilities.
- While certain critical capabilities and underlying technologies were domain-specific, the synthesis effort identified certain critical capabilities that were common across the board, including robust 3D perception, planning and navigation, human like dexterous manipulation, intuitive human-robot interaction, and safe robot behavior.

## MARKET SPECIFIC CONCLUSIONS

### Manufacturing

In manufacturing much of the progress and the processes involving robotics technology historically have been defined by the automotive sector and have been very much driven by price and the need to automate specific tasks particular to large volume manufacturing. The new economy is much less focused on mass manufacturing, however, and more concentrated on producing customized products. The model company is no longer a large entity such as GM, Chrysler, or Ford, but small and medium sized enterprises as for example seen in the Fox Valley or in the suburbs of Chicago. The need in such an economy is far more dependent on higher degrees of adaptation, ease of use, and other factors that enable small runs of made to order products. Although the United States has continued to lead the world over the last decade in increasing manufacturing productivity, it is becoming increasingly difficult for us to compete with companies in low-salary countries producing the same products using the same tools and processes. Through the development and adoption of next generation robotics technology and the advancement of a more highly trained workforce, however, it is possible for the United States to continue to lead the world in manufacturing productivity, especially for small and medium sized companies. Doing so will enable the nation to maintain a strong, globally competitive

manufacturing base, ensure our continued economic growth, and help safeguard our national security.

Logistics

The efficiency of logistics processes is essential to most aspects of our daily lives from mail delivery to the availability of food in grocery stores. The United States currently imports in excess of 100,000 containers daily, the contents of which must be processed, distributed and made available to customers. Robotics technology is already being used to automate the handling of containers at ports in Australia and elsewhere and has the potential to improve the inspection process as well. Once they leave the port or point of origin, the movement of goods usually entails multiple steps. The distribution of food from farmers to grocery stores, for example, involves several phases of transportation and handling. Although a significant portion of food prices is directly related to these transportation/logistics costs, less than 15% of the end to end distribution process has been considered for automation. Next generation robotics technology has the potential to enable greater optimization of such logistics processes and reduce the price of food and other goods by several percent. In order to realize this potential, however, there is a need to provide new methods for grasping and handling of packages and new methods for sensing and manipulation of objects.

Medical Robots

Over the last decade significant progress has been made in medical robotics. Today several thousand prostate operations are performed using minimally invasive robots, and the number of cardiac procedures is also increasing significantly. There are significant advantages associated with robotics enabled minimally invasive surgery, including smaller incisions, less time spent in the hospital, less risk of infection, faster recovery, and fewer side effects. Overall the quality of care is improved and due to shorter periods away from work there are significant economic benefits. Although the number of medical procedures for which robots are used is still relatively small, their use is expected to broadly expand as advances in next generation robotics technology provide improved facilities for imaging, feedback to the surgeon and more flexible integration into the overall process. As such, medical robotics holds the potential to have an enormous impact, economic and otherwise, as our population ages.

Healthcare

The number of people suffering strokes and other injuries attributable to aging will continue to increase and become even more pronounced. When people suffer an injury or a stroke it is essential to have them undergo regularly scheduled physical therapy sessions as soon as possible to ensure that they achieve as full a recovery as possible. Often, however, the rehabilitation/training occurs away from home and due to shortage of therapists there are often serious constraints on scheduling. Next generation robotics technology will increasingly enable earlier and more frequent sessions, a higher degree of adaptation in the training, and make it possible to perform

a certain percentage of these training sessions at home. By facilitating more consistent and personalized treatment regimens in this fashion, robotics enabled rehabilitation offers the potential for faster and more complete patient recovery. Robotics technology is also beginning to be used in healthcare for the early diagnosis of autism, memory training for people with dementia, and other disorders where personalized care is essential and there is an opportunity to realize significant economic benefits. Today early products are on the market, but the full potential is still to be explored.

Services

The use of robotics technology in the service industry spans professional and domestic applications. In professional services, emerging applications include improved mining, automated harvesters for agriculture and forestry, and cleaning of large scale facilities. Domestic services applications include cleaning, surveillance, and home assistance. Today more than 4 million automated vacuum cleaners have already been deployed and the market is still growing. So far only the simplest of applications have been pursued, but an increasingly services-based U.S. economy offers significant potential for the automation of services to improve quality and time of delivery without increasing costs. As people work longer hours, there is a need to provide them with assistance in their homes to provide time for leisure activities. A big challenge in service robotics will be the design of high performance systems in markets that are price sensitive.

International context

The promise of a thriving, next generation robotech industry has of course not gone unnoticed. The European Commission recently launched a program through which 600 mill Euros are invested in robotics and cognitive systems with a view to strengthen the industry, particularly in manufacturing and services. Korea has launched a comparable program as part of their 21st century frontier initiative, committing to invest $1B in robotics technology over a period of 10 years. Similar, but smaller programs are also in place in Australia, Singapore, and China. In the United States, funding has been committed for unmanned systems within the defense industry, but very few programs have been established in the commercial, healthcare, and industrial sectors. Although the industrial robotics industry was born in the United States, global leadership in this area now resides in Japan and Europe. In areas such as medical, healthcare and services, the United States has similarly established an early leadership position, but there are fast followers and it is not clear that we will be able to sustain our leadership position for long without a national commitment to advance the necessary robotics technology.

## POTENTIAL POLICY AND FUNDING RECOMMENDATIONS

1. A Recommendation to develop a position on robotics technology development within the White House Office of Science and Technology Policy to

coordinate interaction across government, advance collaboration with international robotics initiatives and integrate robotics into overall U.S. competitiveness policy.

2. A recommendation that at least $250 million be appropriated in the federal FY 2010 budget for competitive projects in health care, manufacturing, energy, security, transportation, agriculture and education applications of robotic technology. Each project would be designed to advance research on the fundamental technology challenges outlined above and accelerate commercial applications.

The projects could be modeled on the integration of the Grand Challenge type initiatives and/or large scale Multi-University Research Initiatives (MURI). Each project would involve industry participation and be designed to accelerate deployment within major commercial application areas.

Possible appropriation strategies could include the following: Placement of components of the funding in relevant programs in Agriculture, NSF, NIST, HHS, DoE, the Department of Education, DOT and DoD.

It will be essential to consider appropriate implementation mechanisms

Further information

http://www.us-robotics.us

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2. CRA/CCC worked with our communications consultants to ensure maximum dissemination of the prepared roadmap; a sample article is at

http://ehpub.bm23.com/public/?q=preview_message&fn=Link&t=1&ssid=5300&id=1r55rbnuhzqa1fh663m08k6nef2t4&id2=kyrncsv2w6gvdixv7z1vo3mf9t9t1

An article is being prepared for the September issue of *Computing Research News* as well.

**Cyber-physical systems**

New Forms of Industry – Academy Partnership in CPS Research; May 19, 2009. This by-invitation-only workshop was held and a report with follow up activities is in progress.

**Theory**

No forward progress.

**Big-Data computing**

CCC co-sponsored the original set of workshops to bring together academic and industry researchers (Yahoo! was the other co-sponsor). This work has continued without direct CCC contributions.

**One Learning Community per Student: Global Resources for Online Education**

Computing technology plays an increasingly important role in the advancement of education through computational models, reasoning, experimentation and implementation of mobile and ubiquitous pedagogical software. Computation is also growing as a basis for education in core ideas as well as simulations and data management. GROE will influence computing research funding strategies in all these areas, with the intention of accelerating improvement in education at all levels.

Immediate topics of interest include: partnerships, services and tools for learning based on improved understanding of human cognition; improved human-computer interaction for individual productivity (e.g. incorporating human speech and gesture); networking, mobile and ubiquitous computing to support collaboration and create seamless social learning; predictable and robust repositories of learning services and assessment tools; and enhanced software and hardware for personal computer literacy. This process will also address such issues as the business case for education, strategies for distributed intelligence that can be coordinated into common learning activities, means for blending real and virtual worlds, and open questions about how people learn.

Initial activities/workshops are underway.

**System-level, Cross-layer Cooperation to Achieve Predictable Systems from Unpredictable Components**

The Cross-layer Reliability (RelXLayer) visioning process will address the fact that we will no longer be able to reliably design or manufacture fault-free hardware systems. As the critical dimensions of devices, such as transistors and wires, used to implement computer systems shrink to only a few nanometers, rates of transient faults, permanent defects, and variation between devices on the same die are expected to increase to the point where today's fault-tolerant approaches will no longer be practical. Instead, computer systems will need to adopt a model in which each layer in the abstraction hierarchy - applications, O/S, architecture, circuits - is prepared for the layer below to transmit bad data and in which all of the layers in the hierarchy cooperate to deliver correct operation in spite of faults, variations, and other effects. Exacerbating this challenge is the need to continually reduce net energy per operation while providing this protection.

The first workshop was held March 2009 with the report now available on the CCC website. The second workshop was held in July 2009 in Los Alamos.

**Envisioning National and International Research Infrastructures for Multidisciplinary Empirical Science of Free/Open Source Software**

This group proposes within one year to hold an international workshop and supporting meetings focused on developing a strategy for establishing and sustaining a national and international research infrastructure supporting empirical studies of free/open source software (FOSS, or sometimes FLOSS) by academic and industrial researchers in different disciplines. This proposal describes our vision for such a research infrastructure, along with the activities we propose to conduct in order to develop such a strategy. The activities build from recent research meetings on FOSS repositories and the emergence of shared research infrastructures that support multi-disciplinary studies of FOSS development. We also identify our goals, assessment method, activities, outcomes, and results from recent meetings giving rise to this proposal. Following this is a specification of proposed meetings and workshop, budget, budget rationale, and brief biographical description of the proposal organizers.

Workshops are in the process of being scheduled.

**ICT for Development: A New Grand Challenge for Computer Science**

The first workshop is to take place August 1-2 in Berkeley. Anticipated outcomes include:

1. The emergence of a community of Computer Science researchers working on research problems related to global development
2. A set of empirical research methods and metrics of evaluation applicable to this field
3. A list of "grand challenges"
4. A coherent plan for increasing the visibility of the field, both among academics within and outside Computer Science, and with traditional and non-traditional funding sources

The call for participation was published and disseminated to interested parties.

**Visioning workshops under consideration:**

1. Advancing Computer Architecture Research, Torrellas and Oskin; accepted
2. Research in Artificial General Intelligence; Laird, Langley; first stage reviewing complete and communicated to PIs; PIs were able to fund first proposed workshop through ONR

**Broader-Themed Workshop**

*Computing Research that Changed the World: Reflections and Perspectives*
(renamed from Advances in Computing Research)
This Symposium took place as scheduled on March 25, 2009, in the Members Room of the Library of Congress. The website http://www.cra.org/ccc/locsymposium.php contains all information with highlights given here.

1. Video of all sessions is available both on the CCC website and via YouTube on the

computing research channel. While the individual speakers retain copyright, they have all given permission for completely free non-commercial use of their work.

2. We are currently working on producing textual materials for each talk. These will be freely available for use by our constituencies.

The June 2009 *Communications of the ACM* contained an article on the symposium.

**Talks and Articles**

**Talks**

"The Computing Community Consortium: Stimulating Bigger Thinking", Ed Lazowska, Tapia Conference invited talk, April 2009. http://lazowska.cs.washington.edu/Tapia.pdf

"eScience: Techniques and Technologies for 21st Century Discovery", Ed Lazowska, WICHE Commission Meeting, May 2009. http://lazowska.cs.washington.edu/wiche.pdf

**CCC Blog**

CIFellows Status Report, 27JUN09

"Computing Research that Changed the World" - VIDEOS!, 7JUN09

NSF Alan T. Waterman Award, 29MAY09

CCC, CRA Launch New "CIFellows" Opportunity for New PhDs, 15MAY09

"Unleashing Waves of Innovation", 27APR09

Library of Congress Slides are up!, 1APR09

**CCC Website**

continues to be fleshed out with content. For each workshop sponsored by CCC, we are collecting and posting:

1. Lead for effort
2. CCC Council liaison for this effort
3. Lead(s) for this workshop (may be same as overall lead, may not be)
4. CCC Council liaison for this workshop (may be same as overall liaison, may not be)
5. Vision for this workshop (one-pager)
6. Local Arrangements (location, dates, etc.)
7. Agenda/speakers
8. Meeting Materials (slides, talks, webcasts)
9. Participants
10. Highlights (one-pager or so)
11. Blog post to highlight these highlights
12. Final Report including next steps and any requests to CCC for additional support/ effort

**Computing Research Highlight of the Week**

Kidney Exchange Algorithm Launches Chain of 10 Transplants, July 17, 2009.

IBM Claims Cryptographic Cloud Security Challenge Solved, July 3, 2009.

Machine Learning Applied to Indus Script, May 15, 2009.
Robots that Take Orders From the Brain, April 17, 2009.
Brown Scientists Build Robot That Responds to Human Gestures, April 10, 2009.

**NetSE update**

The goal continues to be a report that can be used by the community to motivate research thrusts. The report is entering the home stretch with a solid draft version out for advanced review.

**Research Support for Fresh Ph.D.s**

The CCC has taken the lead in a new effort to ensure the research productivity of young members of the computing research community be developing a proposal, Computing Innovation Fellows, to fund a reasonably large number of new Ph.D. recipients over the next year. The need for doing so is palpable due to the economic climate - both universities and industry are unable to hire the research/teaching talent that they require.

Peter Lee, CCC Council member and incoming CRA Board Chair, leads the effort and Andy Bernat, Ed Lazowska, Anita Jones, Bob Sproull, Fred Schneider, Susan Graham and Ran Libeskind-Hadas of the Council are co-PIs; CRA Board members Robert Schnable, Andrew Chien and Rangachar Kasturi are also co-PIs. The proposal was submitted to NSF on March 26th.

Approval for the new initiative was received on May 15, 2009. We had been building the required infrastructure in parallel to the proposal development/submission and were able to go live on May 15th with the cifellows.org website. All applications, etc., were handled through this website. Announcement of the new program was also sent to the entire CRA membership list, the Forsythe List (PhD granting programs), various underrepresented populations mailing lists and posters were printed and sent to all relevant departments. Ultimately we received over 1200 individuals signing up as potential mentors and 526 valid applications by the closing of the application time period on June 10th.

From concept in mid-February to funded proposal in mid-May to 526 applications in mid-June is an amazing accomplishment by all concerned and a true test of CCC's ability to be nimble and adaptive.

## Goal: Communicate these challenges, needs and thrusts to the broader national community.

## <u>Activities:</u> CCC blog, Computing research highlight, communications support, essays highlighting the promise of computing research, symposium

**CCC Blog**

See above

**Computing Research Highlight of the Week**

See above

**Communications support**

CCC and CRA have jointly engaged Xenophon, a communications consulting firm, to advise us on ways to create a bolder public presence for the computing field.

**Promise essays**

A set of essays produced under CCC leadership to highlight the promise of computing research is available at http://www.cra.org/ccc/initiatives; all of these were provided to (*and actually read by!*) members of the transition team.

**Broader-themed workshops**

*Computing Research that Changed the World: Reflections and Perspectives*

As discussed above

## Goal: Create within the computing research community more audacious thinking.

## Activities: Visioning workshops, talks and articles, CCC blog, CCC website, Computing research highlight, visionary talks, symposium

These activities, each of which was discussed above, are each designed to encourage participants and others to think about deep visions within computing research.

## Goal: See the ideas developed in (1) and (3) turn into funded research programs and/or instruments.

## Activities: working with the Cyber-physical infrastructure effort, working with Big-Data activities, research support

The cyber-physical systems effort is the furthest along in engaging with other federal agencies due to its connection across all areas.

The big-data effort continues to be a collaboration of NSF with companies; during this quarter Yahoo! announced a new partnership.

Research Support for Fresh PhDs; see above.

## Goal: Increase the excitement within computing research and use that excitement to attract students of both genders and all ethnic groups into computing research careers.

## Activities: CCC blog, Computing research highlight, symposium, research support

**CCC Blog**

See above

**Research Highlights**

See above

**Broader-themed workshops**

*Computing Research that Changed the World: Reflections and Perspectives*

As discussed above.

We are making the presentations and videos widely available for use in teaching and recruiting. The talks are ideal for conveying the excitement of computing to a broad audience as they are not specialist talks.

We also have video of the four demonstration projects that were highlighted at the closing session and will make them available.

We intend to produce a booklet based upon one-page summaries of the talks. This will also be provided in source form so that institutions and individuals can use it as is most appropriate for them.

**Research Support for Fresh Ph.D.s**

See above

## Assessment Activity

## Strategic Plan Development

The Strategic Plan was sent to NSF and approved (but after this time frame).

## Network Science and Engineering Research Plan

We have been closely involved with NSF in moving the NetSE report towards conclusion. At this point, a solid draft of the synthesis chapter is complete and has been sent out to the workshop chairs for their comments.

## Operational Matters

1. Council conference calls took place generally bi-weekly for discussion of issues.
2. Calls between the CCC leadership and NSF CISE leadership took place generally bi-weekly for discussion of issues.