

**CRA Conference on**



**Grand Research Challenges in  
Computer Science & Engineering**

Airlie House  
Warrenton, VA  
June 23-26 2002

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# Objectives



- ⌘ Frame some “grand challenges” in “computer systems” that can serve as inspirations for our field
- ⌘ Serve as the “debugging run” for a recurring sequence of meetings modeled on the “Gordon Conferences” but focused on CSE, which would continuously frame “grand challenges” in our field

# So, what's a "grand challenge"?



- ⌘ It is inarguably a significant research challenge – 5, 10, 15 years out
- ⌘ It can be framed in a way that's inspiring not only to computer scientists, but also to the "general public"
- ⌘ Its realization would be widely recognized as a highly significant accomplishment – to society, not just to geeks



## ⌘ Intended audiences

- ☑ Technical community
- ☑ Industry
- ☑ Future computer scientists
- ☑ Public
- ☑ Research funders

# Organization



⌘ Inspired by Anita Jones and Bill Wulf

⌘ 9-person organizing committee

☒ Anita Jones (ch), Bill Aspray, Ambuj Goyal,  
Janie Irwin, Ed Lazowska, Dave Patterson,  
Jordan Pollack, Bob Sproull, Bill Wulf

⌘ 70 attendees, invited on the basis of  
position papers

# Schedule



## ⌘ Sunday evening

- ☒ Overview by Wulf and Jones
- ☒ Talk by science fiction writer Bruce Sterling

## ⌘ Monday

- ☒ Presentation of IBM "Global Technology Outlook" (Ambuj Goyal and Alfred Spector)
- ☒ Two 3-way-parallel sessions to flesh out 6 topics extracted from the position papers
- ☒ Plenary: report-out and feedback => survival, marriage, death, and birth
- ☒ Organizing committee deliberations



## ⌘ Tuesday

- ☑ Parallel sessions to hone the survivors and flesh out the new topics
- ☑ Plenary: report-out and feedback => survival, marriage, death, and birth
- ☑ Organizing committee deliberations

## ⌘ Wednesday morning

- ☑ Writing

# Caveats



⌘ It was explicitly a debugging run

☑ And there were bugs!

⌘ It was focused on “systems”

☑ Although the attendees included, e.g., Ron Brachman, Rod Brooks, Jim Foley, Tony Hoare, Raj Reddy, Elliot Soloway, Andy van Dam)

⌘ The goal was to frame *some* – not *the* – “grand challenges”

☑ Absolutely *not* “exclusionary” – on the contrary!





⌘ All that currently exists is the PowerPoint from the afternoon of the second day

☑ For each challenge

☑ Title

☑ Mission statement (including social impact)

☑ Metrics for success

☑ Technical challenges

☑ Social challenges

☑ Spinoffs: other problems that are solved as a byproduct

No revisions based on plenary feedback; no complete sentences

# Launching boldly forth ...



- ⌘ safety.net: Ubiquitous Computing for Disaster Mitigation, Response and Recovery
- ⌘ A Teacher For Every Learner: Scalable Learner-Centered Education
- ⌘ Systems You Can Count On
- ⌘ Enhancing Individual Productivity and Capability Through Cognitive Assistance
- ⌘ Conquering Complexity: Building Systems with Billions of Parts

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**safety.net**

Ubiquitous Computing for  
Disaster Mitigation, Response and  
Recovery

Friday, July 5

# Mission Statement

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To save lives and minimize damage from disasters through timely prevention, detection, prediction, and coordination.

Enabled by breakthroughs in ubiquitous sensing/actuation, computation, analysis and communication systems.

# A Teacher for Every Learner

Scalable Learner-Centered  
Systems

# 20-Year Vision

- ◆ Information Technology enables all learners to participate in a network of communities, where they engage with other learners, mentors and teachers in self-expression, exploration, and learning by discovery and by doing
- ◆ The learning environment continuously assesses and adapts to each learner's needs

# The Social Challenge

- ◆ Create a universally well-educated citizenry that can adapt to a changing, global society
  - ◆ For economic growth
  - ◆ For social and personal well-being
  - ◆ US international leadership in education
- ◆ Greatly enhance all learners' abilities to learn, and enjoyment of learning, over their lifetime
  - ◆ All levels of learners
  - ◆ Customization for learner's needs
  - ◆ Learning to learn

# Mission

Informed by advances in learning sciences, pedagogical design, and assessment theory, lower the effective student-teacher ratio to 1:1 by building the technological infrastructure to support dynamic, ad-hoc communities of lifelong learners who interact within an environment of learning objects through a creative blend of advanced computing technologies, high performance networks, authoring and collaboration tools.



# Systems You Can Count On



# Mission Statement



- ◆ To create the infrastructure for *Systems You Can Count On*, making today's applications reliable and secure, and enabling whole new classes of critical services
- ◆ Today, information technology is *the weakest link* in many of our most critical applications and services. Digital computing and communications increasingly pervade our lives, our economy, and our nation's critical infrastructure. In many applications this technology simply can't be counted on; it creates problems that range from chronic aggravation to unacceptable vulnerability
- ◆ Our challenge is to design a new generation of *Systems You Can Count On*:
  - ❖ **Systems that are reliable, secure, available, predictable, and trouble-free**
  - ❖ **Systems that can be used with confidence in all elements of our global critical infrastructure**
  - ❖ **Systems that enable new services ranging from a currency-less society to 24x7 location-independent personalized healthcare**
- ◆ These goals require fundamentally re-thinking the way we design, deploy and support our global infrastructure – an essential technical grand challenge



# Enhancing Individual Productivity and Capability

# Mission Statement



Increase individual productivity and capability through cognitive assistance

# Strategy



- ⌘ Augment every individual with teams of Agents and Robots
  - ☑ Agents: Cognitive programs
  - ☑ Robots: Cognitive machines
- ⌘ These teams of People, Agents, and Robots complement, assist, mentor, and monitor each other while collaborating together towards shared goals

# Conquering Complexity

Building Systems with Billions of Parts

June 25, 2002

# Mission Statement

To reformulate computing systems architectures at all levels (from circuits to global-scale distributed systems) that break through the **complexity wall** to deliver robust, scalable, long-lasting, systems.

# Why?

- We need computing systems that are the agent of change in society rather than enemy of change
- Every artifact we build or grow in the future will likely have a computing component
- We have run into a complexity wall, that limits and inhibits growth in business and societal systems



Tomorrow's computing systems cannot be built using methods of today.



# Two Themes

- 1) Complex organized behavior out of many simple unreliable components
  
- 2) Make complex systems simple to the
  - User
  - Administrator
  - Designer

# Additional material



- ⌘ A clear statement of the pervasive role of computer science in the world of today and tomorrow
- ⌘ The “base case” – where we are headed based upon predictable development initiatives building on research that has already taken place

# Many other topics were seriously discussed by the group



1. Technology you can count on
2. Ubiquitous computing (-> 9-1-1.net)
3. Augmented cognition
4. Self-\* systems (-> Complexity)
5. A teacher for every learner
6. Gain knowledge from data
7. The Great Society, Version II
8. Computers and health care
9. Affordable, useful services for the poor (-> B24B)
10. Civil and humane information services
11. Simulated reality
12. Parallel / high performance computing
13. Disaster response (-> 9-1-1.net)
14. Management of complexity (-> Complexity)
15. Telepresence / enriched communication
16. Green computing

# What's next?



- ⌘ Write, edit, submit to a CSTB-style review, revise
- ⌘ Publicize to the research community: publish as a CRA report; also publish in *CRN*, *CACM*, *Spectrum*, etc.
- ⌘ Publicize to CSTB, PI TAC, Congress, relevant Federal agency heads and staff; run a workshop for relevant Federal agency heads and staff
- ⌘ Seek press attention



⌘ Reflect on the process

⌘ Seek leadership and support for a recurring sequence of meetings modeled on the “Gordon Conferences” but focused on CSE, which would continuously frame “grand challenges” in our field