REPORT TO THE PRESIDENT AND CONGRESS

DESIGNING A DIGITAL FUTURE: FEDERALLY FUNDED RESEARCH AND DEVELOPMENT IN NETWORKING AND INFORMATION TECHNOLOGY

Executive Office of the President

President's Council of Advisors on Science and Technology

DECEMBER 2010

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Disclaimer

What follows is an informal interpretation of the report from a member of the Working Group, *not* an officially sanctioned presentation.

For complete information on the report, see http://cra.org/nitrd/ or the PCAST website, http://www.whitehouse.gov/administration/eop/ostp/pcast/

The role of Networking and Information Technology

- **Networking and information technology R&D has changed the world**
  - "The extraordinary accomplishments of America's NIT research and development efforts are amply evident, and have been authoritatively documented." "As a field of inquiry, NIT has a rich intellectual agenda – as rich as that of any other field of science or engineering. In addition, NIT is arguably unique among all fields of science and engineering in the breadth of its impact."
- **The Federal Government has played, and must continue to play, an essential role**
  - "The Federal Government has played an essential role in fostering the advances in NIT that have transformed our world." "The Federal investment in NIT research and development is without question one of the best investments our Nation has ever made." "The 'extraordinarily productive interplay of federally funded university research, federally and privately funded industrial research, and entrepreneurial companies founded and staffed by people who moved back and forth between universities and industry' has been well documented. It is important, however, not to equate the very large industry R&D investment in NIT with fundamental research of the kind that is carried out in universities and a small number of industrial research labs. The vast majority of industry R&D in NIT is focused on development – on the engineering of future products and product versions."

This statement is important because many individuals in policy positions view "engineering fields" as "technology development" which is "industry's job" – they view "research" as equivalent to "traditional science fields" (biology, chemistry, physics, astronomy).

- **Further advances in NIT are central to achieving essentially all of our Nation's priorities**
  - "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:
    - Advances in NIT are a key driver of economic competitiveness …
    - Advances in NIT are crucial to achieving our major national and global priorities in energy and transportation, education and life-long learning, healthcare, and national and homeland security …
    - Advances in NIT accelerate the pace of discovery in nearly all other fields …
    - Advances in NIT are essential to achieving the goals of open government …"

  Previous PCAST and PITAC reports have positioned NIT principally as central to discovery in science and engineering. This report places NIT as *additionally* central to fields such as health, energy, transportation, and education. It also focuses heavily on the exceptional role of NIT as an engine of economic growth.
- **Many Federal agencies don't adequately grasp this central role of advances in NIT**
  - "Federal agencies vary greatly in their appreciation of the dramatically expanded role that advances in NIT – *true advances*, rather than the application of existing NIT systems – play in achieving our Nation's priorities, meeting our challenges, and shaping our world. Some agencies have not yet recognized the extent to which their abilities to accomplish their missions are inextricably linked to advances in NIT."

Necessary investments in NIT R&D focused on achieving America's priorities

- **There must be specific initiatives in NIT R&D focused on achieving America's priorities**
  - "A national, long-term, multi-agency research initiative on NIT for health that goes well beyond the current national program to adopt electronic health records"
  - "A national, long-term, multi-agency, multi-faceted research initiative on NIT for energy and transportation"
  - "A national, long-term, multi-agency research initiative on NIT that assures both the security and the robustness of cyber-infrastructure."

  This is an explicit call – new! – for agencies such as NIH/HHS, the Department of Energy, the Department of Transportation, and the Department of Homeland Security to invest in computing research in areas of critical importance to their missions.

A broadened view of the forefront of networking and information technology

- **Many areas of NIT are now just as important as high performance computing**
  - "Effective use of NIT in increasing our economic competitiveness and achieving our other national priorities depends not only on incorporating innovative NIT into a widevariety of domains, but also on ensuring that the basic science and engineering of NIT remain vibrant and strong. At the time of the High-Performance Computing Act of 1991, the importance of high performance computing and communication (HPCC) to scientific discovery and national security was a major factor underlying the special attention given by Congress to NIT. Although HPCC continues to contribute in important ways to scientific discovery and national security, many other aspects of NIT have now risen to comparable levels of importance. Among these NIT areas are the interactions of people with computing systems and devices, both individually and collectively; the interactions between NIT and the physical world, such as in sensors, imaging, robotic and vision systems, and wearable and mobile devices; large-scale data capture, management and analysis; systems that protect personal privacy and sensitive confidential information, are robust in the face of malfunction, and stand up to cyber-attack; scalable systems and networking (i.e., systems and networks that can be either increased or decreased in complexity, size, generality, and cost); and software creation and evolution. HPCC is but one of many important areas of NIT, and America's prowess in HPCC is but one of many measures of our international competitiveness in NIT."

The NITRD program still bears the clear stamp of its High Performance Computing (HPC) origins. HPC has not become less important. However, other areas of NIT have risen to positions of equal importance. This perspective represents a significant departure from previous reports.

Necessary investments in NIT R&D focused on core areas of broad importance

- **There must be specific initiatives in NIT R&D in core areas of broad importance**
  - "A broad, multi-agency research program on the fundamentals of privacy protection and protected disclosure of confidential data …
  - "A collaborative research program that augments the study of individual human computer interaction with a comprehensive investigation to understand and advance human-machine and social collaboration and problem-solving in a networked, on-line environment …
  - "Fundamental research in data collection, storage, management, and automated large-scale analysis based on modeling and machine learning …
  - "Research in advanced domain-specific sensors, integration of NIT into physical systems, and innovative robotics in order to enhance NIT-enabled inter-action with the physical world."

  The focus on privacy is new. The focus on human/computer collaborative problem solving is new. The focus on automated large-scale data analysis is new. The focus on sensors and robotics extends previous initiatives in cyber-physical systems.

High performance computing: Move beyond the focus on kernel benchmarks of numerical performance

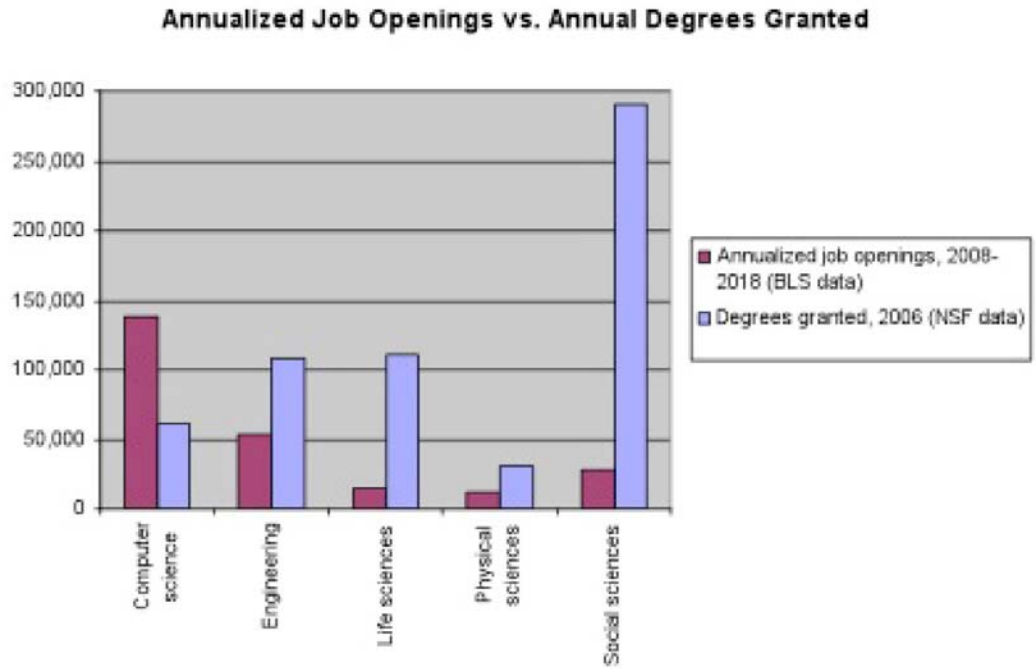
- **Within high performance computing, benchmark-driven competition should not be allowed to crowd out game-changing research or efforts to extract maximum benefit from leading-edge systems**
  - "Competition within the international community to develop what are typically described as the world's most powerful supercomputers has been based to a large extent on a single metric that, while relevant to *certain* HPC applications, increasingly fails to reflect the broad range of capabilities our Nation needs in the area of high performance computing." "While it would be imprudent to allow ourselves to fall significantly behind our peers with respect to scientific performance benchmarks that have demonstrable practical significance, a single-minded focus on maintaining clear superiority in terms of FLOPS count is probably not in our national interest. Engaging in such an 'arms race' could be very costly, and could divert resources away from basic research aimed at developing the fundamentally new approaches to HPC that could ultimately allow us to 'leapfrog' other nations, maintaining the position of unrivaled leadership that America has historically enjoyed in high performance computing." "NSF, DARPA, and DoE should invest in a coordinated program of basic research on architectures, algorithms and software for next-generation HPC systems. Such research should not be limited to the acceleration of traditional applications, but should include work on systems capable of (a) efficiently analyzing vast quantities of both numerical and non-numerical data, (b) handling problems requiring real-time response, and (c) accelerating new applications … In addition to designing next-generation systems, significant effort must be devoted to R&D focused on extracting the greatest possible scientific benefit from current leading-edge systems."

The call to abandon a benchmark focus is precedent-shattering.

Workforce and education

- **NIT is the dominant factor in America's science and technology employment**
  - "All indicators – all historical data, and all projections – argue that NIT is the dominant factor in America's science and technology employment, and that the gap between the demand for NIT talent and the supply of that talent is and will remain large." "Increasing the number of graduates in NIT fields at all degree levels must be a national priority."

Having PCAST acknowledge this, backed up by specific data from BLS and NSF, is important.



- **Computer science must become a core element of STEM (Science, Technology, Engineering, and Mathematics) education**
  - "Today, K-12 education largely ignores computer science." "Fluency with NIT skills, concepts, and capabilities; facility in computational thinking; and an understanding of the basic concepts of computer science must be an essential part of K-12 STEM education."

  Computer science has *not* been viewed as a component of STEM. There is a significant Federal thrust to improve K-12 STEM education. This report, and the recent PCAST report on STEM Education, hitches computer science to this wagon – a critical step.

The Federal NITRD coordination effort

- **There must be a broad, high-level standing committee dedicated to providing sustained strategic advice in NIT**
  - "The NITRD inter-agency coordination mechanism is widely – and we think correctly – viewed as successful and valuable." "NITRD is chartered and staffed to *coordinate* multi-agency programs. *Strategic leadership*, when necessary, must come from those with the authority to implement new strategies, namely OSTP and NSTC, to which NITRD reports. That leadership must have continuity, breadth and depth, and a focus on NIT." "OSTP should establish a broad, high-level standing committee of academic scientists, engineers, and industry leaders dedicated to providing sustained strategic advice in NIT."

  PCAST's responsibilities are too broad for it to provide sustained in-depth attention to NIT. The NIT field, though, is too important to the nation for intermittent attention. The Bush Administration terminated PITAC, an IT-focused Presidential advisory committee. This role must be filled.

- **The Nation is actually investing far less in NIT R&D than is shown in the Federal budget**
  - "The Nation is actually investing far less in NIT R&D than is shown in the Federal budget. A substantial fraction of the NITRD crosscut budget represents spending on NIT that supports R&D in other fields, rather than spending on R&D in the field of NIT itself." "The NCO and OMB should redefine the budget reporting categories to separate NIT infrastructure for R&D in other fields from NIT R&D, and should ensure more accurate reporting of both NIT infrastructure investment and NIT R&D investment." "The NCO should create a publicly available database of government-funded NIT research, and should provide regular detailed reporting to the Director of OSTP."

There is no "mis-expenditure of funds." But, at the same time, we do not have a clear idea what we are actually spending on NIT R&D. We should! (We are spending considerably less than the NITRD crosscut budget would suggest.)

NIT R&D per OMB's Definition	Number of Awards	Percent of Awards	Dollar Value of Awards	Percent of Dollar Value
Yes	4	4%	$10,882,505	2%
Borderline	14	14%	$52,108,659	9%
No	77	77%	$497,208,700	86%
No abstract	5	5%	$14,722,586	3%
Total	100		$574,992,450	

The role of Federal investment, and the nature of industrial R&D

- **The vast majority of industry R&D in NIT is focused on development** – on the engineering of future products and product versions – and not on fundamental research.

	IBM	Microsoft
Total research personnel worldwide	3,000	930
Total R&D personnel worldwide	40,000	36,000
Percentage of R&D personnel engaged in research	7.5%	2.5%

- **Private-sector R&D, while important, is (appropriately) driven by economic incentives that preclude its serving as a substitute for the sustained Federal funding of fundamental research in NIT.**

Chronology

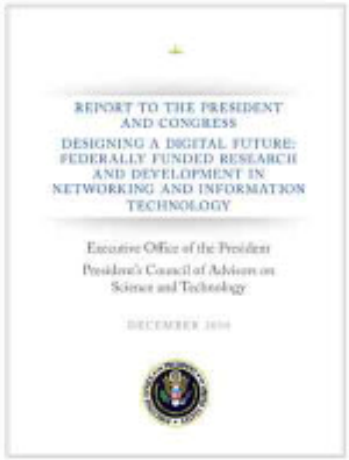
- May 2010: Co-Chairs identified, scope established
- June 2010: Working Group formed, formal work begins
- July 2010: First public meeting
- August 2010: Second public meeting
- September 2010: Draft report complete
- October 2010: Report presented to PITAC
- November 2010: Revised report complete; presented to PCAST Co-Chairs; presented to and adopted by PCAST; key Findings and Recommendations presented to the President
- December 2010: Final report presented to the public (Aneesh Chopra, Vivek Kundra, Philip Weiser, Tom Kalil, Ed Lazowska, David Shaw, Rob Atkinson, Tom Leighton)

Designing a Digital Future:

Federally Funded Research and Development in Networking and Information Technology

Report to the President and Congress
President's Council of Advisors on Science and Technology
December 2010

On Thursday, December 16, 2010, the President's Council of Advisors on Science and Technology (PCAST) released and discussed its report entitled "Designing a Digital Future: Federally Funded Research and Development in Networking and Information Technology." This congressionally-mandated report assesses the status and direction of the Federal Networking and Information Technology Research and Development (NITRD) Program.



This unofficial website links a broad range of information related to the PCAST report. The official PCAST website is here.

The Report

- Executive summary of the PCAST NITRD report
- Table of Contents of the report
- Full text of the report
- Informal and unofficial summary of key points of the report

December 16 report release event

- Agenda
- Press release
- Video archive

Press articles

- "Smarter, Not Faster, Is the Future of Computing Research" - *New York Times*
- "PCAST: The Role of NIT R&D in National Priorities" - Computing Community Consortium
- "White House Offers Strong Show of Support for PCAST IT R&D Findings" - Computing Research Association
- "PCAST Finds IT R&D Critical to U.S. Competitiveness, Calls for Renewed Federal Investment" - *Computing Research News*

Related material

- "Tire Tracks" diagram (the role of research in creating billion dollar industry segments)
  - Original NRC CSTB report
- Library of Congress Symposium (recent computing research breakthroughs)
  - Summaries, slides, videos
- Workforce and education charts
  - Workforce and education section of the report
- "Landmark Contributions by Students in Computer Science"

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Video Archive of the December 16, 2010 Report Release Event

	Aneesh Chopra Federal Chief Technology Officer and Associate Director for Technology, Office of Science & Technology Policy *Introduction*	Windows Media MP4
	Vivek Kundra Federal Chief Information Officer *Impact on the Federal IT Community*	Windows Media MP4
	Philip Weiser Senior Advisor for Technology and Innovation, National Economic Council *Impact on Competitiveness*	Windows Media MP4
	Tom Kalil Deputy Director for Policy, Office of Science and Technology Policy *Importance of NIT Research & Development*	Windows Media MP4
	Ed Lazowska University of Washington PCAST NITRD Working Group Co-Chair *Principal Findings of the Report*	Windows Media MP4
	David E. Shaw Chief Scientist, D. E. Shaw Research PCAST NITRD Working Group Co-Chair *Principal Recommendations of the Report*	Windows Media MP4
	Robert Atkinson President, Information Technology and Innovation Foundation *Independent Commentary*	Windows Media MP4
	Tom Leighton Professor of Applied Mathematics, MIT, and Co-Founder and Chief Scientist, Akamai Technologies *Independent Commentary*	Windows Media MP4
	Audience Q&A *Moderated by Aneesh Chopra*	Windows Media MP4

http://cra.org/nitrd/

Activities in connection with public rollout

- OSTP cybersecurity leadership
- OMB NITRD-related staff
- House Committee on Science & Technology staff
- Senate Committee on Commerce, Science & Transportation staff
- Information Technology and Innovation Foundation Board and Guests
- Interviews: *New York Times*, *Communications of the ACM*, Computing Research Association

Subsequent activities

- Articles (forthcoming): *Issues in Science and Technology*, *Science*, *IEEE Computer*
- Regular interactions with Tom Kalil and Aneesh Chopra regarding specific research initiatives (e.g., robotics, wireless, broadband)
- Regular interactions with NSF regarding specific research initiatives (e.g., robotics, wireless, broadband, data analytics)
- Participation in OSTP-organized wireless broadband summit
- Dinner with John Holdren regarding the nature and role of computing research
- Participation in CCC-organized IT and Energy summit

- Further discussion with Senate Committee on Commerce, Science & Transportation staff, plus Rockefeller staff
- Participation in the planning of a briefing on the Exascale program for the Senate Science & Technology Caucus
- Meetings with Ed Felten (FTC), Aneesh Chopra (OSTP), and Phil Weiser (OSTP) regarding cybersecurity and privacy
- Meetings with Aneesh Chopra (OSTP), Justin Rattner (Intel), Craig Mundie (Microsoft), and Elizabeth Grossman (Microsoft DC office) regarding research related to public safety wireless
- Meetings with Henry Kelly (EERE) regarding research initiatives related to IT and Energy

- Meeting with Steve Koonin (DoE Under Secretary for Science) regarding the role of computing research
- Briefings for Computing Community Consortium, Computing Research Association Government Affairs Committee, Computing Leadership Summit, Computing Research Association Board, Computer Science and Telecommunications Board, NSF CISE Advisory Committee