# 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**

*An informal summary of the key findings and recommendations of the report*
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## 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 wide variety 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 interaction 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 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.

To address this, 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.)

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All quoted material is taken from the report, which is linked from the PCAST website:
http://www.whitehouse.gov/administration/eop/ostp/pcast