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to the
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Committee on Science
The Future of Computer Science Research in the U.S.
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Chairman Boehlert, Ranking Minority Member Gordon, and Members of the Committee. I am pleased to appear before you today to discuss the critical role of computer science research in the Federal government's research and development (R&D) investment portfolio. As ever, I much appreciate the effective ongoing interactions between our office and your committee, which I believe ultimately benefit the Nation's science and technology enterprise.

Federal R&D in networking and information technologies has been and continues to be one of the Administration's highest R&D priorities. It is our view that these technologies provide a foundation for advances in virtually every other area of science and technology and generate myriad new capabilities and tools that grow our economy and make it more productive. Because of their unique role – as universal enablers for advanced science, engineering, and technology – networking and information technologies constitute a strategic component of the Nation's 21st century infrastructure. The Administration clearly recognizes that, and highlights this area as an R&D priority in the President's budget.

Before I address your specific questions, I would like to lay out what I believe is the broad context for our discussion. When I appeared before you in February to testify about the President's FY 2006 R&D budget, I acknowledged that it was subject to considerable pressure, making it the tightest proposal in nearly two decades. The President is committed to winning the war against terrorism, while moderating the growth in overall spending and cutting the deficit in half as a share of the GDP by 2009. These important goals obviously affect budget choices. So I was pleased to report to you that, despite these pressures, overall funding for Federal R&D increases to a record $132 billion in the President's FY 2006 budget – the highest level of government support for R&D in the world and a 45 percent increase over FY 2001's total of $91 billion.

Let me also note here my belief that the overall health of U.S. science and technology today is strong. We are spending three times as much as Japan on R&D and half again as much as all the European nations combined. Our FY 2006 R&D budget is three-quarters of a billion dollars higher than our FY 2005 request.

This basically strong and stable environment for U.S. R&D does not obviate the need to assure that we are spending Federal research dollars wisely and effectively. That entails planning to establish priorities and shifting funds in an orderly way toward the high-priority programs. Well-designed budgets will therefore inevitably have reductions as well as increases within large clusters of programs such as those in the R&D portfolio. These considerations are especially important during a time of significant fiscal constraints.

Now let me turn to your questions.

The first question asks about Administration priorities and how they have changed in the last five years. Clearly, the Administration's priorities in networking and information technology R&D were dramatically affected by 9/11 and the war against terrorism. Networking and information technology R&D investments for national defense, national security, and homeland security purposes received highest priority. Some of this work is classified for obvious reasons.

The 2006 budget proposal of $2.2 billion for the multi-agency Networking and Information Technology Research and Development (NITRD) Program – the Federal government's primary vehicle for long-term, fundamental R&D in networking, computing systems, software, and related information technologies – puts the Administration's cumulative five-year investment in the NITRD activity over the $10-billion mark, to $10.4 billion. Despite significant program redirections, the NITRD budget basically holds steady in the President's FY 2006 Budget.

As our NITRD budgets make clear, this Administration supports the breadth and diversity of the NITRD program's research interests. We view the scope of NITRD activities as one of the program's great strengths – encompassing work to advance high-performance computing and high-speed networking architectures for leading-edge research, to improve the quality and cost-effectiveness of software, to increase the security and reliability of computing and networking infrastructure, and to understand the implications of new technologies for education, workforce development, and social structures. Especially at a time of budget constraints, NITRD's multi-agency collaborative approach strongly supports spending efficiency, by leveraging each agency's expertise, minimizing duplicative efforts, and enabling results – such as prototype all-optical networks – that no single agency could achieve.

We consider all the NITRD activities to be of high priority, for precisely the reason that there is no other broad-based, fundamental IT R&D effort of the kind anywhere in this country. NITRD is a national resource.

We did, as you know, act to address concern about one NITRD domain. When my office chartered the High End Computing Revitalization Task Force (HECRTF) in 2003, it was in the recognition that the Federal R&D effort in high-end computing for vital Federal missions was in need of a new vision and fresh approaches. The Task Force produced a first-rate report, which I was delighted to present to your committee on May 10, 2004. The Administration strongly encourages this long-term revitalization effort guided by a roadmap that points to the key research challenges in hardware, software, and systems technologies. Federal supercomputing capabilities clearly are critical for our national defense and national security missions, as well as for leading-edge scientific research, and more broadly for economic innovation and U.S. leadership in science and technology.

It is relevant to your inquiries that one of the first developments to emerge from the Task Force activity is a new multi-agency program, the High End Computing University Research Activity (HEC-URA) supported by the Defense Advanced Research Projects Agency (DARPA), the Department of Energy (DOE), the National Security Agency (NSA), and the National Science

Foundation (NSF), that funds university-based R&D in high-end applications and system software. This program was launched quickly in FY 2004, resulting in 34 grants with total funding of $27.3 million over three years.

The high-end computing plan also extends access to the Nation's fastest, most powerful computing platforms to the national research community. The 2005 and 2006 budgets fund investments by the National Aeronautics and Space Administration (NASA) and the DOE Office of Science in advanced supercomputing systems whose management will include time allocations for outside researchers selected on a competitive basis. The concept of "national user facilities," being tested with these first two platforms, will itself have a galvanizing positive effect on the U.S. research community.

Another indication of the Administration's interest in the HEC area is that we have rechartered NITRD's HEC Coordinating Group as an Interagency Working Group (IWG), calling for agency membership at a higher level of membership with increased agency commitment.

Two important priorities for NITRD are information security and assurance and the management of enormous data flows.

First, assuring the security, safety, and highly dependable performance of systems, networks, and software in critical applications and infrastructures is one of the most significant and difficult challenges in information technology R&D. The technical complexity of these systems continues to grow rapidly in two directions – ever-larger systems of systems involving thousands of processors and ever-smaller embedded systems and networks of embedded systems. NITRD agencies are doing critical work toward next-generation software, system, and network engineering that incorporates high assurance levels from the ground up, and even "self-healing" capabilities.

We currently rely on systems that are fragile, attackable, failure-prone, and often impossible to troubleshoot. The risks of such problems in safety- and life-critical applications are clear. This is an extremely valuable NITRD focus, carried out across several of its major research areas (Large Scale Networking, High Confidence Software and Systems, Human-Computer Interaction and Information Management, and Software Design and Productivity).

Second, advanced technologies are required for dealing with the overwhelming volume of information currently being generated. This NITRD research tackles the subjects of how technologies can help us capture and process information (such as multimodal language translation and video, sound, and signal recognition), and how technologies can help us integrate and make sense of vast amounts of heterogeneous data in multiple formats (complex data sets). These capabilities are critical not only in military and national security environments but increasingly so in civilian applications such as health care, emergency response, education, and research across the spectrum including in the private sector.

To summarize, the Administration's overall R&D investments clearly have been affected by the Nation's move to a war footing after 9/11. Needs in the national defense, national security, and homeland security arenas have been immediate and great. However, these new demands have

not affected our commitment to the central role of the NITRD Program in filling the pipeline of skilled people and innovative ideas we need for national security, economic competitiveness, and scientific leadership in the years to come.

The second question asked about the relative roles of NSF and DARPA and changes to these roles.

NSF has for several years been the lead agency in the NITRD Program. Over the last five years, NSF's NITRD budget has risen nearly 25 percent, from $643 million in FY 2002 to $803 million in FY 2006. Over the same period, DARPA's NITRD budget has declined 33 percent, from $263 million in FY 2002 to $176 million in FY 2006, reflecting priority changes. Dr. Tether will comment in his testimony on the specifics involved.

As the only Federal research agency with a broad mission to advance both research and education across the physical and social sciences, mathematics, engineering, and technology, NSF plays a unique and invaluable role in the overall Federal R&D portfolio, and certainly in its NITRD activities. The National Science Foundation funds high-risk, long-term, basic research, and it is the only agency supporting that kind of R&D in all the core areas of the NITRD program. The agency identifies the most promising award candidates through a peer-based merit review process and makes awards to single investigators, teams, and center-scale projects. These grants permit investigators to explore promising new research opportunities as they arise, provide funding for projects exploring large-scale, experimental systems, and help educate future generations of computer scientists and provide workforce preparation for others.

In the national IT R&D community, NSF plays a powerful leadership role, constantly working to identify emerging research needs and innovative directions across the spectrum of networking and computing R&D and then developing programs to encourage fresh thinking among researchers and students at colleges and universities. The NSF leadership has compiled a remarkable track record of timely, successful initiatives to maintain leadership in information technology. Specific examples of initiatives follow:

The five-year Information Technology Research (ITR) program, whose concluding grants were awarded in FY 2004, was a foundation-wide initiative explicitly designed to promote multidisciplinary research by expanding computer science R&D into new areas. The program's novel requirements – that proposing teams cross disciplinary boundaries and include computer scientists in proposals addressing multidisciplinary problems – produced good results, not only for multidisciplinary inquiry – an increasingly important aspect of research problem solving – but for integration of computer science applications into all NSF's science and engineering directorates.

A recent committee of visitors convened to review ITR found that the program enabled many "best-of-breed ideas" and resulted in significant community building across disciplines.

Beginning in FY 2004, NSF established a cross-cutting emphasis to encourage the study of the vulnerabilities of networked computing systems. Although this has been a longstanding concern of the NITRD agencies, NSF's Cyber Trust program crystallized the need for new approaches to

cyber security, and also began addressing the national shortage of IT specialists with cyber security training. With the addition of the Cyber Trust program, funding for cybersecurity research at NSF has risen from $57 million in FY 2004 to $70 million in the President's 2006 budget. In FY 2005, NSF is also launching a new Science and Technology Center devoted to cyber security R&D, which I describe below.

NSF is also playing a key role in the NITRD high confidence software and systems work that I cited earlier. NSF's Science of Design theme is supporting development of a rigorous scientific base for greatly improved methods and tools for building software-intensive systems; this effort is funded at $10 million in 2005 and 2006. And in 2006, NSF plans to work with other NITRD agencies in a project to develop a prototype real-time embedded operating system.

In its five-year Network Middleware Initiative (NMI), NSF is spurring innovation in another core computer science area – the evolving layer of services that resides between the network and more traditional applications and enables networked computing systems to interact transparently with the network and other networked resources. Middleware is a critical component of scientific computing that NSF has stepped in to improve.

In 2006, NSF will begin a new $10-million program – Broadening Participation in Computing – to increase the number of domestic students receiving degrees in computer science.

It is clear that NSF is steadfastly and imaginatively pursuing its mission in information technology.

The third question concerned the Administration response to the President's Information Technology Advisory Committee (PITAC) report on cyber security.

In March 2004, my office asked PITAC to undertake an examination of the Federal role in cyber security R&D so that we could better understand what steps are needed to advance the Administration's priority goals of strengthening national and homeland security. During PITAC's study, we asked for and received support from the Office of Management and Budget in identifying Federal agencies' cyber security-related R&D investments, which remain very difficult to pinpoint because cyber security activities are not always clearly delineated or called out within broader programs, and, when they can be identified, it can still be difficult to estimate the extent to which the activities are related to IT *and* security *and* research.

OSTP much appreciates the PITAC's review of this extremely important topic. As I told PITAC members at their April 14 meeting, we began to respond to the report's findings and recommendations long before the published report appeared.

We agree with the PITAC that improved coordination of Federal cyber security R&D activities is key to increasing the efficiency and effectiveness of the Government's investments in this area. I am pleased to report that my office is facilitating one of the report's principal recommendations: integration of the National Science and Technology Council's (NSTC's) Interagency Working Group on Critical Information Infrastructure Protection (CIIP) R&D with the NITRD Program. Under the new structure, the CIIP IWG will have a broader charter integrating it with NITRD

and providing for dual reporting to the NSTC's Subcommittees on Infrastructure and on Networking and Information Technology R&D. The results will be better coordination among researchers from diverse Federal IT security communities, higher visibility for this vital area of Federal R&D, and an improved capacity to gauge the progress we are making toward new security technologies for our computing and networking infrastructures.

Also, before PITAC's final report was released, the CIIP had begun the process of defining our top cyber security R&D needs and mapping those against current activities. This is crucial if we are to better address the critically important issue of defining priorities.

I wish to call your attention to a recent NSF announcement to establish in FY 2005 a new Science and Technology Center devoted to cyber security R&D. Led by the University of California, Berkeley, the multi-institutional collaborative effort will investigate key issues of computer trustworthiness in an era of increasing attacks at all levels on computer systems and information-based technologies.

My office continues to evaluate PITAC's findings and recommendations regarding other specific steps that can be taken to enhance the effectiveness of Federal efforts in cyber security. Certainly, the vulnerabilities in critical U.S. infrastructures pointed to by the report need to be taken very seriously.

The future of computer science R&D will be determined in part by our ability to demonstrate its significance convincingly over time. I believe we need better metrics of our R&D accomplishments and new models for analyzing funding for science and technology in general. Our current indicators are based on a data taxonomy that is decades old and does not really represent the way R&D is actually conducted today.

In the NITRD area, we are making a start at improving these measures. The President's FY 2006 Budget tasks the National Coordination Office for IT R&D and the NITRD agencies to commission a study by the National Academies that identifies and categorizes important scientific questions and technological problems for which an extraordinary advancement in our understanding is difficult or impossible without leading-edge computing capabilities.

Thank you for your attention to this important subject. I would be happy to answer additional questions.