Statement of Dr. David B. Nelson
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to the Subcommittee on Technology, Information Policy, Intergovernmental Relations and the Census of the Committee on Government Reform,
U.S. House of Representatives
On Federal Information Technology Research and Development
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Mr. Chairman and members of the Subcommittee, I am pleased to meet with you to discuss federal information technology research and development.

I am the Director of the National Coordination Office for Information Technology Research and Development under the National Science and Technology Council (NSTC), and I co-chair, with my colleague Dr. Peter Freeman of the National Science Foundation, the Interagency Working Group for Networking and Information Technology Research and Development (NITRD). The NITRD program includes unclassified research and development activities of thirteen federal agencies, organized in seven Program Component Areas. It derives from authorization in the High Performance Computing Act of 1991 (Public Law 102-194), as amended.

The NITRD Program

For Fiscal Year 2005 the President's Budget requests $2.008 billion for the NITRD Program.[1] Detail at the level of Program Component Area is not yet available for Fiscal Year 2005. This level of detail is available for Fiscal Year 2004 and is presented in Table 1, which summarizes the NITRD Program activities and requested funding for Fiscal Year 2004. This table is taken from *Networking and Information Technology Research and Development: Supplement to the President's Budget for Fiscal Year 2004*, often referred to as the "Blue Book."[2] The total request of $2.147 billion for the FY 2004 NITRD program is an allocated or "crosscut" amount, rather than an aggregate of line items, because agencies describe their projects with differing terms. Table 1 also gives the names and requested funding for each of the seven Program Component Areas. Additional information regarding the NITRD program is contained in congressional testimony[3] recently presented by Dr. John H. Marburger, III, Director, White House Office of Science and Technology Policy.

The NITRD Program supports long-range research as well as research infrastructure such as computer centers and research networks. Research is performed at universities, federal research centers and laboratories, national laboratories and federally funded research and development centers, and private companies and non-profit organizations.

[1] http://www.ostp.gov/html/budget/2005/FY05NITRDfinal.pdf
[2] http://www.itrd.gov/pubs/blue04/index.html
[3] http://www.house.gov/science/hearings/full04/may13/marburger.pdf

Historical accomplishments of the NITRD Program and its predecessors include the High Performance Computing and Communications (HPCC) Initiative in the early 1990s and the Next Generation Internet (NGI) Initiative in the late 1990s. The HPCC initiative helped to create modern computational science and today's parallel supercomputers, demonstrated the intimate link between computing and networks, and created the graphical web browser. The NGI initiative helped to create the technology for today's high-bandwidth optical networks and demonstrated the value of distributed computing using high-bandwidth networks, forming the basis for today's grid computing.

Agencies participating in NITRD work together to identify research needs, plan research programs, and review progress. Often agencies coordinate their selection of research performers through joint or coordinated announcements and mutual assistance in proposal review. The program includes numerous interactions with stakeholders through workshops and other meetings and wide dissemination of research results through publications, reports, and presentations. Often activities under the NITRD Program are conducted jointly with other research programs to enhance knowledge and technology transfer.

The President's Information Technology Advisory Committee (PITAC), authorized by the High Performance Computing Act, provides advice and guidance to the NITRD Program. PITAC is governed by the provisions of the Federal Advisory Committee Act; its members are drawn from the private sector. The current PITAC Co-Chairs are Dr. Ed Lazowska, professor of computer science at the University of Washington, who is testifying before the Subcommittee today, and Marc Benioff, Chief Executive Officer of Salesforce.Com. At its next meeting, scheduled for June 17, 2004, PITAC will consider draft recommendations for the contribution of information technology research and development to health care and will discuss the preparation of recommendations in the two areas of cyber security research and computational science.

A notable example of the processes used by the NITRD Program is the recently published *Federal Plan for High-End Computing: Report of the High-End Computing Revitalization Task Force.*[4] This plan was developed during a year of planning under the auspices of the NSTC by more than sixty federal research managers, including representatives from fields of science and engineering that use high-end computing. Input from stakeholders was obtained through a major workshop organized by the Computing Research Association[5], white papers solicited as part of the workshop, and non-disclosure briefings by companies involved in high-end computing. Participating agencies are now working together to incorporate planned activities into their programs. An early result is the High-End Computing University Research Activity,[6] sponsored by the Defense Advanced Research Projects Agency (DARPA), The Department of Energy Office of Science (DOE/SC), and the National Science Foundation (NSF) and solicited through two coordinated research announcements. This activity supports long-lead academic research necessary to revitalize high-end computing.

[4] http://www.itrd.gov/pubs/2004_hecrtf/20040510_hecrtf.pdf
[5] http://www.cra.org/Activities/workshops/nitrd/
[6] http://www.itrd.gov/hecrtf-outreach/hec-ura/index.html

Another closely related example is the High Productivity Computing Systems (HPCS) Program led by DARPA. The HPCS Program precedes development of the *Federal Plan for High-End Computing* and is key to its success. This program seeks to improve productivity of technical computers that might be available in the mid-term, a need shared by all NITRD agencies. Several agencies participate in planning and assessing progress of the HPCS Program and have adjusted their own programs to complement the HPCS Program.

Two examples illustrate how the NITRD Program works with other programs and communities to invent and apply advances in information technology. The first example is the Information Technology Research (ITR) Program of NSF, which has funded projects under its several science and engineering directorates to advance and incorporate information technology into science and engineering. This program specifically aims at rapid transfer of advances in information technology to disciplines that benefit from them. The Digital Government Program is perhaps of interest to this Subcommittee, because it funds research cooperatively with other branches of government specifically to improve government effectiveness through advanced information technology. The second example is the Scientific Discovery through Advance Computing (SciDAC) Program in DOE/SC. This program directly links information technology research with the other research programs of the Office of Science to quickly recognize and apply opportunities for information technology to improve effectiveness of the sciences.

Agencies participate in NITRD activities according to their mission needs. Research agencies such as NSF and DARPA tend to focus their NITRD work on longer term research and underlying technology. Mission agencies such as the National Institutes of Health (NIH), the Agency for Healthcare Research and Quality, the National Oceanic and Atmospheric Administration, and the Environmental Protection Administration focus more on applying basic NITRD advances to their mission activities, such as biomedicine, health care, climate, weather, and the environment. Other mission agencies such as the National Aeronautics and Space Administration, the National Institute of Standards and Technology, and DOE/SC participate both in underlying research and applications of that research. Defense agencies such as the Department of Defense and DOE’s National Nuclear Security Administration participate through open, unclassified research and apply results to their classified national security missions.

A few agencies, such as the Federal Aviation Administration, the Food and Drug Administration, and the General Services Administration, associate with the NITRD Program as observers, contributing research needs and incorporating research advances into their operations.

Value of Historical Federal Investments in Information Technology Research and Development

“Success has many fathers,”[7] yet studies attest to the unique role of Federal information technology research and development investments in creating the information age. In

[7] Attributed to Philip Caldwell

1995 the National Research Council concluded in a Congressionally chartered study[8] of the HPCC Initiative that "Federal investment in information technology research has played a key role in the U.S. capability to maintain its international lead in information technology." The study cited numerous examples of information technologies whose roots lay in Federally funded research or that were nurtured through critical development periods by Federal research funds. These include network technology and the Internet, the Web browser, windowing, computer graphics, reduced instruction set computers, very large scale integration design, storage technology known as RAID,[9] and parallel computing architecture.

In 1999 the National Research Council studied the role of Federal investment in information technology research and development.[10] The study concluded that "Federal funding not only financed development of most of the nation's early digital computers, but also has continued to enable breakthroughs in areas as wide ranging as computer time-sharing, the Internet, artificial intelligence, and virtual reality as the industry has matured. Federal investment also has supported the building of physical infrastructure needed for leading-edge research and the education of undergraduate and graduate students who now work in industry and at academic research centers." The study also stated that, "The effects of federal support for computing research are difficult to quantify but pervasive. Patent data, although a limited indicator of innovation, provide strong evidence of the links between government-supported research and innovation in computing. More than half of the papers cited in computing patent applications acknowledge government funding."

The 1999 National Research Council Study pointed out that information technology has had profound implications, stating:

> "The computer revolution is not simply a technical change; it is a sociotechnical revolution comparable to an industrial revolution. The British Industrial Revolution of the late 18th century not only brought with it steam and factories, but also ushered in a modern era characterized by the rise of industrial cities, a politically powerful urban middle class, and a new working class. So, too, the sociotechnical aspects of the computer revolution are now becoming clear. Millions of workers are flocking to computing-related industries. Firms producing microprocessors and software are challenging the economic power of firms manufacturing automobiles and producing oil. Detroit is no longer the symbolic center of the U.S. industrial empire; Silicon Valley now conjures up visions of enormous entrepreneurial vigor."

Of course, these words were written before the bursting of the dot-com bubble, but the growth of the information technology industry continues, and the use of information technology has recently led to significant productivity increases in broad sectors of the U.S. economy.

U.S. companies have unquestionably led the information technology revolution, and Federal research funding has built the basis for many of these companies through idea

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[8] *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Infrastructure*, National Academy Press, Washington, D.C., 1995

[9] RAID is an acronym for redundant arrays of inexpensive disks.

[10] *Funding a Revolution: Government Support for Computing Research*, National Academy Press, Washington, D.C., 1999.

generation and training of future entrepreneurs. As the 1999 study points out, "Many of these entrepreneurs had their early hands-on computer experience as graduate students conducting federally funded university research." Fortune favors the company that is first to market with new technology through higher margins, greater market share, and a stronger role in standards. It is no surprise then that most of the world's largest and most successful information technology companies are American and that most information technology standards are based on American technology.

The NITRD Program returns value directly to government operations through at least two pathways. The first is through Government purchase of commercial off the shelf (COTS) information technology products – hardware, software and services – that have been invented or improved through federal research. Today the government uses mostly COTS information technology, and even when custom development is undertaken, the development tools are usually COTS. The second pathway is the development of special information technology needed for Government missions. This is clearly shown in the Government's research and development programs, where many of the specialized information technologies have been invented or developed by the NITRD Program, often in direct partnership with the program intending to use these technologies, as described earlier in this testimony.

Value of Current Federal Investments in Information Technology Research and Development

The value of today's research in the NITRD Program can only be based on prediction, and "predicting is difficult, especially about the future."[11] Nonetheless, if we extrapolate from the past, we can be confident that today's investments will have large payoff. The NITRD Program is working in areas such as

- Improving the quality and reliability of software
- Improving the security of operating systems, applications, and networks
- Making it easier and more productive for humans to interact with computer systems, including facilitating access by individuals with disabilities.
- Managing resources distributed over the Internet
- Developing and applying computer modeling and simulation to fields as diverse as medicine, manufacturing, energy, environment, climate and weather, and nanotechnology
- Detecting and responding to natural or man-made threats
- Managing information-intensive dynamic systems
- Supporting life-long learning

Each of these areas has application to important economic, social, and/or national security needs. Of perhaps special interest to this Subcommittee is research on information security, because of its importance to Government operations. Federal agencies are funding applied research to better enable us to cope with security weaknesses in the basic architectures of operating systems and networks, as well as fundamental research investigating ways to improve the intrinsic security in the architecture of information systems and networks. The value of the latter is that if

[11] Attributed to Yogi Berra.

successful it would eliminate the security weaknesses of current architectures. The difficulty is that even if methods to improve intrinsic security are found, they must be compatible with legacy technology and protocols. An example of this research is the NSF Cyber Trust Program, whose awards will soon be announced.

Two examples may serve to illustrate the value of current research programs. The first is the return on the Digital Libraries Initiative, an ongoing part of the NITRD Program that has been sponsored by NSF, NASA, DARPA, and later NIH. A recent article[12] points out that Google, the search engine company that is about to issue a very significant initial public offering of stock and whose name has entered the vocabulary as a verb, owes its technology directly to a Digital Libraries Initiative grant. As the article states,

> "Google was founded by Larry Page and Sergei Brin – two computer science graduate students at Stanford University. Stanford was one of a number of universities that received funding under the "Digital Libraries Initiative" – supported by the National Science Foundation, NASA, and the Defense Advanced Research Projects Agency… The goal of the initiative, launched in 1994, was to 'dramatically advance the means to collect, store, and organize information in digital forms, and make it available for searching, retrieval, and processing via communication networks - all in user-friendly ways.' Larry Page was funded under the DLI as a graduate student researcher, and Sergei Brin was supported with an NSF graduate student fellowship. Page and other Stanford researchers created an algorithm called PageRank. It ranks the importance of each Web page based on the number and importance of other Web pages that link to it. This technological advance enabled Page and Brin to develop a search engine that found useful and relevant information, which was critical to Google's popularity. Google was also prototyped on equipment paid for by the federal government's Digital Library Initiative."

The second example is the ongoing NITRD work on grid computing, supported by several agencies in close collaboration with other research communities. The goal of grid computing is to make it easy to manage and use large-scale computing and data storage resources located anywhere on the network. Among the problems to be solved are the efficient transport of large data sets, synchronization of distributed data bases, access to and management of distributed information technology resources, security and privacy provisions that work across disparate organizations, simple user interfaces that hide the complexity of underlying protocols, and compatibility with legacy technology. Even though the initial applications are to scientific research, commercial information technology applications can also benefit from grid technology. Not surprisingly, several computer companies including IBM, Hewlett Packard, Microsoft, and Oracle are working closely with the grid computing research community and are already offering commercial products and services based on this technology. They are also providing feedback to the research community regarding the practicality of the grid services being developed.

Managing Federal Information Technology Research and Development

The NITRD Program has benefited from talented research leaders and managers in the participating agencies and supported organizations. Because research deals centrally with the unknown and unanticipated, it must be managed deftly. Often research "failure" becomes success, as intractable obstacles point the way to alternative approaches. Both

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[12] http://www.americanprogress.org/site/pp.asp?c=biJRJ8OVF&b=71217

Federal program managers and researchers must have good instincts regarding when to continue the proposed research and when to abandon or modify it. Milestones and benchmarks are helpful in some types of project but can be stultifying in others, especially when they mandate following unproductive paths. The 1999 National Research Council study referenced previously[8] provides cogent recommendations regarding successful management of information technology research:

> "Scientific and technological research explores the unknown; hence, its outcomes cannot be predicted at the start--even if a clear, practical goal motivates the work…. Moreover, even research projects that do not achieve their original objectives can produce meaningful results or generate valuable knowledge for guiding future research efforts…. Other projects show meaningful returns only after a long time because their applications are not immediately recognized or other technological advances are needed to make their usefulness evident….
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> "Such difficulties frustrate attempts to meaningfully measure the performance of research and also highlight the need for ensuring flexibility in the management and oversight of federally funded research programs. Researchers need sufficient intellectual freedom to follow their intuition and to modify research plans based on preliminary results…. Building such flexibility into federal structures for managing research requires both skilled program managers--who understand, articulate, and promote the visions of researchers--and an organizational culture that accepts and promotes exploratory efforts….
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> "Clearly, there are limits to the flexibility that researchers and program managers can be allowed. In development-oriented programs, for example, program managers must ensure that specific objectives are met. In exploratory research, program managers must ensure that research funds are used prudently. But such accountability must be balanced against the unpredictability of research. Structures for managing and overseeing federally funded research need to allow program managers to alter programs midcourse in response to preliminary results and need to recognize that research projects can produce valuable results even if they do not achieve their original objectives. Failing to do so risks stifling creativity and innovation. The history of computing demonstrates the benefits of a flexible approach."

The experience of the NITRD program managers has shown that these are valuable recommendations, and that following them has contributed to the success of the NITRD Program. These concepts are also consistent with the R&D Investment Criteria,[13] which the Administration uses to guide all federal R&D programs.

Conclusion

Thank you for giving me the opportunity to testify before the Subcommittee. I would be pleased to answer any questions that you might have.

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[13] http://www.whitehouse.gov/omb/memoranda/m03-15.pdf

Agency NITRD Budgets by Program Component Area

FY 2003 Budget *Estimates* **and** FY 2004 Budget Requests **(dollars in millions)**

Agency	High End Computing Infrastructure and Applications (HEC I&A)	High End Computing Research and Development (HEC R&D)	Human Computer Interaction and Information Management (HCI & IM)	Large Scale Networking (LSN)	Software Design and Productivity (SDP)	High Confidence Software and Systems (HCSS)	Social, Economic, and Workforce (SEW)	Totals
NSF (2003) estimates	211.7	76.0	128.8	109.0	53.4	63.8	65.9	708
NSF (2004) requests	218.1	97.9	125.3	103.4	55.0	59.9	74.0	734
NIH	77.1	37.8	93.1	128.8	6.8	3.7	12.1	359
NIH	87.6	41.7	99.0	132.2	9.2	3.7	12.2	386
NASA	35.2	26.0	40.8	12.6	55.8	34.7	4.2	209
NASA[a]	45.9	34.6	67.1	28.9	59.2	24.2	6.7	267
DARPA		109.8	42.9	17.6	58.6	3.2		232
DARPA		108.5	78.4	18.2	13.3	4.0		222
DOE Office of Science	98.4	37.3	16.2	28.7			3.5	184
DOE Office of Science	88.9	51.3	16.4	30.0			3.5	190
AHRQ			6.4	5.2				12
AHRQ			32.0	25.0				57
NSA		51.3		2.1		28.1		82
NSA		21.3		1.9		28.1		51
NIST	3.5		6.2	3.2	7.5	2.0		22
NIST	3.5		6.2	3.2	7.5	2.0		22
NOAA	13.5	1.8	0.5	2.8	1.5			20
NOAA	13.5	1.8	0.5	2.8	1.5			20
EPA	1.6		0.2					2
EPA	1.6		0.2					2
ODDR&E		3.6	2.0	4.7	1.0	0.7		12
ODDR&E								
Subtotals	441.0	343.6	337.1	314.6	184.6	136.2	85.6	1,843
Subtotals	459.1	357.1	425.1	345.5	145.7	122.0	96.4	1,951
DOE/NNSA	40.5	37.5		13.5	31.3		4.4	127
DOE/NNSA	41.5	37.3		14.4	32.8		4.4	130
DISA						6.1		6
DISA			46.2	13.2		6.1		66
TOTALS[b]	481.5	381.1	337.1	328.1	215.9	142.3	90.0	1,976
TOTALS[b]	500.6	394.4	471.3	373.3	178.5	128.1	100.8	2,147

Notes:
[a] NASA FY 2004 budget reflects full cost
[b] These totals include discrepancies from what appears in the President's FY 2003 and FY 2004 budgets due to a combination of rounding and shifts in program estimates

Table 1. Fiscal Year 2004 NITRD Program and Budget Request