Information Technology Research: Investing in Our Future

President's Information Technology Advisory Committee
Report to the President

Ken Kennedy
PITAC Co-Chair

http://www.cs.rice.edu/~ken/Presentations/PITAC.pdf
Presentation Outline

• About PITAC
  — Charter
  — Membership
  — Activities
    - Fact finding
    - Some difficult issues
  — Reports and responses

• Findings and Recommendations
  — Investment Strategy
  — Research
  — Management

• Conclusions

President’s Information Technology Advisory Committee
Charter

- The Committee shall provide an independent assessment of:
  - Progress made in implementing the High-Performance Computing and Communications (HPCC) Program;
  - Progress in designing and implementing the Next Generation Internet initiative;
  - The need to revise the HPCC Program;
  - Balance among components of the HPCC Program;
  - Whether the research and development undertaken pursuant to the HPCC Program is helping to maintain United States leadership in advanced computing and communications technologies and their applications;
  - Other issues as specified by the Director of the Office of Science and Technology.
    - Review of the entire IT investment strategy — is it meeting the nation’s needs
Committee Membership

• Co-Chairs:
  - Bill Joy, Sun Microsystems
  - Ken Kennedy, Rice

• Members:
  - Eric Benhamou, 3Com
  - Ching-chih Chen, Simmons
  - Vinton Cerf, MCI
  - Steve Dorfman, Hughes
  - David Cooper, LLNL
  - Bob Ewald, SGI
  - David Dorman, PointCast
  - Sherri Fuller, U of Washington
  - David Farber, Penn
  - Susan Graham, UC Berkeley
  - Hector Garcia-Molina, Stanford
  - Danny Hillis, Disney, Inc
  - Jim Gray, Microsoft
  - John Miller, Montana State
  - Robert Kahn, CNRI
  - Raj Reddy, Carnegie Mellon
  - David Nagel, AT&T
  - Larry Smarr, UIUC
  - Ted Shortliffe, Stanford
  - Les Vadasz, Intel
  - Joe Thompson, Miss. State
  - Steve Wallach, Centerpoint
  - Andy Viterbi, Qualcomm
  - Irving Wladawsky-Berger, IBM
History: Phase I

• February 27-28, 1997: First committee meeting
  — Organized into subgroups for review of Federal research investments
    - Began process leading to report
• June 3, 1998: Committee sends letter to President Clinton summarizing major recommendations
• June 5, 1998: Strong IT endorsement in President’s MIT commencement address
  “In the budget I submit to Congress for the year 2000 I will call for significant increases in computing and communications research. I have directed Dr. Neal Lane, my new advisor for Science and Technology, to work with our nation’s research community to prepare a detailed plan for my review.”
• August 6, 1998: Interim report is released
History: Phase I I

- Following release of interim report
  - Established panels to solidify final recommendations
  - Committee members briefed Congressional and professional groups
  - Agencies convened workshops to develop budget requests

- January 24, 1999: Vice-President Gore announces the FY2000 budget initiative - Information Technology for the Twenty-first Century (IT²)
  - $366 million in incremental budget
    - reviewed later in talk

- February 24, 1999: Final Committee report is released

- May 28, 1999: Release of House Networking & IT R&D Act
  - 92% Increase over five years
Methodology

• Evaluation of Federal Research Investment Portfolio
  — Plans reviewed for each of the major areas:
    - High End Computing and Computation
    - Large Scale Networking
    - Human Centered Computer Systems
    - High Confidence Systems
    - Education, Training, and Human Resources

• Review of Balance in Federal Research Portfolio
  — Fundamental versus Applied
    - Based on our own definition of these terms
  — High-Risk versus Low-Risk
  — Long-Term versus Short-Term
Principal Finding

- Drift Away from Long-Term Fundamental Research
Principal Finding

• Drift Away from Long-Term Fundamental Research
  — Agencies pressed by the growth of IT needs
    - IT R&D budgets have grown steadily but not dramatically
    - IT industry has accounted for over 30 percent of the real GDP growth over the past five years, but gets only 1 out of 75 Federal R&D dollars
    - Problems solved by IT are critical to the nation—engineering design, health and medicine, defense
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  - Most IT R&D agencies are mission-oriented
    - Natural and correct to favor the short-term needs of the mission
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• This Trend Must Be Reversed
  — Continue the flow of ideas to fuel the information economy and society
Remedy

- Increase the Federal IT R&D Investment by 1.4 billion dollars per year
  - Ramp up over five years
  - Focus on increasing fundamental research
Remedy

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• Invest in Key Areas Needing Attention
  — Software
  — Scalable Information Infrastructure
  — High-End Computing
  — Social, Economic, and Workforce Issues
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- Invest in Key Areas Needing Attention
  - Software
  - Scalable Information Infrastructure
  - High-End Computing
  - Social, Economic, and Workforce Issues

- Develop a Coherent Management Strategy
  - Establish clear organizational responsibilities
  - Diversify modes of support
Software

• Findings:
  – Demand for software far exceeds the nation’s ability to produce it
    - IT workforce shortage
  – The nation depends on fragile software
    - Y2K problem
  – Technologies to build reliable and secure software are inadequate
    - Critical infrastructure is at risk
  – The diversity and sophistication of software systems are growing rapidly
  – More and more common activities of ordinary people are based on software
    - Finance, entertainment, travel, government services
  – The nation is under-investing in fundamental software research
    - Example: HPCC Program
Software

• Recommendations
  — Make fundamental software research an absolute priority
  — Fund fundamental research in software development methods and component technologies
    - Component libraries, integration technologies, tools for integration management, language interoperability
  — Support fundamental research in human-computer interfaces and interaction
    - Build on exciting new technologies, less dependence on text and manual dexterity
  — Support fundamental research in capturing, managing, analyzing, and explaining information and in making it available for its myriad uses
    - Integrate non-text information, knowledge extraction
  — Make software research a substantive component of every major information technology research initiative.
Scalable Information Infrastructure

• Findings:
  – Our Nation’s dependence on the Internet as the basis for its information infrastructure continues to grow at a dramatic rate.
  – The Internet is growing well beyond the intent of its original designers,
    - No longer understand it and cannot confidently continue to extend it
  – Learning how to build and use large, complex, highly-reliable and secure systems requires research
    - Scaling to provide robust, reliable, high-speed access.
    - Scaling to provide assured quality of service.
    - Scaling to provide ubiquitous access.
    - Scaling of services to handle users and requests reliably.
    - Scaling of the security of the infrastructure
    - Scaling to support huge information servers.
Scalable Information Infrastructure

- Recommendations
  - Fund research on understanding the behavior of the global-scale network.
  - Support research on the physics of the network, including optical and wireless technologies such as satellites, and bandwidth issues.
  - Support research to anticipate and plan for scaling the Internet.
  - Support research on middleware that enables large-scale systems.
    - Information management, Information and services survivability
  - Support research on large-scale applications and the scalable services they require.
    - National digital library, Next-generation world-wide web
  - Fund a balanced set of testbeds that serve the needs of networking research, research in enabling information technologies and advanced applications, and Internet research.
High-End Computing

• Findings:
  — High-end computing is essential for science and engineering research
  — High-end computing is an enabling element of the United States national security program
  — New applications of high-end computing are ripe for exploration
  — Suppliers of high-end systems suffer from difficult market pressures
    - High-end market not large
  — Innovations are required in high-end systems and application-development software, algorithms, programming methods, component technologies, and computer architecture
    - Scalable parallel architectures not ideal for every application
  — High-end computing capability for the civilian science and engineering community is falling dangerously behind the state of the art
High-End Recommendations

• Research:
  – Fund research into innovative computing technologies and architectures
  – Fund R&D on software for improving the performance of high-end computing
  – Drive high-end computing research by trying to attain a sustained petaops/petaflops on real applications by 2010 through a balance of hardware and software strategies

• Facilities
  – Fund the acquisition of the most powerful high-end computing systems to support science and engineering research

• Management
  – Expand the NSTC CIC High End Computing and Computation (HECC) Working Group’s coordination process to include all major elements of the government’s investment in high-end computing
Social, Economic, Workforce Issues

• Findings
  – The use of information technology—the growing popularity of the Internet and the emergence of global commerce—has introduced a series of important and complex policy issues
  – Policy decisions and IT investments are being made on the basis of incomplete data about the effects of IT on our society
  – All of our citizens must have access to information technology
  – Full participation in information technology research requires access to high-bandwidth connectivity
  – The supply of information technology workers does not meet the current demand
  – A diverse workforce literate in information technology is critical for meeting the challenges and opportunities of the Information Age
  – Both K-12 and post-secondary education are inadequate to meet the challenges of the information age
Social, Economic, Workforce Issues

- **Recommendations:**
  - Expand Federal initiatives and government-university-industry partnerships to increase information technology literacy, education, and access
  - Expand Federal research into policy issues arising from information technology
  - Fund information technology research on socioeconomic issues
  - Create programs to remove the barriers to high bandwidth connectivity posed by geographic location, size, and ethnic history of research, educational institutions, and communities
  - Accelerate and expand education in information technology at all levels—K-12, higher education, and lifelong learning
  - Expand the participation of underrepresented minorities and women in computer and information technology careers
  - Strengthen the use of information technology in education
Management

• Recommendations:
  – Strongly encourage NSF to assume a leadership role in basic information technology research
    - Provide NSF the necessary resources to play this role.
  – Designate a Senior Policy Official for Information Technology R&D
  – Establish a senior-level policy and coordination committee to provide strategic planning and management
    - Agency representatives with budget authority
    - Operations committee can handle detailed planning
  – Extend the HPCC program coordination model to the entire Federal information technology R&D endeavor
    - Currently used for HPCC and NGI
  – Annual review of research objectives and funding modes.
    - Involvement of Presidential Advisory Committee
Modes of Support

• Finding:
  – The Federal IT R&D funding profile is incomplete

• Recommendations:
  – Diversify the modes of research support to foster projects of broader scope and longer duration
    – Teams, funding for 3 years or more.
  – Fund collaborations with applications to drive IT research
    – Take measures to ensure that research remains a primary goal
  – Fund virtual centers for Expeditions into the 21st Century
    – Virtual “think tanks” focused on revolutionary IT by living in the future
  – Establish a program of Enabling Technology Centers
    – Centers focused on research driven by a particular application focus (similar to NSF STCs)
## Proposed Budget

### Basis
- Estimates by individual subpanels
  - Expansion of number of researchers and size of grants

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<th>Area/FY</th>
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<td>733</td>
<td>996</td>
<td>1202</td>
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Questions

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  - Yes: $600M in unused capacity, $350M in facilities, $450M in expanded capacity (2500 new researchers over 5 years)
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- Is NSF the right agency to lead in coordination?
  - Its mission is fundamental research, but is it too conservative?
Good News

• Administration Budget
  – Additional $366 million in FY 2000
    - NSF: $146 million, with $35 million for facilities
    - DoD: $100 million, with $70 million for DARPA
    - DOE: $70 million for SSI
    - NASA: $38 million
    - NOAA: $6 million, NIH: $6 million
  – Prospects for successive years unclear

• Congress
  – Funding Bill from House Science Committee (Sensenbrenner)

• Coordination Mechanisms Established
  – Two committees: strategic committee chaired by President’s Science Advisor and operations coordination led by NSF
IT² Preliminary Plan I

• Fundamental information technology research
  —Software
    - software engineering, end-user programming, component-based software development, active software, autonomous software
  —Human-computer interaction and information management
    - computers that speak, listen, and understand human language
    - information visualization
  —Scalable information infrastructure
    - deeply networked systems; anytime, anywhere connectivity; network modeling and simulation
  —High-end computing
    - improving the performance and efficiency of supercomputers
    - creating a computational grid
    - revolutionary computing
IT² Preliminary Plan II

- Advanced computing for science, engineering, and the Nation
  - Advanced infrastructure
  - Advanced science and engineering computation
  - Computer science and enabling technology
  - National information infrastructure applications

- Research on the economic and social implications of the Information Revolution
  - Economic and social impacts of information technology
  - Information technology workforce
## Proposed Budget for IT²

<table>
<thead>
<tr>
<th>Agency</th>
<th>IT Research</th>
<th>Advanced Computing Sci.&amp;Eng.</th>
<th>Ethical, Legal, Social</th>
<th>Total</th>
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<td>DOD¹</td>
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<td>--</td>
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<td>100M</td>
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<td>6M</td>
<td>62M</td>
<td>2M</td>
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<td>NASA</td>
<td>18M</td>
<td>19M</td>
<td>1M</td>
<td>38M</td>
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<tr>
<td>NIH</td>
<td>2M</td>
<td>2M</td>
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<td>NOAA</td>
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<td>6M</td>
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<tr>
<td>NSF</td>
<td>100M</td>
<td>36M</td>
<td>10M</td>
<td>146M</td>
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<tr>
<td>Total</td>
<td>228M</td>
<td>123M</td>
<td>15M</td>
<td>$366M</td>
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</table>

¹ $70M for DARPA
² Strategic Simulation Initiative
House Networking and IT R&D Act

- Full Five Years of Funding for IT R&D
  - 92 percent over 5 years

- Substantive Increases for NSF
  - $130 million for large grants of up to $1 million for research into high-end computing, software, and networking
  - $220 million for information technology research centers;
  - $385 million for terascale computing hardware
    - Includes some funds redirected from DOE
  - $95 million for universities to establish internship programs for research at private companies
  - $111 million through fiscal year 2002 for the completion of the Next Generation Internet program.

- Permanent R&D Tax Credit for Industry
Implications for Research

• There will be new resources
  – Software will be a primary concern
    - Not just software engineering
  – Information Infrastructure will continue to increase in importance
    - Not just networking
  – Renewed concerns for high-end computing
    - Software and architecture, driving toward Petaops/Petaflops

• Focus will be longer-term
  – Planning and vision will be emphasized
  – Interdisciplinary projects will be important
    - Application-driven research will continue to be prominent
    - Goal of generating IT results will get equal billing
  – Opportunities for large-scale collaborations (Centers, Expeditions)
Conclusions

• U. S. leadership in Information Technology provides an essential foundation for commerce, education, health care, environmental stewardship, and national security in the 21st century.
  — Dramatically transform the way we communicate, learn, deal with information and conduct research
  — Transform the nature of work, nature of commerce, product design cycle, practice of health care, and the government itself

• Assessment:
  — The total Federal IT R&D investment is inadequate and overly focused on the short term

• Remedy:
  — Create a strategic initiative in long-term IT R&D
    - Will require doubling the IT R&D Budget
    - Diversify support to foster risk-taking
Final Observations

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    - “Don’t circle the wagons and shoot inward”
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• Are there other pitfalls?
  — The program must be managed well.
    - NSF must lead effectively, modify the way it does business