*NII, GII, I2 and NGI, and IT*2 Initiatives: Implications to the Digital Library Development in the US*

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1. INTRODUCTION

For over a decade, I have advocated the concept of "Global Digital Library" ever since I have had the pleasure of directing a major and popular interactive multimedia project on the First Emperor of China's 6,000 Terracotta Warriors and Horses since 1984. Figure 1 offers a glimpse of the heavy media coverage of that project which led me to experience the excitement of the "digital" experiments.

Figure 1. Some sample media coverage of the popular project

Six years ago at this very same podium, I delivered a keynote speech entitled "Technological Potentials for the Global Library: Realities and Challenges" (Chen, 1993) at the *International Conference on National*

Libraries - Toward the 21st Century, April 20-24, 1993 in celebration of the 60th Anniversary of the National Central Library. In an over simplistic manner, I presented a global conceptual diagram, and advocated then that technology will soon be ready for us to have "The Global Library" when the world's national and research libraries and other libraries are linked together as nodes of a worldwide information network. In following the history of Internet and World Wide Web, this concept was advocated much earlier than the time when the Internet has become a commonplace for everyone. How things have changed in the last decade or even half decade! Technology has indeed outpaced us in any kind of predictions!

NII and GII Developments - In this last decade, we have witnessed the incredibly fast-paced developments in digital telecommunications technology which has had profoundly changed every aspects of our lives. In anticipating these changes, the Clinton Administration made impressive lead in coordinating the country's national information infrastructure (NII). In a basic document, *The National Information Infrastructure: Agenda for Action*,[1] it stated that:

> "All Americans have a stake in the construction of an advanced National Information Infrastructure (NII), a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips. Development of the NII can help unleash an information revolution that will change forever the way people live, work, and interact with each other.

The document laid out the basic agenda for action in great details, which have guided the development of NII in the US in early years. The American experience has also been modeled throughout the world, and most NII developments elsewhere have built on and modified the American concept and actions to suit their own needs. Readers should consult the reference items for more detailed information.

By 1994, as the NII foundations in the US were laid and action items were moving on track. While continuing the NII efforts, the Clinton administration led its way to the global information infrastructure (GII) development again. Realizing that big money in many multi-billions of dollars are being dumped into the building of a gigantic GII by giant international commercial companies, with the endorsement and push of world-wide governmental organizations, Vice President Gore called for world cooperation in this development. As early as 1994, Vice President Gore in his speech at the International Telecommunications Union (ITU) Meeting in Buenos Aires, Argentina on March 21, 1994, shared his vision of the GII:

> "[The GII would be a] planetary information network [of highways] that transmits messages and images with the speed of light from the largest city to the smallest village on the continent..."
>
> "These highways or, more accurately, networks of distributed intelligence -- will allow us to share information, to connect, and to communicate as a global community. From these connections we will derive robust and sustainable economic progress, strong democracies, better solutions to global and local environmental challenges, improved health care, and -- ultimately -- a greater sense of shared stewardship of our small planet..."
>
> "The Global Information Infrastructure will help educate our children and allow us to exchange ideas within a community and among nations. It will be a means by which families and friends will transcend the barriers of time and distance..."

He called up the world leaders to "work to link the people of the world" and to "create this new path as we walk it together." Subsequently, with the G-7 Ministerial Conference on GII in Brussels, Belgium, February 25, 1995, and several other significant meetings in the following years, we have been well underway for the GII developments. For more information, see The Global Information Infrastructure: Agenda for Cooperation.[2] On October 12, 1998, he further proposed five new challenges which he characterized as *Declaration of Independence*. In which, he challenged the world community further:

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[1] See http://metalab.unc.edu/nii/NII-Table-of-Contents.html. Also see (Chen, 1994, Appendix 3).

[2] See http://www.iitf.nist.gov/documents/docs/gii/giiagend.html. See also (Chen, 1994, Appendix 2).

- to improve access to technology and noted that 65% of the world's household still have no phone services;
- to bridge language barriers by developing technologies with real-time digital translation so that to reduce the cost and increase international cooperation;
- to create a global knowledge network of people working to improve the delivery of education, health care,

For the library and information professionals, many felt that most investment were about technology. "Yet, we must understand that technology is only a means to an end, but not the end itself. We need to be more involved in the development of the information highway, and we need to address first the baseline and fundamental questions related to topics of the NII and GII, such as the definition; objectives and goals; problems, issues, and concerns related; etc. We need to have reality check on where we are in the global scene." As was asked by an information professional, "Just how will the GII manage to reach the smallest village on the continent when half of the world's population lives more than 2 hours from a telephone?" What is the use of the superhighway when we don't know yet what is going to be on it?" (Chen, 1994, p. viii). So, in 1994, NIT '94 devoted entirely to these concerns and the results were published in a book, entitled *Planning Global Information Infrastructure* (Chen, 1994). In addition, the group also produced *the Alexandria Declaration of Principles*[3], which is of particular relevancy to colleagues from developing and less developed countries.

2. NETWORKS AND INTERNET[4]

[3] ***Alexandria Declaration of Principles*** (Chen, 1994, pp. 1-6)
"The GII is an open, self-organizing, interactive, resilient, interconnected system providing dynamic and democratic means for people to find information and to put forward their own ideas. It is intended to be responsive to change - not resisting it but thriving on it." For library and information professionals in each country, it is important for us address our GII effort by adhering to the following principles:

- *Principle 1. Empower Individuals* - The GII should be a means for empowering individuals through knowledge.
- *Principle 2. Educate and Train in Use* - The need to offer education and training in how to use information and the GII.
- *Principle 3. Increase Knowledge* - The GII should increase understanding and decrease exploitation.
- *Principle 4. Develop Local Resources* - Countries need local information that they themselves produce in addition to the information produced outside of their countries. To develop the local strengths, there is a need within each country for professional skills in the management of information.
- *Principle 5. Identify Responsibilities of Information Professionals*
- *Principle 6. Educate the Information Professionals* - Need to educate the information professional to fill these roles.
- *Principle 7. Build from Country to Region to International* - Each country/region should make its own decisions about the GII development. There should be no one recipe, no international mandate, but rather each country/society should develop its own system.
- *Principle 8. National Agencies in Development* - National agencies' roles are crucial.
- *Principle 9. Public/Private Sector Cooperation*
- *Principle 10. Need for Appropriate Economic Policies*

This document in its entirety is free for any organization to use and duplicate.

[4] Based heavily on information provided by the National Coordinated Office of Computing, Information and Communications.

The Internet began in the 1960s with the ARPANET development. Initially it was an experimental network that connected researchers and provided a platform to develop packet-switching techniques and technologies.

The NSFNET was created in 1985 to provide a network infrastructure for the research and education community within the U.S. and also as a testbed for network-related research. It was privatized in April 1995, and the community-level service was turned over to private sector Internet service providers (ISPs). At the same time, the very high performance Backbone Network Service (vBNS) network was created by the NSF. It is a commercial infrastructure that supports the very high performance needs of the research and academic communities (initially at 155 Mb/s). Department of Energy has acquired higher bandwidth network up to OC-3 (155 Mb/s) ATM Connectivity. Higher band width network for R&D connecting has also been developed by the Department of Defense agencies.

In 1991, the US Congress chartered the High Performance Computing Act and since 1992 to 1996, the US Federal government has supported its 10 largest federal agencies' High Performance Computing and Communications (HPCC) program with an annual budget of $600 some million dollars in 1992 to about $1.2 billion in 1997. "The unprecedented growth of the Internet worldwide is a result of stimulation provided by the HPCC Program and from educational, public service, private sector, and personal investment."

vBNS[5]

"In 1993, the National Science Foundation recognized that researchers would require advances in state-of-the-art high-speed and high-performance networking. At the same time, the High Performance Computing and Communications (HPCC) program, a federal effort to develop advanced communications, computer and software technology adopted the goal of advancing the speed of networking. Figure 2 is the vBNS Backbone Network Map.

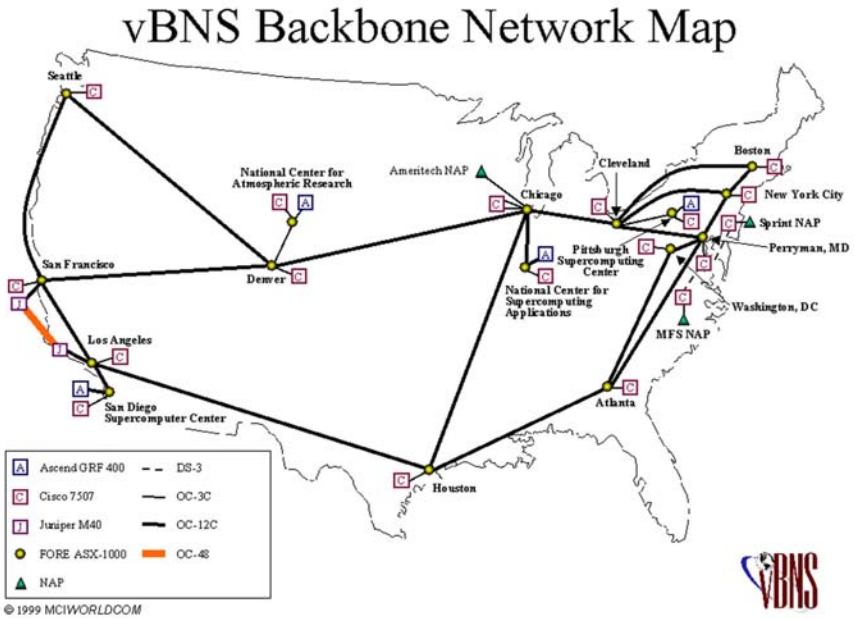

Figure 2. vBNS Backbone Network Map

[5] Based heavily on information provided in *The Next Generation: A History of the vBNS*. (http://www.vbns.net/press/history.html).

In order to keep pace with the development of networking technology and to support the goals of the HPCC, the NSF solicited proposals for the very high performance Backbone Network Service (vBNS). In addition, the NSF restructured its data networking architecture by establishing Network Access Points (NAPs), selecting NAP managers, and selecting a routing arbiter. In 1995, MCI was named as the vBNS provider. Under the terms of the cooperative agreement with the NSF, MCI provides Internet Protocol (IP) and connectionless networking protocol (CLNP) services at 622 megabits per second (OC12). Employing SONET and other fiber optic and high-speed switching and transport technologies, the vBNS will migrate to gigabit speeds by the late 1990s.

The vBNS was designed jointly for scientific and research communities and originally provided high speed interconnection among NSF's supercomputing centers and connection to NSF-specified Network Access Points. Today, the vBNS connects five supercomputing centers, 17 universities, and an additional 47 universities have received grants for connecting to the vBNS (see Figure 3 is the vBNS Logical Network Map).

STAR TAP[6]

STAR TAP (Science, Technology, And Research Transit Access Point) is "a persistent infrastructure, funded by the National Science Foundation Advanced Networking Infrastructure and Research division, which is part of the Computer and Information Sciences and Engineering (CISE) directorate, to facilitate the long-term interconnection and interoperability of advanced international networking in support of applications, performance measuring, and technology evaluations. The STAR TAP anchors the international vBNS connections program." STAR TAP is supported by a major grant from the National Science Foundation to the University of Illinois at Chicago. By supporting STAR TAP, NSF is strengthening U.S. research institutions by enabling them to collaborate worldwide. Internet2 institutions also emphasize STAR TAP as a solution for universal connectivity for them.

"Physically, STAR TAP connects with the Ameritech Network Access Point (NAP) in Chicago, as does the vBNS and other high-speed research networks. It enables traffic to flow to international collaborators from over 100 U.S. leading-edge research universities and supercomputer centers that are now, or will be, attached to the vBNS or other high-performance U.S. research networks." STAR TAP's international connection is shown in Figure 4. For the Asian Pacific region, it shows clearly the current vBNS connections - Singapore, Taiwan, Korea, Japan and Australia. To connect to STAR TAP, an advanced networking group representing a country or a consortium of countries must submit a proposal to NSF. NSF approval enables networks to connect to STAR TAP and have access to vBNS authorized institutions. Connectivity to other networks connected to STAR TAP can then be accomplished with bilateral peering agreements.

3. IT GROWTH ON FAST TRACK - INTERNET 2 AND NGI

During the second half of the 1990s, the use of IT in the U.S. and the world has grown in big ways. According to a US Commerce Department report, *The Emerging Digital Economy*,[7] in the US alone, the IT industry employed 7.4 million workers by 1998. The Traffic on the Internet has doubled every 100 days. It is expected that by the year 2002, Internet Commerce will likely surpass $300 billion dollars. While in 1994, there were a mere 3 million Internet and WWW users, it has grown to 100 million by the year of December 1997, and it will be one billion by the year 2005. This estimate is also in line with a recent study from IDC that it estimated by 2001, business-to-business eCommerce will exceed $175 billion, with nearly $100 billion from the Internet alone.

[6] Based heavily on information provided in the home page of STARTAP, http://www.startap.net/.
[7] See this report on http://www.ecommerce.gov/emerging.htm.

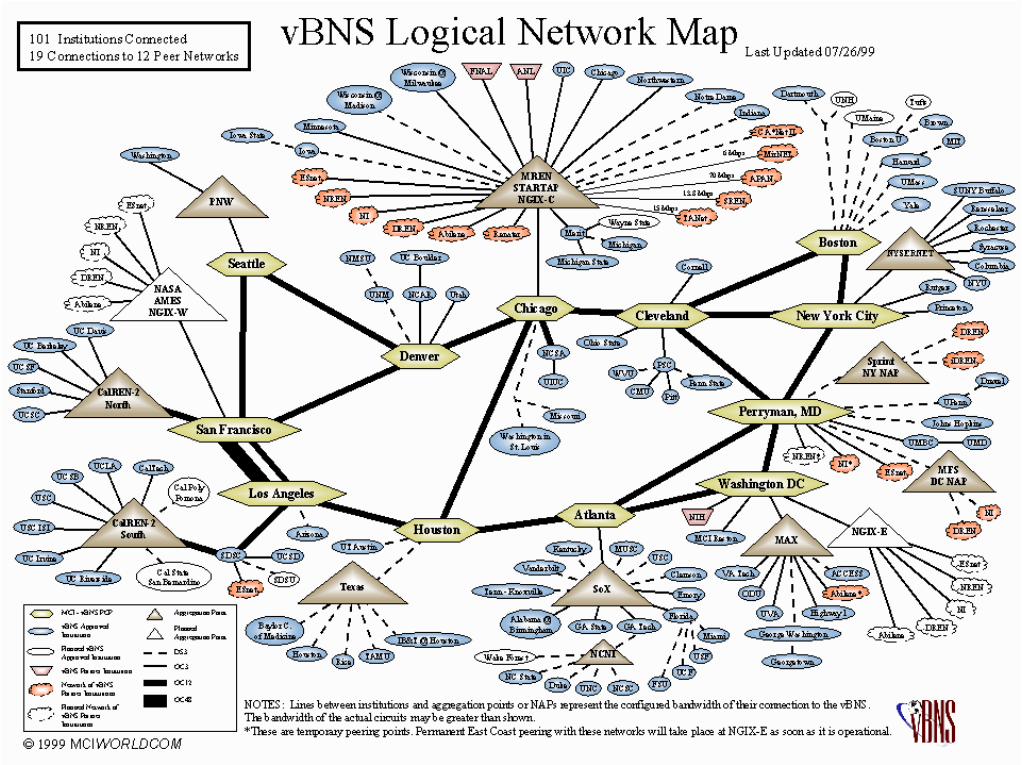

Figure 3. vBNS Logical Network Map

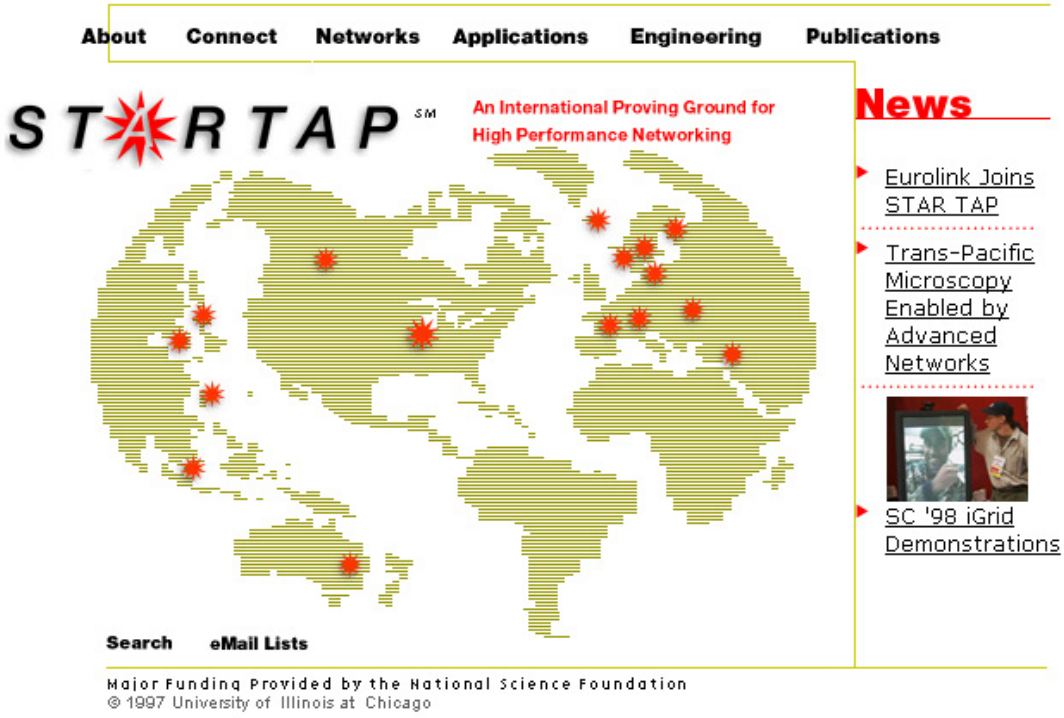

Figure 4. STAR TAP's International Connection

The Internet2 Project[8]

The privatization of the National Science Foundation Network (NSFnet), the congestion of its successor, the Internet, and the fast growing use of the Internet for commercial purposes, have made it clear to the academic and research communities, who were the primary users of the network, that they can no longer use the current Internet for cutting-edge applications. Thus, with a mission to "facilitate and coordinate the development, deployment, operation and technology transfer of advanced, network-based applications and network services to further U.S. leadership in research and higher education and accelerate the availability of new services and applications on the Internet", the Internet2 was born. Announced by 34 research universities in October 1996, Internet2's central goals quickly became a major focus of the Clinton Administration's Next Generation Internet (NGI) initiative. Since then, Internet2 membership has grow to include over 130 US research universities and a host of private company sponsors such as 3Com and MCI Communications.

"Internet2's goals are:

- Enable a new generation of applications
- Recreate a leading edge research and education network capability
- Transfer new capabilities to the global production Internet.

Additional objectives are:

- Demonstrate new applications that can dramatically enhance researchers' ability to collaborate and conduct experiments,
- Demonstrate enhanced delivery of education and other services (e.g., health care, environmental monitoring) by taking advantage of "virtual proximity" created by an advanced communications infrastructure,
- Support development and adoption of advanced applications by providing middleware and development tools,
- Facilitate development, deployment, and operation of an affordable communications infrastructure, capable of supporting differentiated Quality of Service (QoS) based on applications requirements of the research and education community,
- Promote experimentation with the next generation of communications technologies,
- Coordinate adoption of agreed working standards and common practices among participating institutions to ensure end-to-end quality of service and interoperability,
- Catalyze partnerships with governmental and private sector organizations,
- Encourage transfer of technology from Internet2 to the rest of the Internet, and
- Study impact of new infrastructure, services and applications on higher education and the Internet community in general."

Internet2 is a partnership of higher education, government and industry. It is a collaborative effort to create the broadband applications, engineering and network management tools that will enable advanced research and education. Internet2 is closely related to the Clinton administration's Next Generation Internet Initiative led by government research agencies.

Next Generation Internet (NGI) Initiative

On October 10, 1996, President Clinton announced a new "Next Generation Internet" (NGI) initiative to keep America at the cutting-edge of Internet technology. It is a $100 million initiative to kick-start the development and deployment of a Next Generation Internet. The initiative will incorporate and build on the restructured vBNS program and Internet II. The initiative is a multi-agency effort that has three basic goals:

[8] For more information, see http://www.internet2.edu, http://www.uab.edu/internet2 as well as Computer Technology Reearch Corp. (1999, February*). Internet2: The Future of the Internet and Next-Generation Initiatives*. Washington, DC: CTRC. (http://www.ctrcorp.com/ctrcorp/infutofinand.html).

1) Connecting about 100 government, academic, and industrial research labs (NGI sites) with end-to-end performance at least 100 times the speed of the current Internet, and connecting together about ten such sites with a network at least 1,000 times faster building on the DARPA's advanced network including ATDnet.
2) Research and implementation of technologies to support advanced features such as quality of service and security, reliability, robustness, quality of service, etc.
3) The demonstration of advanced applications based on these capabilities. Thus, NGI will enable revolutionary new applications not only in high-end areas which can accelerate the pace of scientific discovery, but also in areas such as telemedicine, distance learning, digital libraries, etc.

The NGI Initiative will support the wide area testbed research, thus most NGI-funded research will likely be at the Internet2 universities. Although neither the efforts of Internet2 and NGI will be available immediately to the public, but it is expected that the new technologies and increased data bandwidth and speeds will trickle down to the global and private computer networks.

It is important to know that although NGI and Internet2 are closely related, they are NOT synonymous.

Internet2 Backbone - Abilene[9]

On September 29, 1998, the first public demonstration of Abilene (Figure 5), a high-performance $500 million network developed by Qwest Communications, Nortel Networks, Cisco Systems, and the University Corporation for Advanced Internet Development (UCAID) was presented. The network, unveiled by Vice President Gore in April 1998, will serve Internet2 universities and will interconnect with existing advanced research and education networks and will work with federal agencies. Thus, Abilene will permit a host of new applications for the Internet, which has become bogged down with the problems of growth of use and limited transmission capacity as discussed earlier.

"The Abilene Project will develop an advanced and separate backbone network to connect regional network aggregation points, called gigaPoPs, being developed by UCAID members and is intended to complement existing research networks already being used by UCAID member researchers and educators." With the more advanced network capabilities, more high-end network research can be conducted, and more demanding applications can be developed over the network.

Initially, the Abilene Project will deploy a national backbone capable of operating at OC48 (2.4 Gigabits per second) among gigaPoPs, with OC12 (622 Mb/s) or OC3 (155 Mb/s) connections from the Abilene backbone to university gigaPoPs or to individual institutions. The design will initially be IP packet over Sonet. However, a compelling motivation for Abilene is the strong desire and technical capability of the corporate partners to increase the backbone capacity to OC192 (9.6 gigabits per second) and beyond. The ability to increase network capacity will be very important as Abilene is more broadly deployed during 1999. It is also planned to phase in advanced services such as multicasting and QoS during 1999.

As expressed by the Abilene Team, it is expected that Abilene will provide UCAID members a high performance backbone network capable of supporting their advanced applications research needs at a reasonable cost. It will also increase the diversity of the advanced networking environment, and offer facilities to carry out advanced network design research. At the same time, this project will stimulate industry to advance the state of the art in production networking and to commercialize the results, so that advanced capabilities will more quickly become widely available to the broader academic and networking communities." Abilene's network operations center is housed at the Indiana University.

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[9] Based on information provided on http://www.internet2.edu/abilene/html/project_summary.html.

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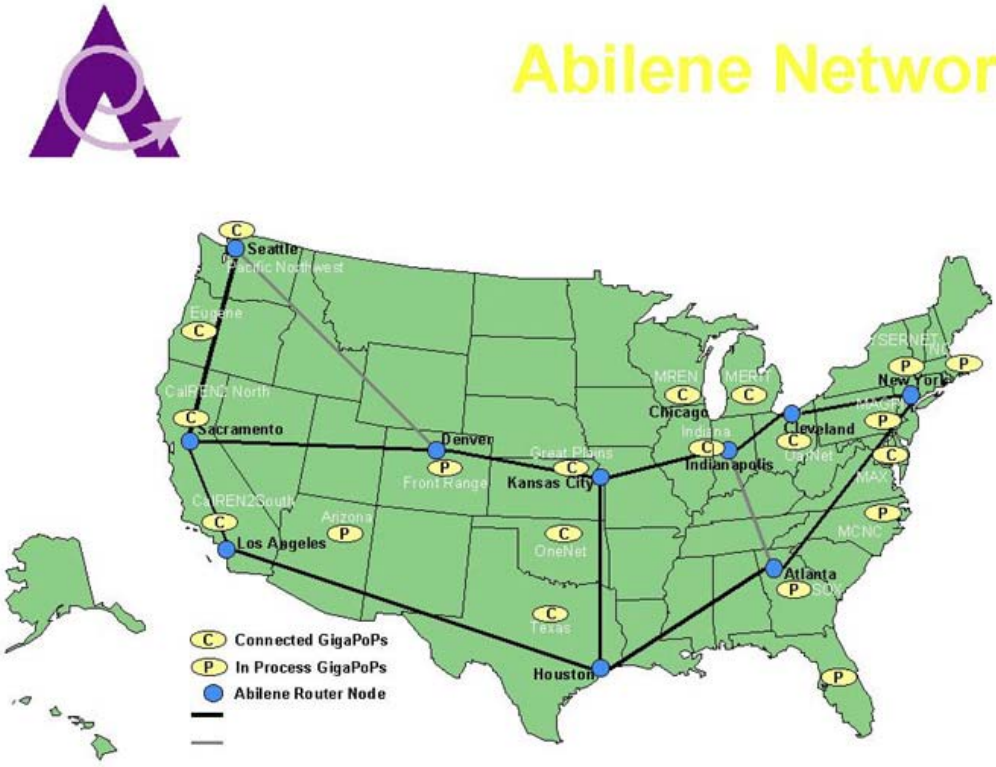

Figure 5. Abilene Network (http://www.internet2.edu/abilene)

4. THE PRESIDENT'S INFORMATION TECHNOLOGY ADVISORY COMMITTEE (PITAC)[10]

On February 11, 1997, President Clinton signed an Executive Order establishing the Advisory Committee on High Performance Computing and Communications, Information Technology, and the Next Generation Internet. The Committee is asked "to assist the Administration's efforts to accelerate development and adoption of information technologies that will be vital for American prosperity in the 21st century." The twenty-five "industry and academic leaders" are appointed to the Committee representing the "research, education, and library communities, network providers, and representatives from critical industries." "As part of the Executive Order, President Clinton has asked them, among others, for an independent assessment of :

- Progress made in implementing the High Performance Computing and Communications (HPCC) Program, and in designing and implementing the Next Generation Internet initiatives,
- The need to revise the HPCC Program, and balance among components of the HPCC Program, and
- Whether the HPCC's R&D is helping to maintain U.S. leadership in advanced computing and communications technologies and their applications.

The Committee's name later changed officially to the President's Information Technology Advisory Committee (PITAC). One of the PITAC's first significant task was to conduct a review of the NGI initiative and submitted a letter report in May 1997. They enthusiastically supported the motivation, goals, and proposed investments embodied in the NGI program, and strongly encourage the Internet2 program.

After months' deliberation, the Committee submitted an Interim Report to the President in August 1998, and a Final Report, entitled *Information Technology Research: Investing in Our Future*, in February 1999 (U.S. PITAC, 1999).

Ten Transformations and Request for More Funding and PITAC Report

PITAC concluded that Information Technology (IT) will be one of the key factors driving progress in the 21st century, and it will transform our society in many ways including: Transforming the way we communicate, deal with information, learn, the practice of health care, the nature of commerce, the nature of work, how we design and build things, how we conduct research, our understanding of the environment, and our government.

It states that "vigorous information technology research and development (R&D) is essential for achieving America's 21st century aspirations. The technical advances that led to today's information tools, such as electronic computers and the Internet, began with Federal Government support of research in partnership with industry and universities. These innovations depended on patient investment in fundamental and applied research."

After careful review of the Federal programs PITAC has concluded that Federal support for research in information technology is seriously inadequate." Warning that the nation's economic future is at risk, PITAC recommends that Federal financing for advanced research in the field of information technology be **doubled** over the next five years in five areas - software, scalable information infrastructure, high end research, high end acquisitions, and socioeconomic.

As summarized by Steve Lohr in the *New York Times* (Lohr, February 24, 1999), the group's report says that software research should be directed increasingly at designing software that can be used as smaller, reliable and re-usable building blocks - "component-based software design." The infrastructure research is needed to make the move to an increasingly wired world in which today's 30 million computers

[10] Based heavily on information provided by the National Coordinated Office of Computing, Information and Communications, as well as public documents available. The author is a member of PITAC, PITAC/NGI Subcommittee and PITAC/IT*2 Review Subcommittee.

connected to the Internet could become billions of devices from hand-held computers to household appliances, all linked to the Internet. The report calls for increased spending to accelerate the performance of supercomputers that can be used for sophisticated applications like weather and climate forecasting, advanced manufacturing design and development of new drugs. It also recommends the creation of a series of well-financed "virtual centers" nationwide. These centers are termed '"expeditions into the 21st century" or "time machines." Equipped with the most advanced computers -- hundreds or a thousand times more powerful than today's desktop machines -- the centers would allow computer scientists and others to experiment with the technology that will become affordable and widespread a decade later. This group also called for social science research on the impact of technology. These include the issues of access to technology, upgrading of workers' skills and encouraging increased participation in the computer sciences by women and minorities.

PITAC Review of the Next Generation Internet Program, and the IT*2 Plan

Having submitted the Final Report of its first two-year term, PITAC has since been asked to continue for another two years. According to The Next Generation Internet Research Act of 1998 (the Act), the President's Information Technology Advisory Committee has been asked to review the implementation of the Next Generation Internet (NGI) program and provide its annual report. The PITAC/NGI Sub-committee completed its first report in April 1999.

5. INFORMATION TECHNOLOGY FOR THE TWENTY-FIRST CENTURY (IT*2)[11]

Federal authorities acknowledge PITAC's warnings, which were first sounded in its preliminary report in August 1998. In an unusually fast reaction to a report on research funding, the Clinton's administration calls for a 28% increase in spending on information technology research in the next fiscal year. This means a direct response of $366 million dollars of new money for the FY 2000 multiagency Federal information technology (IT) research and development (R&D) initiative. This initiative known as IT*2 (Information Technology for the Twenty-First Century) was announced by Vice President Gore in January 1999 even before the submission of the PITAC's Final Report.

IT*2 will support three kinds of activities:

1) Long-term information technology research that will lead to fundamental advances in computing and communications, in the same way that government investment beginning in the 1960's led to today's Internet.
2) Advanced computing for science, engineering and the nation that will lead to breakthroughs such as reducing the time required to develop life-saving drugs; designing cleaner, more efficient engines; and more accurately predicting tornadoes.
3) Research on the economic and social implications of the Information Revolution, and efforts to help train additional IT workers at our universities.

and will be coordinated jointly with the High Performance Computing and Communi-cations (HPCC) programs and the Next Generation Internet (NGI) initiative. The IT*2 Implementation Plan has been proposed by the Federal agencies, and the PITAC/IT*2 subcommittee has started its evaluation of the plan.

6. IMPLICATIONS FOR DIGITAL LIBRARY DEVELOPMENT

Like the IT growth on the fast track, the "digital library" developments have been growing wild as well in the last few years pushed by the enormous growth of Internet and WWW use. This has been particularly true in the last two or three years. Yet, prior to 1997, two parallel tracks of developments were visible but the there were crossing over between the two tracks - the high-end digital library research supported by the National Science Foundation and conducted mostly by researchers in the field of computer sciences, and

[11] More information on the IT*2 initiative is available at http://www.ccic.gov/it2/.

the traditional "digital" library related activities, mostly relating to scanning. During the last two years, the gaps between the two are closing. We shall elaborate on this more in DL-2.

NSF's Digital Library-1 Initiative (DL-1)[12]

The DL-1 is a joint four year $24 million NSF/DARPA/NASA program begun in FY 1995. Its broad goal is to advance the methods used to collect, store, organize, and use widely distributed knowledge resources that contain diverse types of information and content stored in a variety of electronic forms. Digital Libraries basically store materials in electronic format and manipulate large collections of those materials effectively. Research into digital libraries is research into network information systems, concentrating on how to develop the necessary infrastructure to effectively mass-manipulate the information on the Net.. The key technological issues are how to search and display desired selections from and across large collections. These are "research projects" and should not be confused with the development of digital library consortia as many have considered!

Six university-led DL-1 projects have been pursuing this goal in partnership with libraries, museums, publishers, schools, and computing and communications companies (see Figure 6):

1) *University of California at Berkeley's Environmental Planning and Geographic Information Systems* (http://elib.cs.berkeley.edu/) is developing the tools and technologies to support highly improved models of the "scholarly information life cycle." The goal is to facilitate the move from the current centralized, discrete publishing model, to a distributed, continuous, and self-publishing model, while still preserving the best aspects of the current model such as peer review.

2) *University of California at Santa Barbara's Alexandria Project: Spatially-referenced Map Information* (http://www.alexandria.ucsb.edu/adl.html) - The centerpiece is an online information system inspired by the Map and Imagery Laboratory (MIL) in the Davidson Library at the University of California, Santa Barbara. The ADL currently provides access over the WWW to geographic datasets.

3) *Carnegie Mellon University's Informedia Digital Video Library* project studies how multimedia digital libraries can be established and used. Informedia's multimedia library contains over one thousand hours of digital video, audio, images, and text. It is populated automatically encoding, segmenting, and indexing data. Research in the areas of speech recognition, image understanding, and natural language processing supports the automatic preparation of diverse media for full-content and knowledge based search and retrieval. (http://www.informedia.cs.cmu.edu/).

4) *University of Illinois at Urbana-Champaign (DeLIver) Federating Repositories of Scientific Literature* (http://dli.grainger.uiuc.edu/) is developing widely usable Web technology to effectively search technical documents on the Internet. The efforts were concentrated on building an experimental testbed with tens of thousands of full-text journal articles from physics, engineering, and computer science, and making these articles available over the WWW, often before they were available in print.

5) *University of Michigan's Intelligent Agents for Information Location* combines the traditional notions of libraries with contemporary technological capabilities. Instead of the centralized, structured view of a library, it embraces the open, evolving, decentralized advantages of the web and introducing computational mechanisms to temper its inherent chaos. (http://www.si.umich.edu/UMDL/intro.html).

6) *Stanford University' Interoperation Mechanisms Among Heterogeneous Services* (http://walrus.stanford.edu/diglib/) - At the heart of the project is the testbed running the "InfoBus" protocol, which provides a uniform way to access a variety of services and information sources through "proxies" acting as interpreters between the InfoBus protocol and the native protocol.

[12] Based on information from the National Science Foundation and the home pages of the six projects.

Figure 6. NSF's Six Digital Library-1 Projects

NSF's Digital Library-2 Initiatives (DL-2)[13]

"Digital Libraries Initiative Phase Two is a multiagency initiative which seeks to provide leadership in research fundamental to the development of the next generation of digital libraries, to advance the use and usability of globally distributed, networked information resources, and to encourage existing and new communities to focus on innovative applications areas." It is about $8-$10 per year for 4 to 5 years beginning 1998.

Since digital libraries can serve as intellectual infrastructure, this Initiative benefits from the experience and knowledge gained from the DL-1 projects, and looks to stimulate partnering arrangements necessary to create next-generation operational systems in such areas as education, engineering and design, earth and space sciences, biosciences, geography, economics, and the arts and humanities. It will address the digital libraries life cycle from information creation, access and use, to archiving and preservation.

Research to gain a better understanding of the long term social, behavioral and economic implications of and effects of new digital libraries capabilities in such areas of human activity as research, education, commerce, defense, health services and recreation is an important part of this initiative." DL-2 has expanded substantially the number of awarded projects. Several academic research libraries of I2 institutions are participants of the DL-2 funded research and demonstration projects. Also, for the first time, we see sponsoring agencies expand to include the National Library of Medicine, Library of Congress, the National Endowment for the Humanities (NEH). It also partners with National Archives and Records Administration, Smithsonian Institute (SI), and Institute of Museum and Library Services (IMLS). Currently, both NEH and IMLS[14] have their own grant funding programs and have begun to support substantially significant digital projects for education, research, preservation, and the like. Both projects also are connected to the White House Millennium Program announced on April 22, 1998 and pushed by the First Lady (see http://www.whitehouse.gov/initiatives/Millennium/).

NSF's International Digital Libraries (IDLP) Collaborative Research

In January 1999, NSF allowed a new IDLP program (NSF 99-6), which is intended to contribute to the fundamental knowledge required to create information systems that can operate in multiple languages, formats, media, and social and organizational contexts. The program's goal is to enable users to easily access digital collections, regardless of location, language or formats, and enable broad use in research, education, commerce and other purposes. In order to operate in a global information environment, research is needed on:

- interoperable technologies,
- technology for intellectual property protection in a global marketplace, and
- methods and standards for ensuring long-term interoperability among distributed and separately administered databases.

It is hoped that cooperative research can help avoid duplication of effort, present the development of fragmented digital systems, and encourage productive interchange of knowledge and data around the world.

During the program's first year, according to the competition data provided by Steve Griffin, Director of the NSF IDLP Program, 50 proposals were received from 30 countries requesting $25 millions, while the program funding is no more than $10 millions. At this time, only US/UK collaborative proposals have been decided, and 6 projects have been awarded for $5 million in 3 years. The other proposals are yet to be reviewed.

The Digital Library Federation (DLF) and Other Major Developments

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[13] Based heavily on materials from NSF and information gathered from http://www.dli2.nsf.gov/.

[14] For more information on the IMLS award programs related to digital libraries and programs, see http://www.imls.fed.us/nlg98list.htm. See http://www.neh.gov/ for information on NEH programs.

Other governmental programs supporting more "down to earth" digital activities such as those by the IMLS and NEH have been mentioned. Among a host of major developments outside the formal government framework, it is necessary to mention the Digital Library Federation (DLF). DLF (http://www.clir.org/diglib/dlfhomepage.htm) was founded in 1995 to establish the conditions for creating, maintaining, expanding, and preserving a distributed collection of digital materials accessible to scholars, students, and a wider public. The Federation is a leadership organization operating under the umbrella of the Council on Library and Information Resources. It is composed of participants who manage and operate digital libraries. The Federation was founded by 12 large university research libraries and the Library of Congress, the National Archives and Records Administration, the New York Public Library, and the Commission on Preservation and Access. The founding university libraries are California-Berkeley, Columbia, Cornell, Emory, Harvard, Michigan, Pennsylvania State, Princeton, Southern California, Stanford, Tennessee-Knoxville, and Yale. Eight additional university libraries have since joined the Federation: Carnegie-Mellon, Chicago, Indiana, Minnesota, North Carolina State, Pennsylvania, Texas-Austin and the California Digital Library.

"The DLF developments and efforts can be grouped in four broadly defined areas: discipline-based activities; functional developments; digital library architecture; and institutional initiatives. Among the discipline-based activities that the DLF is engaged in are work on social science data archives, the development of an art image exchange, and the creation of a theological digital library. DLF's work on functional includes work on access management, digital archiving, discovery and retrieval (metadata), and digital imaging. DLF developments in digital library architecture include authorization protocol. Clearly DLF have attempted to address some of the most essential topics which are vital to the digital library developments. In addition, with the leading organizations involved, each has major initiative going on in their own institutions. For example, Harvard University announced in February 1998 its Library Digital Initiative (LDI), and the University is coming up more than $10 million dollars of their own money to support the LDI, not mentioning the additional funding which are obtained from other funding sources. It is worthnoting that DLF's academic members are all I2 institutions. Thus, they have also been successful recipient of NSF's DL-2 awards. This is certainly a group to watch.

7. CONCLUSION

As we have been working diligently toward the next revolution in information technology, and contemplating the future digital libraries. This reminded me that during the deliberation of PITAC, we were asked to list an expedition wish list. One co-member of PITAC, Raj Reddy of Carneige Mellon University said about *the "invisible computing"* - "The next revolution in Information Technology will be the creation of a global information grid which is invisible (like electricity) and freely available anytime anywhere (pervasive) as a consumable commodity which is part of the global infrastructure. When a person enters the room the body computers negotiate with room computers (using low power wireless communication) and the person has access to the status of his/her universe through the mediation of agents (possibly numbering in thousands)..." About "digital libraries and universal information resource" - "a Universal Information Resource leads to (a) Democratization of information -- available to all, regardless of socioeconomic status, country or native language, (b) Speed of dissemination - instant world-wide distribution by updating a single source, (c) Access by automated agents - information available for data mining and other forms of analysis, etc."

At the 35th Anniversary of the Laboratory for Computer Science (LCS) of the Massachusetts Institute of Technology, a sneak preview of the MIT's vision for the future of computing was given (*Scientific American*, August 1999 include several articles). It demonstrates how a new infrastructure for information technologies - the Oxygen system - that promises to realize a vision long held by the LCS's director, Michael L. Dertouzos: helping people do more by doing less.

I am sure that all our R&D efforts in information technology now is helping us to be able to accomplish in one day that the technology will be easy, listen to our command, faded away in the background, or disappear but can help us whenever and wherever we need it.

So, in developing our digital libraries, let us try not to do less by doing more with our preoccupation with the technologies (by making a big deal of the technology). Let us remember that technologies are

tools. Let us concentrate more on the global content building by pulling our resources together, so that there will be something worthwhile to be retrieved when the technologies and methods are in place! Aside from numerous "technical challenges" which programs like DL-1, DL-2, and IDLP are addressing, there are a host of other major non-technical problems and issues, such as multilingual, standard and methods (metadata etc.), economy, copyright, privacy, etc. which we must address. We must work together to address these but not working in isolation to glorify each one's own projects. This is why the concept of "global digital library" which I advocated a decade ago still needs to be stressed and work for! This is also what the "million-volume" Universal Library which Raj Reddy has hoped to achieve! Why don't we all work for it together!

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