# ADVANCING THE PUBLIC INTEREST THROUGH KNOWLEDGE AND DISTRIBUTED INTELLIGENCE

Summary of the Leadership Colloquium
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Knowledge and distributed intelligence (KDI) activities "aim to improve our ability to discover, collect, represent, transmit, and apply information, thereby improving the way we conduct research and education in science and engineering. These efforts promise to change how we learn and create, how we work, and how we live … The objective is to create networked systems that can make all kinds of knowledge available to anyone, located anywhere, anytime. "

*National Science Foundation KDI Brochure*

"Access to information is one thing. But the intelligent absorbing, refining, and analyzing of this information to glean useful knowledge is another [thing] altogether. This represents the driving force behind NSF's efforts in knowledge and distributed intelligence. The KDI concept is evolving, and the NSF seeks the broadest possible dialogue and input to further that evolution."

*Neal Lane, Director, National Science Foundation*
*Participant at the September 25-26th Meeting*

"Private foundations and the NSF—this seems to be an obvious partnership."

*Woodward Wickham, Vice President, MacArthur Foundation*
*Participant at the December 12th Meeting*

# PREFACE

The vast potential of information technology to enrich society raises many questions. What new benefits are possible? Which segments of society may benefit? Who could be left behind? How can the most positive outcomes be fostered, and by whom? Some answers to these questions may be found in arenas of social concern, such as education, health care, the arts, and community life. These arenas, which affect all citizens and engage a variety of institutions, including private foundations, increasingly involve the direct or indirect use of information technology. Accordingly, further progress in meeting societal needs will depend in part on science and engineering research, which can shape the technologies, costs, and benefits that eventually affect the quality of life.

The relationship between research on information technologies and efforts to meet societal needs is the underlying theme of this summary document, which synthesizes the proceedings of the Leadership Colloquium on Knowledge and Distributed Intelligence (KDI). Convened at the request of the National Science Foundation (NSF), the major supporter of U.S. science and engineering research and the emerging KDI activity, the colloquium brought together representatives from the NSF and a variety of private foundations so they could discuss their current activities and share insights, concerns, and ideas. The colloquium comprised two meetings in September and December 1997, hosted by the Computer Science and Telecommunications Board (CSTB) of the National Research Council. The agenda and list of participants for each meeting may be found in Appendix A and Appendix B. The meetings provided a neutral ground for the discussion of broad issues and the identification of possible mechanisms for cooperation and subject areas of mutual interest.

Many individuals contributed to the success of the two meetings and to this summary of the proceedings. First and foremost, the CSTB wishes to thank the participants from the private foundations and the NSF for the provocative and lively discussions that took place during the two meetings. We are grateful to presenters and session chairs, including Neal Lane (NSF), Luther Williams (NSF), Mary Clutter (NSF), Elbert Marsh (NSF), Gary Strong (NSF), Alan Gaines (NSF), Nora Sabelli (NSF), Tom Kalil (National Economic Council), Stephen Griffin (NSF), Daniel Atkins (University of Michigan), Alexa McCray (National Library of Medicine), Lloyd Morrisett (Markle Foundation), Anne Petersen (W. K. Kellogg Foundation), Bruce Schatz (University of Illinois-Urbana Champaign), Christine Borgman (University of California at Los Angeles), Juris Hartmanis (NSF), Bennett Bertenthal (NSF), Joan Shigekawa (Rockefeller Foundation), and Andrew Blau (Benton Foundation). David D. Clark (CSTB) presided over both meetings and kept the discussions focused and orderly.

The two meetings attracted great interest within the NSF and private foundation community. We also wish to thank those individuals who provided valuable guidance in the formative stages of this endeavor but were unable to participate in the meetings.

Marjory Blumenthal (CSTB), Stephen Griffin (NSF), and Y. T. Chien (NSF) were instrumental in launching this activity and having the vision to keep it on track. Laura Ost (CSTB consultant) drafted and edited major portions of the text. Janet Briscoe (CSTB) provided excellent support for meeting logistics and report preparation. Lisa Shum (CSTB) provided excellent support for meeting logistics. Rita Gaskins provided excellent support for report preparation. Mark Balkovich (CSTB) provided research assistance and Jane Bortnick Griffith (CSTB) provided valuable feedback that was used to improve this summary.

Alan S. Inouye, Program Officer
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# 1. INFORMATION TECHNOLOGY AND ADVANCING THE PUBLIC INTEREST

Advanced computing and communications technologies already connect many Americans to each other, to powerful databases, and to institutions around the globe. Technology users ranging from schoolchildren to scientists now communicate, learn, and gather information on the Internet, for example. Yet these activities only begin to hint at the vast potential of information technologies to enrich society—benefits that can only be imagined today.

A vision of how society might benefit is emerging. Given the appropriate information technologies and support, communities might develop their own digital histories and share innovative ideas that work for improving education. Doctors might provide specialized yet affordable medical care to remote areas and the home-bound around the world. Individuals with poor reading skills or disabilities might obtain broad access to jobs, training, and information. All citizens might gain access to digital repositories of great masterpieces of art and literature. The Internet could become a tool for promoting public dialog and building democracy.

This vision can be realized through science and engineering research, which often shapes the technologies, costs, and benefits that eventually affect the quality of life.[1] The World Wide Web provides a compelling example. As Neal Lane, director of the National Science Foundation (NSF), observed, "What began as an obscure tool used by physicists and computer scientists to exchange data has become a powerful force for progress and enrichment across society, and it all happened in a very few years." The transformation of the Web into a tool that can be used by all sectors of society has attracted the interest of a wide variety of organizations, such as private foundations, many of which have little or no direct interest in science or engineering but use technology to achieve social goals.

The efforts of scientists and engineers to extend and improve on today's technology seem to complement the ongoing efforts and future plans of many private foundations to exploit, enhance, and augment the practical utility of the Internet. By linking these activities into synergistic joint efforts, both scientific and social programs might achieve revolutionary gains as opposed to the incremental steps so often experienced. It is for this reason that the NSF solicited the interest and input of private foundations in its emerging, cross-disciplinary activity in knowledge and distributed intelligence (KDI).

Research in KDI is expected to enhance intelligent access to information. It will produce new knowledge essential to long-term understanding of the universe and humanity's place in it. It will help explain the nature of intelligence—how humans learn and create, and how the brain and machines receive and process information. It will produce new tools and models for collaboration across fields and disciplines, helping scientists and engineers acquire knowledge that will drive economic growth. It will enhance the performance of both educators and their students, the leaders of tomorrow.

The NSF's broad scope of activities and vast network of researchers enabled its leaders to crystallize the KDI concept, described in the next section. Those leaders also had the wisdom to recognize the challenge of communicating beyond the realm of science and engineering to other communities with similar or complementary interests.

[1] The influence is actually bidirectional, because technology application sometimes affect research directions.

## 2. What is KDI?

> "KDI efforts aim to improve our ability to discover, collect, represent, transmit, and apply information, thereby improving the way we conduct research and education in science and engineering. These efforts promise to change how we learn and create, how we work, and how we live … The objective is to create networked systems that can make all kinds of knowledge available to anyone, located anywhere, anytime." (*NSF KDI brochure*)

The evolution of KDI as a broad theme within the NSF reflects the integration of multiple streams of research and development (R&D) drawing on many scientific and engineering disciplines. The components are enormously varied, including, for example, research in computational biology, computer networks and communications, high-performance computing, database management and information retrieval, mathematical modeling and simulation, artificial intelligence, human learning and cognition, science, mathematics and engineering education, geospatial information systems, and science and engineering indicators. These components are combined into programs of varying scope and scale. The NSF typically funds research and education projects through its individual directorates, which are organized by scientific or engineering discipline. Research support is complemented by support for infrastructure (the equipment, networks, and facilities that support research and education in science and engineering). Funding for research and education in physical and natural sciences is complemented by support for research and education in the social sciences and the field of education, and over the past several years a number of programs have emerged to foster collaboration among scientific disciplines, including the physical (or natural) and social sciences.

The KDI activity advances this trend to a new level of intellectual coalescence. It recognizes the progress made to date in developing and deploying information technology across science and engineering research, and it recognizes that challenges for the future include assuring that such technological support can be used and is useful. "These technologies are changing the basic process of doing science and engineering and education," stated Juris Hartmanis, assistant director of NSF for computer and information science and engineering. "They are changing how we teach and learn. As a matter of fact, they have the potential of changing all of our intellectual processes and also changing our organizations and institutions." And the process is just beginning. "The access we have gained to widely distributed sources of information marks a major accomplishment for human civilization," Dr. Lane said. "It is, nevertheless, only a first step. Access to information is one thing. But intelligently absorbing, refining, and analyzing this information to glean useful knowledge is another [thing] altogether. The KDI concept is evolving, and NSF seeks the broadest possible dialog and input to further that evolution."

Early KDI activities originated within two NSF directorates: social, behavioral, and economic sciences and computer and information science and engineering. The KDI effort now extends throughout the foundation and encompasses some activities and programs that involve other federal government agencies as well as academic and private entities. Organizationally, it is a cross-directorate, cross-disciplinary effort comprising three core components:

- The ***Knowledge Networking*** component is intended to advance understanding of the potential of new information technologies for communication, coordination, and collaboration in science, engineering, education, and other applications. In these contexts, computing power, digital information storage capacity, and communications can enable the distillation and creation of new knowledge across dispersed experts and repositories of information. The fundamental goals of knowledge networking are to develop an understanding of the fundamental processes through which knowledge is created, communicated, validated, and valued in distributed systems of information, both natural and engineered; and to improve the technical, social, educational, and economic performance of knowledge generation and use, collaborative computation, and remote interaction.

- The ***Learning and Intelligent Systems*** (LIS) component is intended to advance understanding of learning in both natural and artificial systems, and how that learning can be supported, harnessed, and used in creative ways. Systems of interest include the brain, computer networks, and adaptive sensors. This component also promotes the use and development of technologies that support enhanced learning for children, workers, and the general public across different disciplines and fields. The activity encompasses both basic research and applied efforts to transfer learning technologies to communities.

- The ***New Challenges in Computation*** component involves the development of methods and tools to discover, model, simulate, display, and understand complex systems and complicated phenomena, and to manipulate large volumes of distributed data in real time. "We need models that can handle various orders of scales within the same simulation, visualization tools that display and enable manipulation in real time, algorithms that allow distributed collaboration among disparate communication, and software that enables real-time interaction and control," said Elbert Marsh, assistant director of the NSF for engineering.

In addition to the core components, there are currently six KDI-related initiatives in specific technological or content domains that are evolving in cooperation with other federal agencies and private-sector organizations. These programs expressly address issues of how to design and develop technologies that can be used more effectively and by more people. They reflect experiences with early information technology in a variety of contexts as well as ambitious objectives for progress. More specifically:

- The ***Universal Access*** activity will explore technology designs that will improve information access for the disabled, individuals with limited reading ability, and, ultimately, all users. To lower barriers to human interaction with machines, technologies will be developed that respond to speech, text, expression, gestures, or different languages. As explained by Gary Strong, acting deputy division director of the NSF Division of Information and Intelligent Systems, the physically disabled (e.g., the blind) are not the only users with diminished access to information. In fact, virtually anyone may have difficulty accessing information—because of language differences, for example, or because of circumstances that prevent the use of manually operated systems.

- The ***Digital Libraries Initiatives***[2] are intended to improve the accessibility, availability, usability, and preservation of electronic information stored in globally distributed repositories. Information available on-line today, such as that on the Web, is often organized in a rudimentary way, and searching with keywords (e.g., searching for all documents containing the word "knowledge") is an inefficient way to navigate the vast volume of content available. Present search mechanisms often retrieve too much information and do not present the results in a format that can be evaluated easily. Research can lead to more intelligent access into digital collections and improved links across collections, thereby providing users with efficient access to the information they need. Thus, a digital library encompasses much more than a digitized collection.[3]

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[2] Phases 1 and 2, or DLI and DLI 2.

[3] The definition is evolving, but the concept was outlined at the 1997 NSF-sponsored Santa Fe planning workshop on distributed knowledge work environments (see http://www.si.umich.edu/SantaFe/). The report notes that "...the concept of a 'digital library' is not merely equivalent to a digitized collection with information management tools. It is rather an environment to bring together collections, services, and people in support of the full life cycle of creation, dissemination, use, and preservation of data, information, and knowledge."

- The ***Next Generation Internet*** initiative will design and develop new technologies and architectures for powerful, versatile networks and stimulate the introduction of new multimedia services. It will also extend deployment of these capabilities more broadly into the research and education communities. A test bed will connect universities, federal research institutions, and other sites to demonstrate new networking technologies to support future research and demonstrate new applications that meet important national goals and missions.

- The ***Integrated Spatial Information Systems*** activity is intended to provide more versatile access to geospatial data systems. An explosion of geospatial data—location-related information used in the physical, chemical, biological, geological, social, and economic sciences—is being generated by new technologies such as satellites and airborne sensors, accelerated environmental research, and advances in computation and communications. The integration of these data could greatly enhance scientific understanding and support socially useful applications ranging from improved availability of real-time demographic, environmental, and economic information to disaster response teams to analyses of where best to site new community facilities.

- ***Functional Genomics*** is an emerging area in the biological sciences. As described by Mary Clutter, NSF assistant director for biological sciences, the effort to collect genetic sequencing data began in earnest in the mid-1980s. By 1995 there were approximately 354 million data elements; by 1997 there were more than 1 billion; and within 5 years scientists are expected to have sequenced the complete genomes of 50 organisms. Geneticists pioneered the use of information technology to share information and build communal knowledge, and they raise leading-edge questions about how to make sense of enormous volumes of information. Research can lead to better ways to organize, communicate, search, and analyze large volumes of data from multiple sources.

- The ***Digital Government Program*** will build on past successes in information technology partnerships, such as the Internet, by supporting the application of emerging technologies to improve government operations and interaction with citizens. Potential research areas and technologies include intelligent information integration, very large scale information acquisition and management for multidimensional data, advanced analytics for large information collections, electronic commerce technologies, information services for citizens, and research in the application of information technology to federal law and regulation. The goal is to support research that will demonstrate pilot systems offering new capabilities for federal agencies, while also identifying new research problems and insights for the academic community. Workshops are being undertaken in cross-cutting domain areas, such as geospatial information systems, crisis management, and federal statistics.

Additional details regarding KDI activities are provided in Appendix C. The KDI proposal solicitation is provided in Appendix D. (Since the 1997 leadership colloquium, the NSF has formed a KDI working group composed of 10 program managers from six directorates. The group, which meets weekly, will manage the solicitation and review of grant proposals and chart the future of the KDI effort. The current chair is Mike McCloskey, Program Manager of human cognition and perception.)

# 3. FUNDING PRIORITIES AND APPROACHES

## National Science Foundation

The NSF, which has an annual budget exceeding $3 billion, primarily sponsors fundamental research at universities in an effort to develop new scientific and engineering knowledge. The time frame is often long term. The overall mission is to advance fundamental science and engineering research within the context of a broad range of application areas, such as health care, learning technologies, world history, literature, fine arts, social welfare, and other aspects of culture. Within its mission, NSF seeks to achieve three interrelated goals: leadership in all areas of science and engineering research; excellence in math, science, and engineering technology education at all levels; and technology transfer, both to integrate the results of the discovery process to answer complex questions and to move products toward applications in society. The KDI effort is relevant to all three goals. Approximately 95 percent of NSF funding is directed to fundamental research in mostly academic institutions, generally awarded in response to program solicitations. Through the KDI activity, the NSF is evolving toward a more proactive stance with respect to shaping the research that it funds.

The NSF solicits research proposals in specific areas and selects projects for funding through a merit-review, or peer-review, process. Proposals may also result from dialog between NSF staff and researchers. Dr. Lane said that KDI activities "evolved naturally out of funding the best scientific and engineering research and education ideas that came to us … You hope the good ideas will emerge by peer review and other processes that are well understood." As an example of how NSF investments in fundamental research produce results that can have broad societal impact, Dr. Lane noted that Marc Andreessen, co-founder of Netscape Communications, invented the first Web browser while Mr. Andreessen was still working as a programmer in an NSF-supported supercomputer center. A profile of the NSF is provided in Appendix E.

## Private Foundations

The majority of the approximately 40,000 private foundations in the United States fund grants to address immediate and pressing social problems or support areas of interest to their founders, staff, or local communities. A number of private foundations carry out programs directly, and a few are engaged in both grantmaking and program operations. The time frame is often short term, with an emphasis on tangible outcomes. Private foundations tend to be more agile and flexible than the federal government in adapting programs to community needs and generally have greater expertise in helping community groups accept innovation. They are also minimally influenced by the current political climate. Loosely organized and idiosyncratic by design, most of the private foundations in the United States are small and have a local or regional sphere of interest. At the other end of the spectrum, a few foundations have vast resources and international reputations for supporting cutting-edge activities in medicine and other areas of interest.

Grant recipients are sometimes selected from unsolicited proposals submitted by groups or individuals. The process typically begins with a letter of inquiry or telephone call. The proposal is evaluated for its relevance to program guidelines, and a decision to fund or decline the proposal is made by the foundation's program staff. It is the responsibility of the program officers to develop the grantmaking strategy and program. Joan Shigekawa, associate director for the Arts and Humanities Division of the Rockefeller Foundation, describes the process as follows. Given a foundation's commitment to address a broad challenge, the program officers propose a specific grantmaking strategy. For example, a foundation interested in ending world hunger might seek to increase agricultural production in developing countries by supporting rice biotechnology. After an internal dialog and debate within the foundation concerning the merits and risks of the strategy, a case is made to the foundation's board of trustees as to why this is an effective use of foundation resources. The trustees have final approval over the foundation's programs and areas of work.

Foundations vary widely in terms of the monetary value of their assets but typically pay out approximately 5 percent of the asset base, the level required to retain legal status as a tax-exempt private foundation. In 1995, U. S. private foundations awarded $12 billion in grants, and corporations (excluding corporate foundations) awarded an additional $6 billion through direct giving programs. Among the foundations represented at the colloquium, areas of investment include education, the arts, rural development, community information systems, and health care. Foundation profiles and activities are summarized in Appendix F.

A few foundations (e.g., the Andrew W. Mellon Foundation) have formal programs in information technology, but this is the exception; most foundations do not have significant experience with information technology. However, interest in the area of information technology is growing rapidly, and a number of foundations are considering the establishment of such programs.

**Project Assessments**

Whether investments are made by individual organizations or in cooperation with others, the benefits of funded projects need to be assessed. Private foundations focus on social benefits. As Mario Morino, chairman of the Morino Institute, noted: "In the end, you get asked, 'What is the social outcome that was achieved?' Not the toys, not the glitz, not the glamour, not the technology, but what in fact was actually achieved and who benefited? Where was the social systemic change that came out of those actions?"

Several colloquium participants reported a common lesson learned from past assessments of technology projects—the importance of investing not only in hardware but also in people, who can provide consultation and support as needed to customize systems and solve practical problems. "It is estimated by many, many wise observers of the scene that, of investments in educational informational technology, only one-third should be in the hardware," Dr. Hartmanis said. "The rest should be in the support, the training of teachers and so on."

Similarly, Robin Willner, director of corporate social policy and programs for IBM, said evaluations of IBM's school programs after 15 months found that "the most valuable service IBM provided, the thing [our partners] cited most often, was our project managers … That was much more important in the end than whether they had four more classrooms that had PCs in them." The managers brought with them creative approaches and worked to tailor solutions to the specific needs, she said.

Lloyd Morrisett, president of the John and Mary R. Markle Foundation, said his most successful interactive technology projects have followed the deployment process all the way through, supporting any additional work needed to ensure successful applications and participating in commercialization and distribution. "We have tried it saying, 'Well, we will only go so far and [then] somebody else should do the job.' Frequently, nobody else does the job," he said.

Thus, one of the concerns of the private foundations regarding KDI is a possible overemphasis on technology and research with insufficient attention given to social outcomes. Richard Quandt, senior advisor to the Andrew W. Mellon Foundation, said "the question that is not asked enough is how it [information technology] affects the productivity of activities." From the perspective of private foundations, the paramount consideration with respect to KDI is whether it will advance their programmatic endeavors.

Diane Strahan, executive director of MCI Corporation Community Partnerships, said it is difficult to quantify benefits. She suggested that a discussion of quantitative and qualitative approaches might be useful. For example, it might be helpful to identify common data points (distilling information down to a data point can be difficult) and agree on a representation of the data so that it can be analyzed to develop theories and conclusions.

## 4. BENEFITS AND RISKS OF COOPERATION

Partnerships offer the opportunity for mutual gain through leveraged investments and reduced risks. Moreover, the combination of NSF's history of successful fundamental research and technology development with private foundations' expertise in identifying and addressing community problems could enhance the effective application of advanced technology to meet social needs. The decision to form partnerships can be informed by past experiences as well as the consideration of risks and barriers.

Cooperation between private foundations and the NSF may assume various forms, ranging from informal and spontaneous activities to highly coordinated and intense programs. Communication is one form of interaction, in which information is shared but program management remains largely independent. Coordination is an intermediate state in which the work processes of one foundation are somewhat influenced by the work of another foundation. Collaboration suggests considerable dependence on the work of one's partner. Teams are a more intense form of collaboration.

### Examples of Mutual Investments and Collaborations

The NSF often works with other federal agencies, such as the Defense Advanced Research Projects Agency (DARPA). Outside the federal government, the NSF typically works with educational institutions, at both the K-12 and post-secondary levels, and with the states. Often a project involves multiple partners, each carrying out a different role. Luther Williams, assistant director for education and human resources, said NSF educational projects are best characterized as "collaborations" in the sense that the partners interact in project evaluations and in forming strategies for the future. The NSF also collaborates successfully with other types of organizations, including private foundations. A project with the Whitaker Foundation is focusing on how new technologies could contain health care costs. In this project, the partners jointly reviewed the proposals. The NSF sometimes works with other research organizations, such as the Electric Power Research Institute, and is working toward the development of cooperative research programs with the European Commission.

Education is an area of mutual interest to both public and private foundations. In an encouraging example of how collaboration evolves, ongoing NSF support for urban school activities encouraged IBM's investment, according to Ms. Willner. "When we identified our educational grants, the fact that districts have urban systemic initiative grants meant that they had already established a set of commitments with the NSF to standards-based reform to focus on math and science. They had a set of commitments that coincidentally mirrored some of the things that we were going to have in our relationship with them … We very much tried to leverage the resources that NSF had in place, so that we could focus on technology understanding [while NSF provided] funds for professional development."

Both the NSF and private foundations have contributed to aspects of the Digital Libraries Initiative (DLI). The first phase of this initiative was supported by three federal agencies (NSF, DARPA, and the National Aeronautics and Space Administration [NASA]).[4] The projects were led by six universities, which performed fundamental research, established test beds, and worked with various partners. The private foundations contributed to specific areas of interest. For example, one DLI activity involved the design of special interfaces and approaches to enable a teacher to achieve effective use of the Web in a 50-minute class. The W.K. Kellogg Foundation supported dissemination of the innovation into Detroit schools. In another project, the Andrew W. Mellon Foundation funded a pilot program on the digitization of scholarly journals. The successful program resulted in the formation of JSTOR, an independent, not-for-profit organization that helps the scholarly community take advantage of information technology advances to improve access to scholarly journals, explained Kevin Guthrie, executive director of JSTOR.

Daniel Atkins, founding dean of the University of Michigan's School of Information and a DLI project director, articulated the rationale for the important role of collaboration in digital library activities. "It is not enough simply to use these technologies to automate, to go down a path of extrapolation to make faster, better, cheaper what we are already doing," he said. "The real opportunity is that of innovation, figuring out how to use this technology to do things in fundamentally new ways, to get higher in these vision states." Thus, the benefits of collaboration include not only the leveraging of scarce resources and pooling of complementary resources, but also the coupling of diverse perspectives to foster innovation. Private foundations and the NSF typically bring very different, but complementary, strengths to a project.

## Risks and Barriers

Private foundations have often been reluctant to collaborate with the federal government. Anne Petersen, senior vice president for programs at the Kellogg Foundation, said Kellogg historically shied away from partnerships, which can be difficult because of the need for time-consuming communications. "It would seem that the benefits of [partnerships], if they were clear, could counteract the time that it takes. But there would have to be clear benefits for all the partners. I think that is what we would have to identify—what people would get out of it."

Dr. Morrisett said Markle has also been reluctant to collaborate and that he would rather not spread the investment risk or project accountability. There is a particular risk of partners going into a project with unstated assumptions about outcomes, he said. For a partnership to be successful, the partners must have goals that are in concert, and each should bring something unique to the table, he said.

Another barrier to collaboration is the absence of support for, and even awareness of, fundamental research among private foundations, which have been virtually absent from the arena since World War II. Mr. Morino explained that foundations lack R&D cultures and therefore they might find it difficult to work with a research-oriented agency such as the NSF. "The NSF needs to market and promote its resources and projects," he said.

There is also a risk that changes in institutional goals or priorities will result in a sudden loss of funding. For example, in its Arts and Humanities Division, the Rockefeller Foundation has had several partnerships with the National Endowment for the Arts (NEA). One such public-private collaboration, The Artists' Projects Regional Initiative, a funding partnership involving the NEA, Rockefeller Foundation, and the Andy Warhol Foundation, came to a sudden end when the NEA made a unilateral

[4] The Digital Libraries Initiative - Phase 2 is sponsored by the NSF, DARPA, National Library of Medicine, The Library of Congress, NASA and the National Endowment for the Humanities and in partnership with the National Archives and Records Administration and the Smithsonian Institution.

decision to terminate its support for individual artists. Dr. Lane noted that the federal government is political and subject to the priorities of elected leaders. "The higher the profile of the partnership, the more risk, I think, that it is going to get, at some point, politicized—caught up in the larger issues that have nothing particularly to do with the importance of what is going on … In our system we can never absolutely guarantee [anything] because there are other folks in the decision-making stream." There is also a potential for shifts in direction at private foundations, where funding priorities depend heavily on the goals of individual program officers and the composition of the board. The departure of key individuals can lead to a loss of support for particular programs.

Projects selected for collaboration need to be carefully considered to ensure that the benefits of collaboration do indeed outweigh the costs, as Dr. Petersen suggested. Thus, the key is to bring together individuals who have common interests, vision, and passion and select topics that are sufficiently high on their agendas to ensure that time will indeed be allocated to the activity. Alan Paller, chief executive officer of the CIO Institute, suggested that potential collaborations be focused on specific cases, based on his observation that "energy spikes [among meeting participants] turn out to be when someone describes something real" (i.e., an actual project rather than a theoretical example).

Some of the perceived risk might be counteracted through increased awareness of the NSF among private foundations. "Private foundations don't have a clear understanding of how the NSF works. The NSF is a large and complex institution whose resources and grant budgets are far greater than those of any [other] U.S. foundation. Most private foundations, the majority of which are local or regional, know very little about NSF programs," explained Ms. Shigekawa, who suggested that "one would have to know the programs of the NSF very well to understand how to engage the institution effectively."

There are also differences between the NSF and private foundations with respect to organizational culture. The NSF is dominated by scientists and engineers, many of whom are former academics. Private foundation professionals tend to have a wider diversity of backgrounds, with some emphasis in the social sciences and humanities, and they are generally application oriented. Andrew Blau, director of communications policy at the Benton Foundation, observed that "what counts as a well-formed question for my colleagues at the NSF doesn't really work for the private foundation people and vice versa." Some accommodations will be need to be made to support effective communication between the NSF and private foundations.

In general, colloquium participants expressed cautious optimism about the possibilities. "It is an obvious partnership," said Woodward Wickham, vice president of the John D. and Catherine T. MacArthur Foundation. Christopher Harris, vice president of the Council on Foundations, Inc., said he "applaud[s] the NSF for taking the initiative. It makes sense for the NSF and the private foundations to work together, and the Council is interested in assisting in any way that we can."

## 5. MECHANISMS FOR COMMUNICATION, COORDINATION, AND COLLABORATION

### Identifying and Communicating Opportunities to Cooperate

The formation and maintenance of cooperative activities requires ongoing communication and information exchange. To lay the groundwork for this process, prospective partners need to identify their priorities and determine their respective niches in the R&D and technology transfer arenas. Discussions may also be needed concerning the roles of the public and private sectors, funding mechanisms, and intellectual property issues. In addition, mechanisms for communication and collaboration need to be identified. Roles and mechanisms can be difficult to define because project concepts are often developed informally. For example, domains for DLI projects are selected through a series of internal discussions.

There are a number of possible mechanisms for identifying and communicating opportunities for cooperation between the NSF and private foundations. The following information sources might be useful in identifying areas of common interest:

- ***Existing NSF databases***. Electronic abstracts of NSF awards, programs, and speeches can be searched using specific words or topics as search terms. However, the level of granularity is low, and concepts cannot be used as search terms. Moreover, the databases do not reflect all possible funding areas because NSF also responds to stimulating new ideas and outstanding new investigators. Innovative networking and searching methods could be designed to improve access to the information. For example, NSF knowledge bases might be categorized or mapped in such a way that private foundations could identify disciplined and process-oriented approaches for dealing with societal issues. Mel Ciment, deputy assistant director of the NSF for computer and information science and engineering, said the NSF databases are useful tools but will change rapidly. "Don't get caught up in what our portfolio is [today]," he cautioned. Stimulating ideas from community-based organizations will bring new players into the domain.

- ***KDI "help desk***." A clearinghouse, directory, or other resource could be established to provide information regarding KDI-related contacts, research, and programs at NSF and activities funded by private foundations. The NSF has already established a KDI Web site, which might be expanded. A complete list of all federally funded grants is available (RaDiUS, operated by the RAND Corporation), but it is not available to the public free of charge, and there is no comparable list for private foundations. A prototype directory could be developed as a first step.

The NSF is structured primarily to support interaction with academia. Innovations in the NSF's organizational structure and processes could facilitate the establishment of cooperative activities with private foundations. Possible innovations include the following:

- ***NSF liaison to private foundations.*** Because KDI transcends disciplinary and directorate boundaries, it would be useful if a specific individual or mechanism monitored all related activities throughout the NSF and served as a link to private foundations. Dr. Petersen suggested that "a human connection into NSF might be more productive than searching the grant database." Innovations are needed so that private foundations do not need to understand the NSF fully before initiating cooperative activities. The World Bank has such a liaison for private foundations, which might serve as a model for the NSF. Dr. Strong announced that Y. T. Chien, division director of the NSF Division on Information and Intelligent Systems, has volunteered to serve as a broker to assist private foundations in identifying potential cooperative relationships with the NSF. (Michael Lesk has agreed to handle these duties while Dr. Chien is on a 2-year sabbatical.)

- ***Outreach activities at the NSF***. Structural innovations could include the addition of KDI and private foundation representatives to existing NSF directorate advisory groups and committees of visitors. Outreach activities by NSF science and technology centers could be extended to include KDI activities. For example, the cognitive science center at the University of Pennsylvania already deals with language learning and conducts outreach at Philadelphia schools.

- ***Sabbaticals and fellowships***. A program might be established at the Council on Foundations to enable NSF staff members to spend a year at the Council and perhaps some time at one or more private foundations, suggested Nora Sabelli, NSF senior program director for learning and intelligent systems. The program could be similar in spirit to the White House Fellows program. The idea would be to temporarily move a technologist to "where the assignment is to find out something that the community needs to know. At the same time, they transfer technical knowledge to the community," explained David Clark, chair of the Computer Science and Telecommunications Board and chair of the colloquium. Of course, the NSF could also pursue the reverse approach, arranging for program officers at private foundations to spend time at the NSF, suggested Deborah Crawford, program director for physical foundations of enabling technologies.

- ***Enhanced private foundation presence at scientific meetings and workshops***. Representatives from private foundations could be invited to NSF workshops focusing on KDI-related subjects or regular meetings of program grantees (e.g., semi-annual DLI meetings). Invitees should include not only large foundations with national or international scope but also smaller foundations that fund state or local projects.

- ***Operational private foundations as direct grantees of the NSF.*** Several foundations that operate their own programs (e.g., the Shoah Visual History Foundation and JSTOR) rely heavily on information technology, although technology development is not a part of their missions per se. Bennett Bertenthal, NSF assistant director for social, behavioral, and economic sciences, said the NSF often funds research based on existing data sets but that investments in infrastructure are less certain. To some extent, it depends on the importance of the research question. One alternative would be to pair academic researchers with foundation program managers based on their complementary interests. Academic researchers would benefit by gaining access to a real-world context in which to develop and test their research questions, whereas operational foundations would gain access to the researcher's start-of-the-art knowledge in the relevant disciplines. Such a team could also develop proposals for funding within the NSF paradigm that presumes an association with a researcher, providing an entree for private foundations to possible NSF support. However, "this could be a painful relationship" because of the different priorities and backgrounds of academic researchers and program managers in operational foundations, warned Sam Gustman, director of technology for the Shoah Visual History Foundation. To promote such relationships, the NSF could formalize rules and guidelines based on common resources, similar to those used by operational foundations. This approach was used on the Antarctic project.

Direct mechanisms could also be used to bring the NSF and private foundations together. Possible mechanisms include the following:

- ***Private foundation affinity groups***. Private foundations communicate with each other through affinity groups formed to deal with specific issues, such as education, environment, population, agriculture, health, and the arts. These groups are informal arms of the Council on Foundations. Affinity groups are better established in the social sciences than in the hard sciences. Foundation representatives at the colloquium expressed interest in forming an affinity group for information technology, which might also serve as a link to the NSF.

- ***Bring together program managers and grantees with similar interests from the NSF and private foundations.*** Meetings or workshops could be organized to bring together program officers from private foundations and the NSF who have similar interests. The corresponding grantees could also be invited. Bill Duggan, manager of special projects at the Ford Foundation, noted that in some initiatives supported by the foundation, the grantees meet annually. In addition, the Ford Foundation is considering a more systematic effort to help groups of grantees interact more frequently using the Internet. A group of grantmaking foundations with interests in learning technologies and education held such a workshop, funded by the NSF, in early 1998, Dr. Sabelli said.

The NSF provides funding for meetings of this nature on a routine basis. A neutral convening organization might set up a few meetings to serve as a proof of concept. The 1997 KDI colloquium described in this summary was, as Ms. Shigekawa observed, a forum for "conversations about having a conversation." The next meeting(s) would feature conversations about specific topics. Dr. Duggan proposed that such meetings focus on the following objective: "Develop possible collaborative action and problem-oriented research projects on science, education, organizational, social, and cultural problems and opportunities for digital information collection, access, and use." Several participants noted that the cooperative process improves after even one face-to-face meeting.

## Technology Test Beds

Test beds might provide a context for collaboration. The NSF typically supports test beds to refine new technology for particular applications and assess its effects, usually by engaging the academic community and forming partnerships with organizations that deal directly with communities. For example, in a LIS project called Academy I, or TAPPED IN, teachers discuss pedagogical issues surrounding the integration of technology into the classroom. In one example, earth science teachers provide a real-world test bed for assessing how the process builds intellectual coherence.

Test beds are integral to the Clinton Administration's Next Generation Internet (NGI) initiative, which will support networking test beds of sufficient scale to identify new applications. The NSF will take the lead in connecting 100 universities at speeds 100 times faster than today's Internet—enough bandwidth to transmit an entire encyclopedia in less than one second. DARPA will take the lead in more ambitious projects, including the connection of some institutions at speeds 1,000 times faster than today's Internet. New applications, such as "collaboratories" (i.e., laboratories without walls), will be explored. Private foundations might be interested in NGI applications that could be relevant in multiple situations, serving to increase the "collective IQ" of different communities of interest.

Test beds and demonstration projects could help solve practical problems faced by foundations. For example, Mr. Gustman said 150 terabytes of information have been collected about Holocaust survivors but cannot be disseminated because of the high cost of purchasing long-distance bandwidth. Thomas Kalil, senior director to the National Economic Council, said the White House will push the technology state of the art so that terabyte networks will emerge, and will try to motivate deployment of those networks by demonstrating the applications possible at those speeds. Dr. Ciment said the NSF supports a very broadband network system (vBNS) project that originally connected five supercomputer centers but has evolved to connect 66 universities. The system can be used by nonprofit organizations for research, but the acceptable-use policy would need to be extended if the system were used for commercial purposes. The vBNS backbone transmits 622 megabits per second (Mbps), whereas connections to universities are somewhat slower at 155 Mbps.

Bruce Schatz, professor and principal investigator in the DLI program at the University of Illinois at Urbana-Champaign, said the era is approaching when research on large systems will require test beds in particular application areas. "If the only people who are pushing it are commercial interests, [then] they also push advertising or pornography," he said. "You see what happened to the Web. If you want good things to happen, like problem solving and sharing, then what you need to do is have more public-spirited people be the pushers."

## Data Collection, Sharing, and Analysis

Data collection, sharing, and analysis offer another potential context for cooperation. However, this is a multifaceted issue that raises concerns about data access, costs, ownership, revenue, accountability, privacy, and quality.

For example, access and costs vary, depending on who owns the data. Although the NSF is not a policy or regulatory agency, it insists on certain standards with regard to the development, dissemination, and sharing of data. All data generated from NSF grants is to be shared. In addition, it is federal policy that agencies not charge any more for data beyond the actual costs of dissemination. "In the current environment, costs for dissemination, if not zero, are close to zero. So a lot of federal agencies are making [data] available for free, and the White House is certainly encouraging that," Mr. Kalil said. For example, the National Library of Medicine (NLM) is now making its databases available free of charge.

By contrast, states and localities and the private sector set their own policies on data access and costs. Mr. Morino said tight budgets have prompted some cities and states to outsource information processing, and these agreements often give contractors the right to the redistribution and pricing of the data. Seldom is this practice even disclosed for public viewing and discourse, he said.

A number of data sources and tools may be of mutual interest to the NSF and private foundations:

- ***National spatial data infrastructure***. Geospatial information systems (GIS) integrate advanced technology and the geosciences with geography, a social science dealing with the spatial aspects of culture, economics, and politics. These systems can have meaningful social and political applications; for example, a GIS system can provide visual information on global change to a policymaker. The NSF works with the Federal Geographic Data Committee (FGDC), which is promoting the development of the national spatial data infrastructure, a common set of terms that will enable data generated in one community to be used by others. Also participating are states, counties, cites, and the Open GIS Consortium, a nonprofit trade organization representing industry, government, and international agencies. The consortium is dedicated to the integration of geospatial data and geoprocessing software in interoperable systems. Many cities use GIS as a management tool, but data from different communities are generally not compatible. The FGDC and consortium activities may intersect with the interests of private foundations. The Kellogg Foundation, for example, advises communities to create their own local information databases to improve planning. Some foundations are interested in how the arts and culture communities can learn to design compatible and searchable databases. One FGDC unit is dealing with cultural data.

- ***NSF national surveys***. The NSF supports several national surveys, which can be supplemented with questions added by other groups, as long as the questions serve legitimate scientific goals. The General Social Survey examines attitudes, beliefs, and life conditions based on a national sample. The Panel Study of Income Dynamics examines the economic fates of families over time and the effects of factors such as household income on children. The National Election Studies reveal the forces that shape presidential and congressional elections. The Rockefeller Foundation has added questions on sexuality to the General Social Survey for a few thousand dollars, and novelist Andrew Greeley has invested some of his royalties to add religion questions. The NSF has supported a demonstration project in which a comprehensive questionnaire data and analysis system has been placed on the Web using the General Social Survey. Valuable for both research and education, this system provides the 3,000 questions that have been asked, abstracts of 3,000 publications based on the survey, easy-to-use tools for analyzing data on-line, and full data files that can be downloaded for more sophisticated statistical analysis. The system can be accessed through the University of

Michigan's home page (see Appendix G). The data might be used to establish Web sources on sociology themes.

- ***Internet community data***. Data is accumulating on the Internet community (e.g., users of on-line computer games and retrieval systems), but to date neither scholars nor commercial interests have performed multidimensional analyses of user characteristics. Christine Borgman, a professor at the University of California at Los Angeles who also holds the University of California system's presidential chair in information studies, said some researchers have been monitoring on-line retrieval systems for years, accumulating perhaps millions of data points. "You've got an unobtrusive trace of what [users] did, but not why they did it. You need to triangulate with other kinds of interview data or laboratory data, and you quickly get into psychological issues of user modeling to do it. So it touches on a much deeper area of KDI research, and it may be more of an area of collaboration between multiple communities than was obvious on the surface," she said. As an example of the insights that can emerge from this type of research, Ms. Shigekawa said the first on-line game for adults reflected an interesting social phenomenon, in which a subgroup of "killers" emerged first among the players, followed by a group of "guardians."

- ***Corporate customer databases.*** Corporations often gather customer data, much of which is proprietary because it drives business plans. However, some of that data, if disaggregated as necessary, could be useful to private foundations for planning purposes. A consortium of corporations might be formed to provide access to data for broad social purposes and foundation program planning. Before such data could be shared, a company would need to determine which data elements were in the public domain or governed by tariff. Those seeking access to the data would need to determine the key questions to be answered and the target areas of intelligence gathering. Then legal and regulatory officers would need to be consulted to determine which data could be made available. Data sharing raises questions about privacy and other issues, which might be interesting topics for discussion among leading technology companies. To circumvent these issues, some companies perform research using their proprietary databases on request from outsiders but release only the results, rather than the raw data.

- ***Industry research services***. Companies often buy or subscribe to data on public or consumer attitudes collected by market research or polling companies. Private foundations typically do not use such data and might benefit from a briefing on industry research services. In the KDI context, data on public attitudes might assist in the social application of technology. For example, Mr. Morino cited a research publication, available free of charge, that explains why electronic commerce has evolved so slowly.

- ***Database design and analysis tools***. Some NSF grantees study database designs and analytical tools that might be useful to private foundations. For example, Dr. Schatz discussed methods for statistical analysis and data or text clustering that are currently used to help doctors improve the electronic retrieval of articles about specific types of cancer cases. These tools might be applied, for example, to the development of a statewide immunization registry for children, but only if patient records were formatted and worded in a consistent manner, which they typically are not. Dr. Borgman said it is a major challenge to determine which information-retrieval algorithms transcend different domains, and which ones are domain specific. "There are ways of organizing information that work well in health care that, say, do not work well in geospatial information systems, and vice versa," she said.

- ***Syntheses of NSF research findings for private foundation use.*** Deanna Marcum, president of the Council on Library and Information Resources, suggested that a synthesis of the NSF's past research would be an invaluable resource, considering the breadth and depth of the activities. As Dr. Crawford remarked, the NSF has "done nearly everything." To be practical, such an undertaking would have to target a relatively small subset of the research. Private foundation needs also must be defined, Ms. Shigekawa suggested. The NSF might make funding available to develop these syntheses, but it is not clear who would receive the grants and perform the work. Dr. Clark advised answering the question by determining whose "career interest" would be served if they were to distill research information for use by private foundations. One possibility is the library and information science community. Richard Ekman, secretary of the Andrew W. Mellon Foundation, suggested awarding funds for such syntheses projects to library and information science graduate schools.

## 6. POSSIBLE TOPIC AREAS FOR COOPERATION

There is already some overlap among activities currently supported by the NSF and private foundations. Dr. Morrisett suggested that there is perhaps a 5 percent overlap. Dr. Petersen said she has been surprised to learn how many Kellogg projects also receive NSF funding, but without deliberate coordination to leverage the investments. The following is a summary of areas that seem to offer common ground.

### Digital Libraries

Federal support for digital libraries may intersect with the interests of private foundations in ***historical archives*** and many other applications. For example, access to the Shoah Foundation's collection of 41,000 interviews in 30 languages could be enhanced through the combined efforts of experts in linguistics, computer science, engineering, voice recognition, and other fields. This type of research is currently supported by the NSF through programs such as the DLI, which is intended to improve the accessibility, availability, usability, and preservation of information in on-line repositories. Phase 2 of the DLI was formally announced in March 1998 and is focused on improving both electronic and intellectual access to digital collections. Stephen Griffin, DLI program manager, explained: "Instead of just being able to say 'Can I get to the bits and can I get to some string sequences in the bits?' the goal is to say "Can I get to the meaning that is contained in the bits?' This requires semantic access to various types of information at various levels." The new program encompasses research, test beds, content, collections, development, domain applications, and operational environments.

Digital library research also has the potential to benefit ***community knowledge bases***. The Kellogg Foundation has invested in community library and information services in an effort to help convey knowledge to the greatest possible number of individuals in the most meaningful way. "We don't think that is even being dealt with as a social issue very effectively. The science is way ahead of that," said Gail McClure, Kellogg's vice president for programs. Relevant research was discussed by Dr. Schatz, who worked with the Getty Information Institute on a global cultural memory project in which a content-based retrieval system was designed for 5,000 indexed images collected in Champaign County, Illinois. "It is clear to the people who watch this kind of technology closely that in 10 years you will be able to go into Wal-Mart and buy a community repository package, just like now you can go in and buy something that puts up a Web page," he said. "This will let you take all the information in your entire community and index it in some way such that you can effectively compare it with other ones, and there will be this big national infrastructure that is like the Internet with switching machines. The switching machines will be switching knowledge across communities, not switching packets between computers."

***Health care*** and ***education*** applications are supported by the NLM, which has had electronic databases since the late 1960s and supports research in information science, artificial intelligence, learning technologies, and image processing. The NLM also helps health care professionals incorporate new technologies in health care and educational settings and awards research contracts in ***telemedicine***. There is broad public- and private-sector interest in telemedicine, one of the applications planned for the NGI. Private foundations interested in health care might contribute to telemedicine by, for example, supporting physician training in rural settings.

Other NLM digital resources of possible interest to private foundations include extensive knowledge sources and database-searching tools. One data set consists of 45 gigabytes of visual images of the human body, produced from computerized axial tomography scans, cryosection images, and magnetic resonance imaging. Approximately 500 individuals and institutions have signed licenses to use the Visible Human data, said Alexa McCray, director of the Lister Hill National Center for Biomedical Communications. (The licenses are used for tracking purposes.) The NLM also supports the Unified Medical Language System project, which focuses on enhancing conceptual access to data. The NLM's largest knowledge source is the metathesaurus, available over the Internet, which integrates some 30 biomedical thersauri and includes more than 300,000 concepts as well as lexicon tools. Other projects include the digitization of papers written by a former director of the National Institutes of Health (NIH) and by NIH Nobel laureates, for both archival and educational purposes.

### Education

Both the NSF and the private foundation community strongly support education. For example, a LIS center for ***learning technologies*** in urban schools involves Northwestern University, the University of Michigan, and Chicago and Detroit schools. Dr. McClure of The Kellogg Foundation said she is familiar with this project and views it as a good example of where private foundations and the NSF can connect. There is also mutual interest in ***distance learning***, which potentially could involve millions of students. William Bainbridge, science officer of the NSF Directorate for Social, Behavioral, and Economic Sciences, predicted that Web-based distance learning could replace a significant fraction of current college courses, presenting both challenges and opportunities for educational institutions. He urged foundation representatives to communicate with each other and with the pioneers of such courses to compare insights on software barriers and teaching techniques.

Several colloquium participants emphasized the need to move beyond supporting model educational programs to find ways to scale up pilot projects to meet real community needs. For example, KDI technologies could be used to ***share innovative ideas*** so that a given community can transfer and adapt model projects to meet their own needs. Ms. Strahan said the "influencers" in a community need to be engaged early in the R&D process or else innovations will not be adopted. Ms. Shigekawa said educational research indicates that "overcoming the model program is the greatest barrier to having action happen at the local level. We need to understand that—that the model program itself is a huge stumbling block that people choke on at the grassroots level."

Dr. Hartmanis said the NSF supports a consortium led by Apple Computer that collects ***educational "objects,"*** including academic software and scientific demonstrations developed at universities and elsewhere. These programs can be expensive, but the consortium encourages their use free of charge, and even encourages users to modify and improve them. Once used, the objects are either returned to the repository or sold by the user (a percentage of sales is returned to the consortium). "I think it is a very, very interesting way to get volunteer participation in the engagement of the educational objects, as well as a potential [mechanism] for people who are trying to exploit [courseware] to make money both for the consortium and for themselves. I think that is a very, very creative approach," he said.

Mr. Wickham of the MacArthur Foundation concluded that because the NSF and private foundations have strong interests and extant programmatic efforts, education is "an extremely high-payoff area" to pursue for potential cooperative activities, both within and outside the KDI context. Several cooperative projects are already under way involving the NSF and private foundations, but there appear to be many more opportunities to pursue.

## Social Issues

Both the NSF and private foundations support projects designed to promote ***universal access.*** The NSF concentrates on access for persons who have physical disabilities or little or no reading ability. "Intermedia" systems are being designed to enable the translation of modalities (e.g., text-to-speech systems to assist blind users). ***Telework***, telemedicine, and "human augmentation" systems are being explored to help the physically disabled live and work independently. To help nonreaders participate in society, the NSF supported the development of an automated reading system that also listens. This system has had "absolutely amazing results in getting children at the bottom of the class up a couple of grade levels in a few months," said John Cherniavsky, division director of the NSF for experimental and integrative activities. In the private sector, the Markle Foundation is supporting a number of studies on universal access, beginning with a large-scale policy study of the Medicare system and California State Department of Employment as possible vehicles for the implementation of universal e-mail. Dr. Morrisett said the implementation of universal e-mail will require a change in government policy; he suggested that the NSF try to place this issue on the federal agenda.

In a related area, there might be opportunities for collaboration between the NSF and private foundations in the development of KDI-related ***rehabilitation therapies*** for the disabled. For example, academic researchers supported by the NSF could use the Internet capabilities at universities to design and set up the systems, which might be manufactured or disseminated with funding provided by private foundations.

Another social research area of possible mutual interest is ***the unintended consequences of new technologies.*** For example, the NSF is interested in scaling up Web-based laboratory experiments on computer-mediated interactions in small groups. Data have been collected on how these interactions affect social outcomes, but the effects in large groups (of perhaps 1,000) are not known. Similarly, it is not yet known how the shift from physical libraries to digital libraries will affect journal publishing, for example, or overall levels of access to information.

Both the public and private sectors are watchful of the evolution of the Internet, which is increasingly commercially driven. The Rockefeller Foundation is interested in seeing the Internet become more pluralistic, a site for public discourse and participatory government. To achieve this vision and promote interdisciplinary social applications of KDI (e.g., to improve participation in the political process or enhance disaster response), input is needed from groups that are typically uninvolved in technology development or uninterested in its use, said James Hung, a consultant to the Rockefeller Foundation. Ms. Shigekawa suggested that a "national conversation" be held on the public policy concepts of the future of the Internet as a medium for creative expression and a public space. Private foundations have said that the overhead of collaboration can easily demand more effort than direct funding of a project. However, a topic such as ***the Internet as a public space***—which can be framed properly only through the successful interaction of diverse stakeholders, ranging from experts on network technologies to experts on the needs of underserved communities—may well be an excellent candidate for collaboration, Dr. Clark concluded.

Dr. Strong suggested that the NSF might provide a ***futuristic vision for social experiments***. For example, although technology cannot eliminate poverty, it might offer a solution to related difficulties, such as the lack of telephones in some households. Apart from households that never had a telephone in the first place, social scientists have observed a phenomenon of families giving up telephones so they can afford cable television. DARPA has expressed interest in a *Star Trek* type of communicator, a voice-based interactive device. A school might provide a central information server and give each student a communicator, which could be taken home and used by the entire family. "In fact, maybe the result would be that school districts become kind of a community focal point, even more so than they are right now, to provide families connections to the information society through the children," Dr. Strong said.

### The Arts

Many synergistic interactions take place involving science and the arts, such as the case of a young filmmaker who recently received free assistance with imaging technologies provided by experts at supercomputer centers and NASA's Jet Propulsion Laboratory. The NSF supports the development of ***advanced visual integration and virtual reality technologies***. "There is clearly a tremendous arsenal of technology, of science, which we may channel in the direction of the arts," Dr. Hartmanis said, suggesting that private foundations might benefit from the NSF's vast store of visual interface technology and expertise.

For example, the NSF funds the Integrated Media Systems Center at the University of Southern California, which is also supported by the city, county, and state as well as the Hollywood community. The center is designing ***perceptive interfaces*** involving touch screens as well as face and body-language recognition. "When we communicate with each other, we look in each other's eyes and we can get a sense of what we are feeling from the other party we are communicating with. Your PC may be able to do this in the future," Dr. Crawford explained. The center is also developing tools for searching large databases of mixed types of data and will be involved in several test beds, such as a virtual museum that will represent the arts in all shapes and forms. With a tactile interface, a user could "feel" a sculpture. Another test bed is a multimedia university academy targeting "at risk" students aged 17 to 21. It is hoped that the perceptive interfaces will promote learning and help students acquire the skills needed to land jobs in the entertainment industry or enter college.

***Digital art*** might provide a basis for cooperation. Many art collections are now being stored digitally. Private foundations might provide access to art collections and other cultural content to NSF grantees, who could digitize the material and use it for research and then provide foundations with state-of-the-art data analysis methods in return. Another possibility would be to engage the NSF in private foundation work dealing with the value of arts and culture as assets for building vibrant communities. The NSF might also support efforts to create a laboratory and "think tank" to foster the creative convergence of science, art, and technology.

## 7. CULTURAL CONCERNS

The colloquium discussions mirrored a debate under way in the social sciences concerning the effects of technology. As Dr. Borgman explained, there are basically three perspectives on this issue. The technological determinists argue that technology drives social change, whereas the social constructionists believe that inventions emerge from a social context to drive the creation of more technology. There is also a group in between that views social-technical systems as reflexive, meaning that as technology is developed, users adapt it to meet their needs. Dr. Borgman suggested that KDI research could help resolve some of these debates. She argued that history supports the moderate perspective in demonstrating an evolutionary rather than revolutionary process of change.

Among the cultural concerns expressed about the application of advanced technology were the divides between the scientific and humanistic communities, the need for "friendly" technology, and the possibility of increased socioeconomic stratification.

**Bridging the Gap Between Scientific and Humanistic Communities**

The design of technology that solves real social problems will depend on successful communication between the scientific (i.e., NSF) and humanistic (i.e., private foundation) communities, which have different cultures, norms, semantics, and world views. Dr. Petersen of the Kellogg Foundation, who was formerly deputy director of the NSF, said: "I feel acutely that I am between two cultures here." She said some private foundation officials would not perceive the relevance of the colloquium to their own social concerns.

A two-way communication path is needed between the researchers with creative ideas for new technology and the social scientists and educators who are in touch with community needs. More specifically, this communication is needed before and during the technology design process, rather than afterwards, so that systems can be tailored specifically to satisfy the end user. Dr. Clark observed: "When we are just throwing [technology] over the fence, it is not at all obvious that it is hitting anything."

To facilitate the communication process and create a "legitimate synergy" between the two cultures, scientists and engineers need to learn more about what the public is thinking, and those working for social change need to communicate their needs upstream to the basic research community. However difficult this may be, such dialog is critical. "Building successful scholarly communities and problem-solving communities is a critical research challenge in and of itself," Dr. Borgman said.

**Developing "Friendly" Technology**

The achievements of IBM's chess master computer, Deep Blue, illustrates what some see as a growing divide between people who are intrigued by technology and those who are frightened by it. "I think very few people think technology is benign anymore," Ms. Willner said, suggesting that people either depend increasingly on technology and have strong positive feelings about it or fail to see the benefits and develop fearful, negative feelings about it. However, the successful adaptation of many manufacturing processes to be environmentally benign may demonstrate the possibility of—and suggest a model for—the design of information technology that is both user friendly and socially useful. For example, the design of a standard interface (or "intellectual-ergonomic informational tool," a term suggested by Bruce Umminger, NSF division director for integrative biology and neuroscience) that could be used by anyone might reduce the fear of information technology among the lay public.

Universal access is one mechanism for promoting widespread familiarity with, and usefulness of, technology. The NSF recently funded the Web Accessibility Initiative, which is housed at the Massachusetts Institute of Technology and involves a consortium from industry, to provide accessibility guidelines for Web information. Mr. Kalil noted that universal access is a regulatory term of art referring to the telecommunications policy of providing deep discounts to schools and libraries. Private-sector mechanisms for achieving universal access to computerized information systems might include advertiser-supported e-mail or the development of ultralow-cost information devices. An appropriate investment in research and engineering could change the way costs are distributed.

## Economic Stratification

There is great sensitivity within NSF to the possibility that new technology will exacerbate social divisions, but the actual effects remain uncertain. As Dr. Lane put it, "Is this increased access to information enriching us all as individuals, as a society? Is it creating opportunities to benefit all Americans? Critics and cynics point out that these advantages have numerous unanticipated and perhaps undesired consequences. There are disturbing signs that these new technologies have further widened long-standing gaps and divisions on our society, creating a world of technological haves and have-nots. Even some of our strongest supporters have openly wondered if all we have done is create newer and faster ways to grow that variety of our species called the couch potato, or new distractions, perhaps, for our young people that prevent them from [pursuing] their studies."

And yet technology also has the potential to equalize power and collect and distribute knowledge in innovative and socially beneficial ways. In particular, KDI research could be geared toward creating new models for sharing intelligence and building systems that recognize distributed intelligence in unconventional ways. One challenge is to tap the information that resides in "undeveloped places"—information that is important not only to local residents but also to outsiders who might learn from it. Existing information systems are typically not structured to recognize and distribute these hidden sources of intelligence because of both social and economic factors affecting design and deployment.

Mr. Morino said a key problem to be overcome is the current overemphasis on hardware and software and the insufficient attention to human capital, an area in which leadership and vision are needed. Most of the population cannot use the technology that already exists, he said. "We have great systems today, and what limits the technologies used in these areas is that we fail to recognize the enormous people cost and process issues that technology needs to be nurtured along … The technology is the easiest part of the equation in almost every case. It is the application that is the challenge."

# APPENDIX A

## AGENDA AND LIST OF PARTICIPANTS
## SEPTEMBER 25-26, 1997 MEETING

### LEADERSHIP COLLOQUIUM

### ADVANCING THE PUBLIC INTEREST THROUGH KNOWLEDGE AND DISTRIBUTED INTELLIGENCE

**National Academy of Sciences Building,**
**2101 Constitution Avenue, N.W., Washington D.C. 20418**

***September 25-26, 1997***
***Agenda***

**Thursday, September 25, 1997, Lecture Room**

| | |
|---|---|
| 7:45-8:30 a.m. | Continental Breakfast |
| 8:30-8:45 | Welcome and Agenda Overview |
| | *David Clark, Computer Science and Telecommunications Board Chair and Colloquium Chair* |
| 8:45-9:15 | Visions from the National Science Foundation:<br>Joint Progress in Technology, Research, and Applications |
| | *Neal Lane, Director, National Science Foundation* |
| 9:15-10:15 | Through the Kaleidoscope: Evolving Activities in Knowledge and Distributed Intelligence at the NSF |
| | Chair: *Luther Williams, National Science Foundation* |
| | Discussants: *Bennett Bertenthal, Mary Clutter, Juris Hartmanis, and Elbert Marsh, all from the National Science Foundation* |
| | Moderated NSF panel discussion and reaction from foundation participants |
| 10:15-10:30 | Break |
| 10:30-11:45 | Emerging Projects and Ideas Under Consideration<br>Chair: *Mary Clutter, National Science Foundation* |
| | Projects Recently Underway<br>Discussants: *Y. T. Chien, Stephen Griffin, Donald Lewis, Gary Strong, all from the National Science Foundation* |

| | |
|---|---|
| | Prospective Projects and Areas for Exploration<br>Discussants: *Alan Gaines, Toni Kazic, Nora Sabelli, all from the National Science Foundation; and Thomas Kalil, National Economic Council, Executive Office of the President*<br><br>Brief presentation of specific directions and kinds of projects underway and contemplated for fiscal years 98-99. These highlights will provide a basis for discussing levels of interest and kinds of opportunities for interaction among private foundations. |
| 11:45-12:30 p.m. | Practical Perspectives on Collaboration<br>*Stephen Griffin, National Science Foundation; Daniel Atkins, University ofMichigan; Alexa McCray, National Library of Medicine*<br>Panel discussion of actual experiences and concrete process examples. |
| 12:30-1:30 | Lunch |
| 1:30-3:00 | Private Foundations: Current Activities and Future Directions<br>Chair: *Lloyd Morrisett, Markle Foundation*<br>Discussants: All Participants from Foundations<br>*Zoe Baird, Markle Foundation*<br>*Andrew Blau, Benton Foundation*<br>*Sam Gustman, Shoah Visual History Foundation*<br>*James Hung, Rockefeller Foundation*<br>*Linda Jacobs, Charles Culpeper Foundation*<br>*Gail McClure, W. K. Kellogg Foundation*<br>*Kathleen McDonnell, Getty Information Institute*<br>*Mario Morino, Morino Institute*<br>*Anne Petersen, W. K. Kellogg Foundation*<br>*Caleb Schutz, MCI Foundation*<br>*Joan Shigekawa, Rockefeller Foundation*<br>*Diane Strahan, MCI Foundation*<br>*Mary-Anne Waikart, Morino Institute*<br>*Judy Whang, Robert Wood Johnson Foundation*<br>*Robin Willner, IBM Philanthropy*<br><br>A moderated discussion led by foundation participants on the types of foundation programs, program rationales, and foundation trends and plans. This discussion will explore the substance of work supported by private foundations and possible areas of intersection with knowledge and distributed intelligence. It will examine the spectrum of emphases, from elements of information technology, per se, to domains such as education or health care in which information technology may be used. |
| 3:00-3:15 | Break |
| 3:15-4:30 | Private Foundations: Work Processes<br>Chair: *Anne Petersen, W.K. Kellogg Foundation*<br>Discussants: *All Participants from Foundations (see above)*<br><br>A moderated discussion led by foundation participants comparing and contrasting how foundations accomplish their work and how they assess success and failure. It will examine elements of foundation decision-making, the nature and role of key constituencies, and orientations to research, demonstration, or implementation. |

| | |
|---|---|
| 4:30-5:15 | Practical Perspectives from Researchers<br>*Bruce Schatz, University of Illinois at Urbana-Champaign and*<br>*Christine Borgman, University of California at Los Angeles*<br><br>Panel discussion of actual experiences of researchers benefiting from both NSF and privatefoundation support in areas relating to knowledge and distributed intelligence. |
| 5:15-6:00 | Reception, **Rotunda** |
| 6:00-8:00 | Dinner, **Members' Room** |

**Friday, September 26, 1997, Lecture Room**

| | |
|---|---|
| 7:45-8:30 a.m. | Continental Breakfast |
| 8:30-8:45 | Goal Setting and Mechanism Development<br>Chair: *David Clark, Computer Science and Telecommunications Board Chair and Colloquium Chair*<br><br>A series of round-table discussions among NSF and private foundation participants. |
| 8:45-10:00 | Targets of Opportunity: Areas for Collaboration<br>Chair: *Juris Hartmanis, National Science Foundation*<br><br>A moderated discussion to identify the most promising topics for continued communication and collaboration among NSF and private foundations. |
| 10:00-10:15 | Break |
| 10:15-11:30 | Mechanisms Needed for Collaboration<br>Chair: *Bennett Bertenthal, National Science Foundation*<br><br>A moderated discussion of the range of steps that can be taken to build on the leadership colloquium: what kind of further interaction is possible, and how can it be achieved? Whether the goal is simple communication or joint program development, what can be achieved most easily and how, what options might require more planning and effort, and what are possible obstacles to interactions of different kinds? |
| 11:30-12:30 p.m. | Articulation of Summary Points and Action Items<br>Chair: *David Clark, Computer Science and Telecommunications Board Chair and Colloquium Chair* |
| 12:30-1:30 | Lunch |
| 1:30-2:30 | Working Groups to Develop Points for Next Steps and Summary Writeup<br><br>Breakout sessions will be formed based on the morning's discussions and interest to explore specific options for continuing the interaction. |
| 2:30-3:00 | Concluding Remarks<br>Chair: *David Clark, Computer Science and Telecommunications Board Chair and Colloquium Chair* |
| 3:00 | Adjourn |

## List of Participants

Daniel Atkins
University of Michigan

William Bainbridge
National Science Foundation

Zoe Baird
John and Mary R. Markle Foundation

Bennett Bertenthal
National Science Foundation

Andrew Blau
Benton Foundation

Christine Borgman
University of California at Los Angeles

John Cherniavsky
National Science Foundation

Y.T. Chien
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Melvyn Ciment
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David D. Clark
Computer Science and
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Chris Dede
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Robert Eisenstein
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Alan M. Gaines
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Stephen Griffin
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Sam Gustman
Shoah Visual History Foundation

Edward Hackett
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Juris Hartmanis
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Neal Lane
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George Lea
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John Lehmann
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Donald Lewis
National Science Foundation

Elbert Marsh
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Michael McCloskey
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Gail McClure
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Alexa McCray
National Library of Medicine

Kathleen McDonnell
Getty Information Institute

Mario Morino
Morino Institute

Lloyd Morrisett
John and Mary R. Markle Foundation

Anne Petersen
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George Strawn
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Gary Strong
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Judith Sunley
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Mary-Anne Waikart
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Thomas Weber
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Judy Whang
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Maria Zemankova
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Mark Balkovich, Research Associate
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Laura Ost, CSTB Consultant

# APPENDIX B

## AGENDA AND LIST OF PARTICIPANTS
## DECEMBER 12, 1997 MEETING

**LEADERSHIP COLLOQUIUM**

**ADVANCING THE PUBLIC INTEREST THROUGH KNOWLEDGE AND DISTRIBUTED INTELLIGENCE**

**National Academy of Sciences Building**
**2101 Constitution Avenue, N.W., Room 180**
**Washington, DC  20418**

***Friday, December 12, 1997***
***<u>Agenda</u>***

8:45-9:30 am *Continental Breakfast*

9:30-9:45 *Welcome and Agenda Overview*
Chair: David D. Clark, Computer Science and Telecommunications Board

9:45-10:45 *What is KDI and Why Should Private Foundations Care About It*?
Chair: David D. Clark, Computer Science and Telecommunications Board

The September meeting was an exploration of the concepts and structure of Knowledge and Distributed Intelligence (KDI), a major activity that is currently evolving at the National Science Foundation (NSF), and a discussion of how components of KDI might assist private foundations in their programmatic activities. Private foundations and the NSF possess different but complementary strengths and a number of common interests, which were articulated, and led to a preliminary discussion of how cooperative efforts might be mutually beneficial.

A draft summary was written based upon September's deliberations and we use that as a baseline for today's discussions. Comments from all participants will be solicited as a means to validate and build upon the draft summary. The final summary will be the product of the deliberations of the September and December meetings. Several participants from the September meeting will be asked to begin this session.

10:45-11:00 *Break*

11:00-12:30 pm *Mechanisms for Cooperation Between Private Foundations and the National Science Foundation*
Chair: Joan Shigekawa, Rockefeller Foundation
A moderated discussion about the mechanisms for cooperation–fromcommunication to coordination and partnerships/collaboration–that would further the work of private foundations and the NSF within the context of KDI. How affinity groups work and how they could facilitate communication among private foundations and the NSF? What kinds of public information could be shared that would assist private foundations and the NSF in their work? If such information is not readily shared,

why not? What kinds of proprietary information, such as from corporate databases or research services, could be shared? How might this be accomplished? What resources (e.g., Council on Foundations) already exist to facilitate cooperative efforts? What processes should be established?

See section 5 of the draft summary for additional details.

| | |
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| 12:30-1:30 | *Lunch* (in the meeting room) |
| 1:30-3:00 | *Content Areas for Communication, Coordination, or Collaboration*<br>Chair: Andrew Blau, Benton Foundation |

This session is a moderated discussion about the types of private foundation programs and activities that are the best candidates for cooperative effort with the NSF under the general rubric of KDI.

In the September meeting, a number of specific content areas were identified as possible areas for cooperation including community knowledge bases, health care information, learning technologies, universal access, the Internet as a public space, and digital art (refer to section 6 of the draft summary for the complete list with particulars). Do you have cooperative efforts in any of these areas? Which of these areas do you see as the best opportunities for cooperation? Which topics should be added to the list?

Which topics are likely to produce the biggest payoff as collaborations? Which topics are candidates to produce revolutionary gains as opposed to gains as a result of "more and better?"

| | |
|---|---|
| 3:00-3:15 | *Break* |
| 3:15-4:15 | *How Do We Proceed? Designing a 1998 Workshop*<br>Chair: David D. Clark, Computer Science and Telecommunications Board |

The Computer Science and Telecommunications Board is planning to convene a workshop in early 1998 to explore some of these issues in greater depth. Which issues deserve in-depth consideration? Who (people or organizations) should be invited as speakers or discussants? As participants?

Articulate and agree on other specific actions to be pursued.
Concluding remarks.

## List of Participants

Stephanie Barish
Shoah Visual History Foundation

Bennett Bertenthal
National Science Foundation

Andrew Blau
Benton Foundation

Lawrence E. Brandt
National Science Foundation

David D. Clark
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Deborah L. Crawford
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William Duggan
Ford Foundation

Richard Ekman
Andrew W. Mellon Foundation

Alan M. Gaines
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Les Gasser
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Stephen Griffin
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Kevin Guthrie
JSTOR

Christopher Harris
Council on Foundations

James Hung
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Deanna Marcum
Council Library & Information Resources

Gail McClure (via telephone)
W. K. Kellogg Foundation

Alan Paller
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Richard Quandt
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# APPENDIX C

## NATIONAL SCIENCE FOUNDATION RESEARCH ACTIVITIES RELATED TO KNOWLEDGE AND DISTRIBUTED INTELLIGENCE

The purpose of research on knowledge and distributed intelligence (KDI) is to revolutionize the understanding of complex systems, both natural and artificial, by developing improved theoretical, computational, and technical means to model these systems and analyze, predict, and influence their behaviors. The National Science Foundation (NSF) aims to enable, across the scientific and engineering communities, the next generation of human capabilities to:

- generate or gather, model, and represent more complex and cross-disciplinary scientific or engineering data from new sources and at enormously varying scales;
- transform this information into knowledge by combining, classifying, and analyzing it in new ways;
- deepen understanding of cognitive, ethical, educational, legal, and social implications of new types of interactivity; and
- collaborate in groups and organizations, sharing this knowledge and working together interactively across space, time, disciplines, and scientific cultures.

The payoffs of KDI research are expected to include increased scientific and engineering productivity and depth; improved timeliness and quality of results; and enhancements in the performance of complex systems, science and engineering education, and capabilities to communicate and transfer technological innovations to society. The application of KDI research in various institutional domains (as represented by private foundations) is expected to yield large paybacks in improving societal welfare, although these benefits and the mechanisms for achieving them are not well articulated (and indeed, is an important reason for these proceedings).

The core KDI research effort encompasses research in knowledge networking, learning and intelligent systems, and new challenges in computation. Activities in specific technological or content domains in concert with other federal agencies and private sector organizations include Universal Access, Digital Library Initiative, Next Generation Internet, Integrated Spatial Information Systems, Functional Genomics, and Digital Government.

### Knowledge Networking

The growth in computing power, digital storage capacity, and communications capabilities is creating an opportunity to develop a "knowledge network" for collaboration across time and space, sophisticated data searching, and the distillation and creation of new knowledge. The KDI program in knowledge networking focuses on the integration of knowledge from different sources and domains across time and space. The intent is to move beyond connectivity to achieve new levels of interactivity, increasing the semantic bandwidth, knowledge bandwidth, activity bandwidth, and cultural bandwidth among people, organizations, and communities.

The overarching goal is to improve the understanding of, and ability to manage, increasingly large and complex natural, social, and material phenomena. Objectives include the design of new types of tools for gathering and analyzing data, construction of the next generation of representations (e.g., methods for visualizing scientific and mathematical notations), and extension of the human infrastructure that underlies knowledge networking. Expansion of the knowledge networking community will require the mastery of a common language and a generally accepted set of theories and conceptual models, adoption of communally defined processes of collecting and analyzing data, development of proficiency in design and reasoning, and acceptance of a common set of values.

Knowledge networks could be valuable in research and education and also help meet larger societal goals. For example, such networks could enable the effective management of natural disasters or the monitoring and restoration of natural environments damaged by human activities.

## Learning and Intelligent Systems

The goal of the Learning and Intelligent Systems (LIS) program is to stimulate research that will advance understanding of intelligence in both natural and artificial systems, and how that intelligence can be harnessed and used in creative ways. Systems of interest include the brain, computer networks, and adaptive sensors. The program emphasizes the integration of theory with experiments that ground, test, and advance basic understanding of learning and intelligent behavior.

There are two rationales for the LIS program. First, the growing convergence of concepts, models, and technologies used in many disciplines highlights issues related to the development of information technologies and their application to learning and intelligent systems. Second, as understanding of learning, intelligent systems, and information technologies grows, the need to integrate the knowledge generated and apply it within a broad social context is growing even faster.

Information processing, which involves the passive input and retrieval of information, is different from true learning, which is an adaptive and dynamic process of information selection and processing based on both prior knowledge and the current situation. For example, IBM Corporation's Deep Blue may be a chess champion, but the computer is still a very fast and complex information processor that was expertly programmed, as opposed to a system that learns. A system that learns can intelligently adapt to its physical, intellectual, and social environment.

The LIS program supports three types of projects: basic research, learning technologies research and development (R&D), and human capacity building. Research topics include neurophysiological, computational, and educational studies of sequence learning and cognitive planning; developmental motor control in real and artificial systems; and the learning of minimal representations for visual navigation and recognition. The program also supports three R&D centers. The center for innovative learning technologies provides mentoring for post-doctoral research on learning, in an effort to produce the next generation of education faculty members who understand science and can work on multidisciplinary projects. The center for the study of tutoring concentrates on the use of artificial intelligence in tutors. This center provides practitioners with the latest resources and information on new theoretical and pedagogical concepts. The third center focuses on learning technologies used in Chicago and Detroit schools.

## New Challenges in Computation

The KDI program on New Challenges in Computation (NCC) focuses on the challenges and opportunities associated with generating representative data (e.g., through data reduction algorithms) from simulations and observations, and developing tools and algorithms to promote the use of that data to enhance decision making and innovation in science and engineering. The program includes research that might be described as the leading edge of computational science but it encompasses a much broader scope, scale, and multidimensionality. The program is designed to help address the most challenging scientific and engineering problems, which are computationally intensive, data intensive, and require difficult representations.

The program involves the development of methods and tools to model, simulate, display, and understand complex systems and complicated phenomena, and to manipulate large volumes of distributed data in real time. The aim is to design models that can handle various orders of scales within the same simulation, visualization tools that display and enable manipulation in real time, algorithms that allow distributed collaboration among disparate communication, and software that enables real-time interaction and control. For fiscal year 1998, NCC will emphasize scientific and engineering problems involving interactions between pheonomena at different scales or structures, and problems requiring a dynamic interplay between computations and data.

## Universal Access

The NSF's Universal Access activity is intended to dramatically improve access to information for all citizens, as envisioned by the nation's leaders and scientific communities. The 5-year program will combine the interests of several NSF directorates and encompass research, education, and infrastructure components. Other federal agencies, such as the Departments of Education and Veterans Affairs, are expected to participate.

The multifaceted program will explore technology designs that improve access for the disabled, illiterate, and, ultimately, all users. To lower barriers to human interactions with colleagues and machines, multimodal technologies will be developed that respond to speech, text, expression, gestures, or different languages or that mediate retrieval of, or dialogue with, stored information. In addition, new approaches for representing, storing, and transmitting information will be designed that are independent of display types and modalities. This work will require new theories of information measurement and expression as well as research on human perception and cognition. The objective is to enable all citizens to access knowledge regardless of their ability or technology and independent of place and time.

Interdisciplinary research topics will include principles of technology design for universal use; scientific principles of human communication through voice, expression, gesture, or other modes; and protocols for modality and bandwidth recognition. New Internet tools, database designs, and other infrastructure elements will be constructed to validate algorithms and approaches and integrate research, education, and training to achieve universal access. The education component of the initiative will include efforts to ensure that classroom software is accessible to students with learning disabilities.

## Digital Libraries Initiative

Digital libraries research seeks to improve the accessibility, availability, usability and preservation of electronic information. The first phase of the Digital Libraries Initiative (DLI) is supported by the NSF, Defense Advanced Research Projects Agency (DARPA), and National Aeronautics and Space Administration (NASA). The four-year initiative, which ends in 1998, comprises six university-led projects, managed via cooperative agreements (not grants), each of which includes fundamental research, a large test bed, and partners who share the costs on an approximately 1:1 basis with the participating federal agencies. The dozens of other participants include computer and communications companies, publishers and other content providers, professional societies, primary and secondary schools, and private foundations. Research areas include search and retrieval of digital video segments, software agents and new cross-disciplinary capabilities, interoperability and access issues, geospatial information systems, intelligent searching and retrieval, and multimedia information management.

The second phase of the DLI, which was formally announced in early 1998, is sponsored by the NSF, DARPA, National Library of Medicine, the Library of Congress, NASA, and the National

Endowment for the Humanities; in cooperation with the National Archives and Records Administration and the Smithsonian Institution. The goal is to increase both electronic and intellectual access to digital collections. This phase will extend into new research areas and feature an increased emphasis on interoperability, technology integration, and collection development and management. Operational digital libraries will be tested that provide collections of value to various communities of users, including all levels of education. The study of interactions between humans and digital libraries in various social and organizational contexts will also be emphasized.

**Next Generation Internet**

The Next Generation Internet (NGI) initiative fosters partnerships involving government, industry, and academia aimed at sustaining U.S. leadership in computing and communications. The Internet, which began as a government-funded research network, is a significant driving force for communications and economic growth. It has been doubling in size every year since 1988, and Internet traffic has been growing at an annual rate of 400 percent in recent years. New industries have been created, and both the public and private sectors have become dependent on the Internet. However, the limitations of current capabilities are becoming increasingly evident amid growing demand for high-bandwidth access, multimedia applications, and real-time response.

The Clinton Administration has committed $100 million per year for three years to the NGI initiative, which will design and develop new technologies and architectures for powerful, versatile networks and stimulate the introduction of new multimedia services. The three goals are to (1) promote experimentation with the next generation of networking technologies, (2) develop a next-generation test bed to connect universities and federal research institutions at rates that demonstrate new networking technologies and that support future research, and (3) demonstrate new applications that meet important national goals and missions. The federal agencies involved include the NSF, DARPA, Department of Energy, National Institute of Standards and Technology, National Aeronautics and Space Administration, and National Library of Medicine.

Specific objectives include the interconnection of at least 100 sites (federal research institutions, universities, and others) at speeds 100 times faster than those of today's Internet, or 100 millions bits per second, and the interconnection of approximately 10 sites at speeds 1,000 times faster than those of today's Internet, or 1 billion bits per second. This network fabric will provide a proof-of-concept test bed for the hardware, software, protocols, security, and network management required in the commercial NGI.

**Integrated Spatial Information Systems**

An explosion of geospatial data location-related information used in the physical, chemical, biological, geological, social, and economic sciences is being generated by new technologies such as satellites and airborne sensors, accelerated environmental research, and advances in computation and communications. The integration of these data could greatly enhance scientific understanding, but progress in this area is currently impeded by barriers to the interoperability of existing data sets and processing systems.

The goal of Integrated Spatial Information Systems (ISIS) is to achieve full, functional interoperability of diverse geospatial data systems, enabling access to distributed, heterogeneous resources from any type of platform. As envisioned, the next-generation geospatial information system will provide capabilities to visualize, analyze, and model dynamic, three-dimensional spatial data and integrate non-numerical spatial information. This system will enable information sharing as well as full integration of diverse data sets to achieve new scientific and practical capabilities. For example, real-time observations could be incorporated into models of environmental phenomena to derive predictive capabilities, or critical demographic and economic data could be delivered in real time to disaster response teams.

The ISIS goal is shared by several existing organizations involving federal agencies, the private sector, and academia. Among those involved is the interagency Federal Geographic Data Committee, which is developing the national spatial data infrastructure encompassing standards for data documentation, collection, and exchange. The NSF is a member of the FGDC and also internally supports a broad spectrum of research and infrastructure that generates, uses, and disseminates geospatial data and environmental information. The NSF envisions developing a partnership with the other organizations devoted to ISIS activities.

### Functional Genomics

An emerging area of interest is the explosion of genome sequence information that has become accessible because of advances in genome sequencing technology—high throughput, chip-based automated assay systems. A number of microbial genomes including the yeast genome have already been completed and published. In principle, the genome of an organism contains all the information necessary to understand its development and function. But having the DNA of an organism in a database is not enough to tell us how the organism develops and functions. Where do we go from there? How are sequence patterns related to functional patterns? These are the questions within the domain of functional genomics.

The explosion of data offers unprecedented opportunity to understand living systems, but to make full use of this information—to mine the data effectively, and to make it accessible for collaborative research across time and space—requires sophisticated computation and communication tools. Linking specific genes to specific traits and constellations of traits that can be linked to specific consequences at higher levels of biological organization are the kinds of questions to be pursued in functional genomics.

### Digital Government

Digital Government harnesses computer and information science and technology to improve the efficiency of Federal government operations and create opportunities for new services, enhanced productivity, and greater citizen awareness of and involvement in government. The growth of networked information systems throughout society makes it essential for the Federal Government to utilize advanced information technology-based services to interact with the public. The focus of the Digital Government Program is to fund research in computer and information sciences that can be applied to the needs of the Federal information services community.

Federal agencies are in the midst of transitioning their information services from legacy systems, through Internet applications, toward more advanced multi-dimensional and integrated systems. The Digital Government Program will support projects that demonstrate how research in computing and information sciences contribute to meeting the challenging and unique requirements of federal agencies for advanced information technologies. The goal is to enhance connections between academic and industrial researchers and Federal information service providers, and undertake pilot projects to demonstrate capabilities for Federal agencies. Workshops in cross-cutting areas also are being conducted to help develop the scope of the Digital Government Program.

# APPENDIX D

## NSF PROPOSAL SOLICITATION
## KNOWLEDGE AND DISTRIBUTED INTELLIGENCE

The recent growth in computer power and connectivity has changed the face of science and engineering. The future promises continued acceleration of these changes. The challenge today is to build upon the fruits of this revolution.

This rise in power, connectivity, content, and flexibility is so fundamental that it is dramatically reshaping relationships among people and organizations, and quickly transforming our processes of discovery, learning, exploration, cooperation, and communication. It permits us to study vastly more complex systems than was hither to possible and provides a foundation for rapid advances in understanding of learning and intelligent behavior in living and engineered systems. Today's challenge is to realize the full potential of these new resources and institutional transformations.

Knowledge and Distributed Intelligence (KDI) is a Foundation-wide effort designed to catalyze this next step.

## Aims of KDI Activity

The National Science Foundation (NSF) aims to achieve, across the scientific and engineering communities, the next generation of human capability to generate, gather, model, and represent more complex and cross-disciplinary scientific data from new sources and at enormously varying scales; to transform this information into knowledge by combining, classifying, and analyzing it in new ways; to deepen our understanding of the cognitive, ethical, educational, legal, and social implications of new types of interactivity; and to collaborate in sharing this knowledge and working together interactively.

**The anticipated payoffs of KDI research include:**

- Deep, far-reaching scientific discovery
- Increases in scientific productivity, and in the timeliness and quality of the results
- Increased ability to handle problems of greater complexity, scale, and structure
- The creation of new scientific and engineering communities to exploit novel discoveries Enhancements in science and engineering education through development of richer learning tools, technologies, and environments, and more universal access to richer resources and tools
- Enhanced understanding of the processes and results of learning and applications thereof
- A more complete understanding of the fundamental processes of distributed intelligence in natural and artificial systems and their application
- An understanding of the legal, ethical, and societal implications of the increased capability to gather and access information
- Enhanced ability to communicate and transfer new understanding and technological innovations to society
- Advances in statistical data reduction, data visualization, data mining, and data organization for retrieval so as to utilize vast stores of data
- Improved methods for expressing, computing with, and evaluating different types of uncertainties in real-world data

### Three Foci of KDI

To achieve the aims of KDI, proposals are solicited from individuals or groups for research that is inherently multidisciplinary* or that, while lying within a single discipline, has clear impact on at least one other discipline.

In FY 1998, KDI will have three foci: Knowledge Networking (KN); Learning and Intelligent Systems (LIS); and New Computational Challenges (NCC). This document describes the three KDI foci, and serves as a solicitation for proposals in all three areas. We anticipate that research on many important problems will span the foci of KN, LIS, and NCC, and proposals that do so are most welcome.

KN will focus on attaining new levels of knowledge integration, information flow, and interactivity among people, organizations, and communities.

LIS will emphasize research that advances basic understanding of learning and intelligence in natural and artificial systems and supports the development of tools and environments to test and apply this understanding in real situations.

NCC will emphasize new computational approaches to frontier science and engineering problems as well as problems involving data intensive computations and simulations.

More detailed information about the three foci and their particular emphases for FY 1998 follows.

- Knowledge Networking (KN)
- Learning and Intelligent Systems (LIS)
- New Computational Challenges (NCC)

* *Throughout we will use "multidisciplinary" to include "interdisciplinary" and "cross-disciplinary."*

## KNOWLEDGE NETWORKING

### Introduction

Knowledge Networking research aims to build the scientific bases for attaining new levels of interactivity and flow of information and knowledge among people, organizations, and communities. Thus, it will enable scientists, engineers, and other members of society to act in concert to address ever more complex scientific and societal problems.

The goals of Knowledge Networking (KN) are:

- To understand the fundamental processes through which knowledge is created, communicated, validated, and valued in distributed systems of information, both natural and engineered; and
- To improve the technical, social, educational, and economic performance of knowledge generation and use, collaborative computation, and remote interaction.

KN will support multidisciplinary research on developing and employing the next generation of communication networks, associated information repositories, collaborative technologies, and knowledge management techniques to gather, create, distribute, use, and evaluate knowledge in new and secure ways. This explicitly includes research on the human, behavioral, social, and ethical dimensions of knowledge networking.

The objectives of Knowledge Networking are:

- To enhance communication across disciplines, languages, and cultures;
- To improve the processing and integration of knowledge from different sources, domains, and non-text media types;
- To increase the effectiveness of teams, organizations, classrooms, or communities that work together across distances or over time; and
- To deepen understanding of the ethical, legal, and social implications of new developments in connectivity

Proposals should address one or more of these objectives.

### Research Emphases for FY 1998

In FY 1998, KN will emphasize three broad areas of knowledge networking: foundational research; prototype development and research; and ethical, social, and behavioral research. These areas are described more fully below. The examples given below are meant to be illustrative, not limiting.

### Foundational Research

The foundations for KN require basic research on organizing, distilling, securing, and collectively acting upon information through dynamic distributed processes; methods for building and linking complex data structures, computations, and knowledge processes; and tools for navigating, gathering, and displaying widely scattered and disparate information. These foundations focus on transforming information into knowledge and broadly disseminating that knowledge. The usage of these tools in transforming and disseminating scientific knowledge will depend critically on the participation of scientists and engineers working in the specific knowledge domains of their expertise and on the processes of scientific research in those domains.

### Processes and Dynamics of Distributed Intelligence

- Computational aspects of distributed intelligence: dynamic task allocation, interaction, coordination, process and organization representation, collective learning, consistency management, protocol, negotiation.
- Cognition by groups, teams, and organizations.
- Dynamics, adaptation and evolution of knowledge networks with particular attention paid to the utilization of domain specific knowledge and processes.
- Pathologies in large-scale distributed knowledge systems, such as malicious agents, viruses, overload, "knowledge storms."

### Managing Heterogeneity and Achieving Interoperability

Computational and organizational foundations for coupling models, knowledge, functionality, and human activities across scientific disciplines and within different branches of individual disciplines, including:

- Managing heterogeneity and interoperability in dimensions such as syntax, semantics, scale, and structure;
- Composition of distributed models and activity; and

- The use of discipline-specific scientific information and processes in the design of knowledge interoperability criteria within and between disciplines.

### Computational Infrastructure, Tools and Environments

- Secure and efficient network and communications infrastructures for interactivity, including approaches to resource-limited and real-time interactivity;
- Security, validation, authentication, and credibility of information;
- Large-scale remote data acquisition, distributed data analysis, experiment and sensor control, and simulation; especially interactive and real-time aspects; and
- Distributed knowledge: sharable ontologies, processes for distributed classification and taxonomy, collaborative knowledge construction, representation and filtering tools, digital libraries and repositories across disciplines and application domains, and translation of representations.

### Prototype Development and Research

KN requires basic research and the accumulation of experience in creating, using, and understanding the performance of domain-specific prototype knowledge networks.

- Constructing and using working prototypes of domain-specific, multidisciplinary knowledge networks and collaboratories. Of specific interest are prototypes and experiments that are compatible across networks and disciplines, accessible to outside communities, and inclusive of disaggregated or virtual teams and members of very different disciplines;
- Studies of the physical, behavioral, and organizational design of knowledge networks and electronic collaborative work environments, including organizational and decision-making processes and problems specific to individual scientific disciplines;
- Development of engineering tools and methods for designing, reproducing, and extending knowledge networks; and
- Empirical studies of knowledge networks as arenas for scientific experimentation, data gathering, analysis, and decision making.

### Ethical, Social and Behavioral Research on Knowledge Networks

Knowledge networks create new patterns of information flow, interaction, and organization that require basic research into their social, political, ethical, and economic characteristics. Normative and empirical research are needed to address complex problems raised by the new technologies envisioned under KN.

### Knowledge Dissemination and Sustainable Use of Knowledge Networks

- Cognitive and social processes of creating, developing, maintaining, and dismantling knowledge networks;
- Intellectual property, privacy, confidentiality and credibility of information and of participants in knowledge networks; and
- Adapting knowledge networks to human needs, preferences, and abilities, including cognitive, cultural, economic, and educational differences in the access, use, and benefit from knowledge networks.

### Social Integration and Impacts of Knowledge Networking

- New methodologies, metrics, and investigations of the scientific, technical, economic, and human performance capabilities and the social, organizational, and economic impacts of knowledge networks
- Ethical, social, political, legal, and economic processes that influence the creation, use, ownership, and governance of knowledge networks
- Creation, distribution, life course, and other characteristics of "knowledge capital"

## LEARNING & INTELLIGENT SYSTEMS

### Introduction

Efforts to understand the nature of learning and intelligence, and the realization of these capacities in the human mind, are among the most fundamental activities of science. The goal of LIS is to stimulate research that will advance and integrate concepts of learning and intelligence emerging from theoretical and experimental work in a variety of disciplines, including education, cognitive science, computer science, neuroscience, engineering, social science, and physical science. Accordingly, LIS encompasses studies of learning and intelligence in a wide range of systems, including (but not limited to) the nervous systems of humans or other animals; networks of computers performing complex computations; robotic devices that interact with their environments; social systems of human or non-human species; and, formal and informal learning situations. LIS also includes research that promotes the development and use of learning technologies across a broad range of fields. Development of new scientific knowledge on learning and intelligent systems, and its creative application to education and learning technologies, are integral parts of this solicitation.

There are two parallel and compelling reasons for focusing on the general area of learning and intelligent systems:

*First*, there has been a convergence of techniques and ideas addressing questions in cognitive science and behavior of intelligent systems. For example, there has been a growing use of neural networks, pattern recognition, visualization, simulation, nonlinear dynamical systems analysis, and probabilistic and statistical learning theory in these fields. As another example, researchers in many disciplines—including biochemistry, biophysics, neuroscience, and cognitive science—are studying how the nervous system changes as a result of experience, at levels ranging from individual synapses, to neural circuits, to brain systems subserving complex perceptual and cognitive functions. Although concepts and methods differ across levels of analysis, a growing integration across levels is creating fruitful theoretical frameworks and rich bodies of data for advancing our understanding of learning and intelligent systems.

*Second*, as our knowledge and understanding of learning, intelligent systems, and information technologies grows, so does the need to integrate and apply this understanding within a broad social context. Research on associated technologies and systems can and has enabled better understanding of learning and cognition and has led to better classroom practice. Integrating research with prototyping in these critical areas promises rapid advances in both theory and application.

For information regarding proposals funded by LIS in FY 1997 see
http://www.ehr.nsf.gov/lis/award97.htm

### Research Emphases for FY 1998

The research emphases for LIS in FY 1998 are essentially the same as in FY 1997. Specifically, LIS seeks projects that propose:

1. To identify, investigate, and model the ways natural and artificial systems operate in order to arrive at unifying principles that explain:

- How learning and intelligent behavior occur in humans, in other natural systems, and in artificial systems;
- The types of learning tasks and decision making that are best suited for each;
- The kinds of information and decisions each characteristically produces or creates; and
- The impact of interactions among alternative interactive learning environments, social contexts and experiences.

2. To enhance the ability of students and researchers to learn and to create by developing a comprehensive set of learning and research tools, methods and technologies that use biological, behavioral, cognitive, linguistic, social, and educational concepts with interactive, collaborative, and multisensory technologies, and are accessible to people with varied abilities, knowledge, and expectations

3. To further basic research designed to develop fundamental knowledge concerning the nature of learning and intelligence in natural or artificial systems, and to apply such knowledge in a variety of situations such as education, learning technologies, design of robotic devices and smart instrumentation, and networks of computer systems.

## NEW COMPUTATIONAL CHALLENGES

### Introduction

New Computational Challenges (NCC) focuses on research and tools to discover, model, simulate, display, and understand complex systems or complicated phenomena; to control resources or deal with massive volumes of data in real time, particularly distributed resources or data; to represent, predict, and design complex systems; and to understand their behaviors. NCC builds on the success, but broadens the scope, of prior NSF efforts such as the Grand Challenge initiatives.

CC aims to enable wide scientific collaboration and effective management of complex systems. This will require significant advances in hardware and software to handle multiple representations, scales, and structures; to enable distributed collaboration among disparate communities; and to facilitate real-time interactions and control.

Any phenomena are too complicated to understand in detail from simple observation or by reduction to isolated components and often require the coupling of disciplinary scientists and engineers and those involved in enabling methods and technologies in order to produce new ways to approach previously intractable problems. The very structure of the problem—its mathematical, logical, or computational form—may change as scale, level of resolution, or granularity changes. Many important problems require multiple data types, qualitative information, feedback during the computation to steer it, and a variety of numerical and symbolic computations. Advances in raw computing power have outpaced the effectiveness of existing tools and the degree to which they will scale to large numbers of distributed systems. The development of meaningful simulations that combine disparately structured models into new types of simulations is critical. While understanding complex phenomena is obviously important, predicting their behavior and potentially controlling or changing it, and doing so in real time, alter the fundamental nature of the problem and introduce enormous challenges across a broad spectrum of science and engineering research.

### Research Emphases for FY 1998

As noted in the introduction, many scientific and engineering problems are encompassed by new challenges in computation. For Fiscal Year 1998, NCC will emphasize only two of these:

- Scientific and engineering problems involving interactions between phenomena at different scales or structures; and
- Problems requiring a dynamic interplay between computations and data.

Proposals that address these two problems or that use them to motivate advances in enabling computational technologies are welcome. In subsequent years, the focus of NCC may be broadened to include other computational challenges in addition to the two chosen for emphasis in FY 1998.

### Problems of Scale and Structure

Problems involving multiple scales in space or time occur throughout engineering and science. Examples include inferring macroscopic properties of a material from its microstructure; turbulence, which plays a critical role in fluid flows as varied as mixing of fuel and air in combustion engines, airflow around an airplane, and blood flow in the heart; scaling of flow in porous media from the pore level to the field level, which has important applications to oil recovery and environmental issues; and fluid circulation in the oceans and the atmosphere. The brain, a dynamic, highly-connected, multi-level organization, involves both scale and structure. An overlapping set of complex computational problems are those concerning phenomena that arise from interactions among large numbers of relatively simple objects or elements. Examples include the complex perceptual and cognitive phenomena that arise from interactions among neurons in the brain; the behavior of the immune system in responding to antigens; social behaviors in animals ranging from insects to humans; human economic and social activities; and, the operation of distribution networks such as power grids and communication systems.

### Interplay Between Computations and Data

Better understanding of complex phenomena now requires a dynamic interplay between computations and data, often in real time. Most simulations are entirely initial-value in style: guess at a start, compute, see what happens, then change the guess. Simulations that could adapt to intermediate results or changing data would greatly reduce the number of iterations. In addition, some problems require this adaptive interplay for effective solution. These include command-control problems such as air traffic control, dispatch systems, radar and sonar identification, and other recognize-and-respond problems. Resource management and process control problems, especially with time constraints, are also of this kind.

Data-mining problems are of a different nature. Here the idea is to discover "unusual" items in a large dataset. Examples arise in seismology, high-energy physics, astronomy, credit card fraud, and management and protection of networked resources such as databases or computers.

Another kind of problem is combining different kinds of data. There are difficulties in validating data, assessing the effects of individual errors and their combinations, and in representing and visualizing data; practical methods for a multiplicity of large-scale datasets are needed.

Understanding of complex phenomena often depends on mapping different kinds of data against each other. Examples include tracking any time evolution or spatial evolution of phenomena against a spatial database (GIS, satellite and other map data), such as agricultural data, erosion and floods, epidemics, and other ecological/environmental phenomena; and mapping measurements of a behavior against measurements of physiological change, (e.g., speech or vision against brain activity).

The examples given in the preceding paragraphs are meant to be illustrative and not limiting.

## Proposal Submission

*Who May Submit*

Proposals submitted on behalf of individuals or groups in response to this solicitation will be accepted from colleges, universities, and other nonprofit research institutions in the United States. Multi-institutional arrangements are permitted and partnerships with industry are encouraged.

*How To Submit*

Letter of Intent

To help plan for the review process for KDI proposals, a short electronic message of intent to submit a proposal should be sent prior to April 1, 1998 to kdiletin@nsf.gov.The message (at most two pages, in unencoded ASCII text) should indicate as specifically as possible the subject and a short description of the anticipated research, the focus (or foci) you judge to be most closely related to the project (i.e., one or more of KN, LIS, and NCC), and a list of the probable participants and their institutional affiliations.

## Proposals

KDI proposals are required to be submitted electronically using the NSF FastLane system for electronic proposal submission and review, available through the World Wide Web on the FastLane Home Page . Instructions for preparing and submitting a standard NSF proposal via FastLane are located at http://www.fastlane.nsf.gov/a1/newstan.htm.

In order to use NSF FastLane to prepare and submit a proposal, you must use a browser that supports multiple buttons and file upload (e.g., Netscape 3.0 and above for Windows, UNIX, or Macintosh). In addition, Adobe Acrobat Reader is needed to view and print forms. Adobe Acrobat Exchange 2.0 or above, Adobe Acrobat Distiller 2.0 or above, or Adobe Acrobat 3.X (which includes Adobe Exchange and Adobe Distiller) is needed for creating PDF files.

To access the FastLane Proposal Preparation application, your institution needs to be a registered FastLane institution. A list of registered institutions and the FastLane registration form are located on the FastLane Home Page. To register an organization, authorized organizational representatives must complete the registration form. Once an organization is registered, PIN for individual staff are available from the organization's sponsored projects office.

For questions or problems concerning submitting a KDI proposal via FastLane, please contact a FastLane User Support person at electronic mail: flprop@nsf.gov or phone: (703) 306-1142 (If you reach the automated attendant, please dial extension 4686).

It is advisable to submit your proposal before the day of the deadline to avoid the possibility of encountering a queue.

The submission must follow GPG guidelines, with the following additions and exceptions to the guidelines:

On the cover page you must enter NSF 98-55 as the program solicitation number and you must enter KDI/KN, KDI/LIS, or KDI/NCC, as the NSF organization to consider this proposal. In case the proposal is at the intersection of several KDI foci, choose the primary one and indicate in the Project Description the overlap.

The following makes up the Project Description file to be uploaded to FastLane:

- Project Summary
- A project description of up to 15 single-spaced pages. The description should indicate the roles of the senior investigators on the project.
- For each PI or co-PI, up to 2 additional pages to describe results of prior NSF support focusing only on those results relevant to the proposed project.
- An additional section, up to 2 pages, that describes and justifies specifically a) the plans for dissemination of the results and b) the institutional commitment as to space and equipment.
- For projects with a three year budget exceeding $1.0 million (optional for projects with smaller budgets), an additional page describing realistic performance goals for each year.
- For projects involving more than one university department, or more than one organization, an additional 1-page description of the project management plan. Subcontracts may be used in multi-institutional proposals.

Full proposals must be received at NSF no later than 11.59.59 P.M. EST, May 8, 1998.

A hard copy of NSF Form 1207 (Cover Sheet) with original signatures must be received by 5:00 P.M. EST, May 22, 1998. The Cover Sheet should be sent to the following address:

**Proposal Number ______________**
**Solicitation No. NSF 98-55**
**NATIONAL SCIENCE FOUNDATION PPU**
**4201 WILSON BLVD.**
**ARLINGTON, VA 22230**

All proposals will undergo review by a panel or panels specially constituted for the KDI theme. Ad hoc mail reviews will be employed where additional disciplinary expertise is necessary.

**KDI Review Criteria**

All proposals are subject to the guidelines and review criteria described in the newly revised NSF Grant Proposal Guide (GPG), NSF 98-2.

For a description of NSF program activities, refer to: Guide to Programs, NSF 97-150. Single copies of these publications are available at no cost from the NSF Publications Clearinghouse (301) 947-2722, or via E-mail (Internet: pubs@nsf.gov), and they can be found on the NSF web site.

The new NSF general review criteria specified in GPG for proposals submitted to NSF after October 1st, 1997 are:

1. What is the intellectual merit of the proposed activity? and
2. What are the broader impacts of the proposed activity?

Under these broad criteria, for this solicitation, reviewers, to the extent they are qualified to make judgments, will consider the following questions:

**I. Intellectual Merit**

- To what extent does the proposed activity suggest and explore creative original concepts?
- What is the potential and general impact of the project on the science being addressed?
- Is there potential multidisciplinary synergism among the various research components? What is the potential multidisciplinary impact of the research?
- How well conceived and organized is the proposed activity?
- What is the potential of the project to make new advances, mobilize new human resources, or lead to fundamental changes in methodology?
- How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.)
- Is there sufficient access to resources needed for the project?
- In the case of group proposals, is there an effective management/leadership plan and what is the evidence that the team can work together?

**II. Broader Impacts**

- How well does the proposed activity advance discovery and understanding while promoting teaching, training, and learning? Is the training of students and researchers integrated into the project?
- How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?
- To what extent will the proposed activity enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships?
- Do the concepts and methodologies being developed have the long term potential for applicability to real world problems including research and development in education?
- How effective are the plans for dissemination of the results across several science and engineering disciplines, educational communities, and/or application groups?

## Award Information

Under this announcement, NSF solicits proposals for any funding amount up to $1.0 million per year for up to three years, and expects to make grants at a wide variety of award sizes and durations.

NSF expects to fund approximately 60 to 75 standard three year research awards under KDI, depending on the quality of submissions and the availability of funds. In exceptional cases, awards for up to five years may be considered if the justification and promise are compelling.

All awards will be made as grants subject to specified reporting procedures. Approximately $50 million will be available for KDI in FY 1998. A second KDI competition will be held in FY 1999, subject to availability of funds. An updated solicitation, which may include revised research emphases or adjustments to submission and review procedures, will be released in advance of this competition.

## Grant Administration

Awards made as a result of this announcement are administered in accordance with the terms and conditions of NSF GC-1, "Grant General Conditions," or FDP-III, "Federal Demonstration Partnership General Terms and Conditions," depending on the grantee organization. Copies of these documents are available at no cost from the NSF Publications Clearinghouse (301) 947-2722, or via e-mail pubs@nsf.gov (Internet).

More comprehensive information is contained in the NSF Grant Policy Manual (NSF 95-26, July 1995), for sale through:

**The Superintendent of Documents**
**Government Printing Office**
**Washington, DC 20404**.

The telephone number at GPO is (202) 783-3238 for subscription information.

## Reporting Requirements

Upon completion of the project, a Final Project Report (NSF Form 98A), including Part IV Summary, will be required. NSF will send the form with Part I information preprinted to the Principal Investigator (Project Director) approximately one month prior to the grant's expiration date. Applicants should review the sample form in the GPG prior to proposal submission so that appropriate tracking mechanisms are included in the proposal plan to ensure that complete information will be available at the conclusion of the project.

The Foundation provides awards for research in the sciences and engineering. The awardee is wholly responsible for the conduct of such research and preparation of the results for publication. The Foundation, therefore, does not assume responsibility for the research findings or their interpretation.

## Additional Information

The Foundation welcomes proposals from all qualified scientists and engineers and strongly encourages women, minorities, and persons with disabilities to compete fully in any of the research related programs and activities described here. In accordance with federal statutes, regulations, and NSF policies, no person on grounds of race, color, age, sex, national origin, or disability shall be excluded from participation in, be denied the benefits of, or be subject to discrimination under any program or activity receiving financial assistance from the National Science Foundation.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities (investigators and other staff, including student research assistants) to work on NSF projects. See the program announcement or contact the program coordinator at (703) 306-1636.

Privacy Act and Public Burden. The information requested on proposal forms is solicited under the authority of the National Science Foundation Act of 1950, as amended. It will be used in connection with the selection of qualified proposals and may be disclosed to qualified reviewers and staff assistants as part of the review process; to applicant institutions/grantees; to provide or obtain data regarding the application review process, award decisions, or the administration of awards; to government contractors, experts, volunteers, and researchers as necessary to complete assigned work; and to other government agencies in order to coordinate programs. See Systems of Records, NSF 50, Principal

Investigators/Proposal File and Associated Records, and NSF-51, 60 Federal Register 4449 (January 23, 1995). Reviewer/Proposal File and Associated Records, 59 Federal Register 8031 (February 17, 1994). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of your receiving an award.

Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to:

**Gail McHenry**
**Reports Clearance Officer**
**National Science Foundation**
**4201 Wilson Boulevard**
**Arlington, VA 22230.**

The National Science Foundation has TDD (Telephonic Device for the Deaf) capability, which enables individuals with hearing impairment to communicate with the Foundation about NSF programs, employment, or general information. To access NSF TDD, dial (703) 306-0090; for FIRS, 1-800-877-8339.

**Inquiries**

Questions of a general nature regarding KDI (submission, review and award processes, award sizes, general requirements, etc.) should be submitted via e- mail to kdi@nsf.gov.

Specific topical questions on one of the three KDI focus areas should be e- mailed to the respective address:

KN: kn@nsf.gov
LIS: lis@nsf.gov
NCC: ncc@nsf.gov

Additional detailed information on KDI in general, as well as KN, LIS, and NCC can be obtained from http://www.nsf.gov/kdi. In particular, lists of reports, studies, and workshop proceedings, as well as motivating scientific problems relevant to these foci can be accessed at this website.

# APPENDIX E

## PROFILE OF THE NATIONAL SCIENCE FOUNDATION

**The National Science Foundation**
**4201 Wilson Boulevard**
**Arlington, VA 22230**
**703-306-1234**
**http://www.nsf.gov**

### Creation and Mission

The National Science Foundation (NSF) is an independent agency of the U. S. Government, established by the National Science Foundation Act of 1950, as amended, and related legislation, 42 U.S.C. 1861 eq seq., and was given additional authority by the Science and Engineering Equal Opportunities Act (42 U.S.C. 1885), and Title I of the Education for Economic Security Act (20 U.S.C. 3911 to 3922). The Acts establish NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense."

The NSF comprises of the National Science Board of 24 part-time members and a Director, each appointed by the President with the advice and consent of the U. S. Senate. Other senior officials include a Deputy Director and the Assistant Directors of the NSF, who oversee the major disciplinary directorates-biological sciences; computer and information science and engineering; education and human resources; engineering; geosciences; mathematical and physical sciences; social, behavioral, and economic sciences.

### Goals and Strategy

The NSF's long-range goals, as stated in its strategic plan, reflect NSF's unique role in science and engineering research and education and to the Federal research portfolio, within the context of national research and education priorities:

- Enable the U. S. to uphold a position of world leadership in all aspects of science, mathematics and engineering. This goal grows from the conviction that a position of world leadership in science, mathematics, and engineering provides the Nation with the broadest range of options in determining the course of our economic future and our national security.
- Promote the discovery, integration, dissemination, and employment of new knowledge in service to society. This goal emphasizes the connection between world leadership in science and engineering on the one hand, and contributions in the national interest on the other. It provides the impetus for setting fundamental research priorities in areas that reflect national concerns.
- Achieve excellence in U. S. science, mathematics, engineering, and technology education at all levels. This goal is worthy in its own right, and also recognizes that the first two goals can be met only by providing educational excellence. It requires attention to needs at every level of schooling and access to science, mathematics, engineering, and technology educational opportunities for every member of society.

To move towards the achievement of these goals, the NSF has established core strategies that it is employing. These strategies reaffirm the Foundation's traditions, especially its reliance on merit review of investigator-initiated proposals, yet at the same time point to new directions for the Foundation:

- Develop intellectual capital:  Seek out and support excellent activities among groups and regions that traditionally have not participated as full stakeholders in science, mathematics, and engineering, including women, minorities, and individuals with disabilities.
- Strengthen the physical infrastructure:  Modernize existing facilities and instruments and plan for future needs, including taking full advantage of the capabilities of emerging information technologies.
- Integrate research and education:  Infuse education with the joy of discovery and an awareness of its connections to exploration through directed inquiry, careful observation, and analytic thinking for students at all levels.
- Promote partnerships:  Continue to collaborate with the academic community, industry, elementary and secondary schools, other Federal agencies, state and local governments, and comparable organizations worldwide.  NSF's approach to partnerships emphasizes shared investments, shared risks, and shared benefits.

### Interests in Information Technology

See Appendix C for a summary of the NSF's interests in information technology as related to KDI, which are extensive and broad-ranging.

### Organizational Structure of the National Science Foundation

Assistant directors of the NSF oversee each directorate, which are organized by major disciplinary areas.

Directorate for Biological Sciences
- Division of Biological Infrastructure
- Division of Molecular and Cellular Biosciences
- Division of Integrative Biology and Neuroscience
- Division of Environmental Biology

Directorate for Computer and Information Science and Engineering
- Division of Advanced Computational Infrastructure and Research
- Division of Advanced Networking Infrastructure and Research
- Division of Computer-Communications Research
- Division of Experimental and Integrative Activities
- Division of Information and Intelligent Systems

Directorate for Education and Human Resources
- Division of Education System Reform
- Division of Elementary, Secondary, and Informal Education
- Division of Graduate Education
- Division of Human Resource Development
- Division of Research, Evaluation, and Communication
- Division of Undergraduate Education

Directorate for Engineering
- Division of Bioengineering and Environmental Systems
- Division of Electrical and Communications Systems
- Division of Chemical and Transport Systems
- Division of Civil and Mechanical Systems
- Division of Engineering Education and Centers
- Division of Design, Manufacture, and Industrial Innovation

Directorate for Geosciences
- Division of Atmospheric Sciences
- Division of Earth Sciences
- Division of Ocean Sciences

Directorate for Mathematical and Physical Sciences
- Division of Physics
- Division of Astronomical Sciences
- Division of Mathematical Sciences
- Division of Materials Research
- Division of Chemistry

Directorate for Social, Behavioral, and Economic Sciences
- Division of Social, Behavioral and Economic Research
- Division of Science Resources Studies
- Division of International Programs

Office of Polar Programs

# APPENDIX F

## PRIVATE FOUNDATION PROFILES

In this summary, the term "private foundations" refers to a class of non-profit organizations that seek to fulfill missions in the public interest. Some of these missions are focused and well defined (e.g., by geography or professional area), whereas other missions may be very broad. Some foundations have modest financial resources and a handful of staff, whereas others have very large endowments and a large cadre of professional staff. Many foundations provide grants to others to fulfill their mission, but some foundations choose to direct the work themselves. In establishing the agenda to support their missions, private foundations operate in a complex environment and must balance the preferences of many stakeholders-their benefactors, board of directors, professional staff, grantees, community organizations, the ultimate recipients of program benefits, and the community of foundations generally. The following are brief profiles of the private foundations that participated in these proceedings:

**The Benton Foundation**
**1638 Eye Street NW**
**Washington, DC 20006**
**202-638-5770**
**http://www.benton.org**

***Mission and Values***: The Benton Foundation operates in three major areas: (1) strategic communications that strengthen the communications capacities of nonprofit organizations; (2) programs that use the children's arena as a laboratory to demonstrate new media techniques and explore communications opportunities; and (3) communications policy that involves and engages nonprofit organizations in shaping the future of communications systems. Core values include expansion of the access to communications channels, diversity of ideas, equity in the availability of information and communications resources, and education to support effective and strategic use of communications tools and techniques.

***Interests in Information Technology***: The foundation seeks to infuse the emerging communications environment with public-interest values. Projects involve the use of communications and information to enhance public life and promote positive social engagement and social change. Project ideas emerge from connections to the policy community, including the Federal Communications Commission and White House. For example, in one new program, public radio stations are working with community-based health organizations to increase public understanding of health issues and solutions. The foundation is also working with the National Endowment for the Arts to build technology infrastructure for the arts, such as points of public access to the Internet in arts institutions.

**The Charles E. Culpeper Foundation**
**695 East Main Street, 3rd Floor**
**Stamford, CT 06901**
**203-975-1240**
**http://www.culpeper.org**

***Mission and Values***: The Charles E. Culpeper Foundation funds projects in the domains of health research and education; undergraduate education in the liberal arts and sciences; mechanisms for access to, and participation in, arts and cultural activities; and criminal justice education programs. Health programs support basic biomedical research, health services research, the study of social and ethical issues in health and disease, and U.S. medical education. Arts and culture programs seek to provide access in an effort to build understanding and appreciation of art forms and cultural activities. Criminal justice programs focus on evaluating and improving education for professionals in the field and heightening public understanding of the justice system.

***Interests in Information Technology***: Some education projects involve the use of technology. For example, areas of emphasis include foreign language teaching and international programs, particularly those that have a cultural emphasis and make use of new technologies; and the use of technology in teaching and research across the curriculum.

**The Ford Foundation**
**320 East 43rd Street**
**New York, NY 10007**
**212-573-5000**
**http://www.fordfound.org**

***Mission and Values***: The Ford Foundation focusses its efforts on strengthening democratic values, reducing poverty and injustice, promoting international cooperation, and advancing human achievement. Ford encourages initiatives by those living and working closest to where problems are located; to promote collaboration among the nonprofit, government, and business sectors; and to assure participation by men and women from diverse communities and at all levels of society. Such initiatives help build common understanding, enhance excellence, enable people to improve their lives, and reinforce their commitment to society.

***Interests in Information Technology***: Information technology projects may reside in any of the Ford Foundation's areas of emphasis: asset building and community development; economic development; community and resource development; education, knowledge, and religion; media, arts, and culture; peace and social justice; and governance and civil society. Examples of information technology projects include the development of electronic networks in several Russian regions through the Vernadsky Center for Biosphere Studies and the Digital Partnerships Program, a two-year project aimed at enhancing the role of technology companies in community economic development.

**The Getty Information Institute**
**1200 Getty Center Drive, Suite 300**
**Los Angeles, CA  90045**
**310-440-6576**
**http://www.gii.getty.edu**

***Mission and Values***:  The Getty Information Institute bridges art and technology, working to ensure a strong presence for cultural information on emerging worldwide networks for the purposes of research, education, and community development.  Key areas of concern include intellectual property rights, communication exchange, and access among dispersed systems; the management of cultural heritage information as a strategic asset; and models for partnering with the private sector.

***Interests in Information Technology***:  Activities in advocacy and education include various efforts to digitize, preserve, and facilitate access to cultural heritage information.  For example, the institute represents the United States in an international effort to accelerate the digitization of cultural heritage information, interconnect existing and future cultural heritage databases, facilitate access by diverse audiences, and protect intellectual property rights.  The institute also helped develop a system for identifying art objects that can be shared over networks for the purposes of stemming traffic in stolen art. The institute also supports an electronic gateway demonstration project that links Los Angeles residents to their cultural heritage by enabling the creation and digitization of new cultural content; the interconnection of existing digital cultural resources; and the accessibility of these resources for research, exhibition, and education.

**IBM Corporation**
**New Orchard Road**
**Armonk, NY  10504-1787**
**914-499-5242**
**http://www.ibm.com/ibm/ibmGives/**

***Mission and Values:***  IBM's corporate community relations goal is to support the most effective education that will produce the highest level of achievement for all students  Reinventing Education, IBM's flagship  initiative in public education, supports fundamental restructuring and broad-based systemic change to improve student performance.  Key principles include high performance standards and accountability, the commitment to review and revise all standard operating procedures, technology as a tool for change, and a clear link between financing and accountability.

***Interests in Information Technology:***  Reinventing Education projects team IBM Research and IBM Global Services with school district partners to develop new applications of technology to promote high school achievement.  New technologies under development include interactive speech recognition tools for children in early literacy, advanced imaging technology for math and science in the middle grades, digital tools to support more-effective implementation of portfolio assessments, network applications for teacher training and home-school interactions, and data warehousing and data mining for school improvement planning.  IBM is also working with not-for-profit organizations to increase access to technology to address community issues.  In particular, IBM is working with 11 social service agencies in the field of work force development and job training.

**The Robert Wood Johnson Foundation**
**Post Office Box 2316**
**Princeton, NJ 08543-2316**
**609-452-8701**
**http://www.rwjf.org**

***Mission and Values***: The goal of The Robert Wood Johnson Foundation is to ensure that all Americans have access to basic health care at reasonable cost; to improve the means by which services are organized and provided to people with chronic health conditions; and to reduce the personal, social, and economic harm caused by substance abuse (i.e., tobacco, alcohol, and illicit drugs). The foundation supports demonstrations, training and fellowship programs, policy analysis, health services research, technical assistance, public education, and communications.

***Interests in Information Technology:*** The foundation supports health information systems as a tool for improving health care and the health status of Americans. The basic problem to be addressed is not technology development but rather infrastructure issues how to connect doctors to hospitals, and the need for standardization. Other important issues include the collection of health care data and privacy protection in an environment defined by managed care and the trend toward privatization of health information.

**JSTOR**
**188 Madison Avenue**
**New York, NY 10016**
**212-592-7345**
**http://www.jstor.org**

***Mission and Values*****:** JSTOR's initial objective is to apply advances in information technology to improve access to the archives of important scholarly journals while simultaneously ensuring their long-term preservation. By converting back issues of journals into electronic formats, JSTOR is building a reliable and comprehensive archive of important scholarly journal literature. JSTOR's operating philosophy is built on taking a system-wide perspective, balancing the needs of libraries, publishers, and scholars. The JSTOR database offers libraries of reducing their long-term expenditures for the storage and care of journal collections, while creating the opportunity of significantly expanded access to those materials through telecommunications networks. JSTOR also assists scholarly associations and publishers in making the transition to electronic modes of publication and plans to study the impact of providing electronic access on the use of scholarly journals. JSTOR, which began as a pilot project sponsored by The Andrew W. Mellon Foundation, became an independent not-for-profit organization in 1995.

***Interests in Information Technology*****:** JSTOR has developed a completely browsable, searchable, and retrievable system for gaining access to the backfiles of important scholarly journals over the World Wide Web using standard browser software. Journal pages are scanned at very high resolution to create a full collection of page images. Optical character recognition software is used to build a text file, which is used to update index files to facilitate searches. JSTOR keeps abreast of the continuing evolution of software and database technology and incorporates new technology as appropriate.

**The W.K. Kellogg Foundation**
**One Michigan Avenue East**
**Battle Creek, MI  49017-4058**
**616-969-2133**
**http://www.WKKF.org**

***Mission and Values:*** The W.K. Kellogg Foundation seeks to help people help themselves through the practical application of knowledge and resources to improve their quality of life and that of future generations. Focus areas include health care, food systems and rural development, education, and philanthropy and volunteerism. Values and principles include attention to the vulnerable in society; pursuit of diversity and inclusion as means of promoting creativity and innovation; recognition of community power and other assets; nurturing of individuals and families, pursuit of partnerships and collaboration as a basis for improving organizations and achieving social change; appropriate use of knowledge, science, and technology; and wise use of human and natural resources.

***Interests in Information Technology:*** Information systems and technology is a cross-cutting theme. The focus is on capacity building to close the gap between technology and those who lack the knowledge and ability to use it effectively in building communities. Funding is provided for leadership, information systems, efforts to capitalize on diversity, and community development programming. For example, social marketing techniques will be used to increase awareness and hasten the diffusion of information technology as a tool for improving the quality of life in communities. Recently, the Kellogg Foundation launched an initiative called Managing Information with Rural America, a five-year effort designed to help people in rural communities determine how technology can be used to address the growing concerns of rural populations on such matters as economic development, education, health, and leadership.

**The John D. And Catherine T. MacArthur Foundation**
**140 South Dearborn Street**
**Suite 1100**
**Chicago, IL  60603-5285**
**312-726-8000**
**http://www.macfdn.org**

***Mission and Values:*** The MacArthur Foundation is dedicated to helping groups and individuals foster lasting improvement in the human condition. The Foundation seeks the development of healthy individuals and effective communities; peace within and among nations; responsible choices about human reproduction; and a global ecosystem capable of supporting healthy human societies. The Foundation pursues this mission by supporting research, policy development, dissemination, education and training, and practice. Much of the work of the Foundation operates under two integrated programs: The Program on Human and Community Development, and the Program on Global Security and Sustainability. In addtion, the Foundation operates the MacArthur Fellows Program and a General Program.

***Interests in Information Technology:*** The support for communications activities is a routine aspect of all foundation programs. Support for communications is a welcome component of all proposals. The foundation is likewise receptive to proposals for work that will deepen understanding of the present and imminent impact of the digital revolution on society. The foundation is also interested in providing support to increase the communications capabilities of non-profit organizations. The MacArthur Foundation has a particular interest in promoting affordable, equitable access to digital technologies.

**The John and Mary R. Markle Foundation**
**75 Rockefeller Plaza, Suite 1800**
**New York, NY 10019**
**212-353-4285**
**http://www.markle.org**

***Mission and Values:*** The John and Mary R. Markle Foundation supports the development of communications technologies to encourage learning experiences outside of formal educational settings and promote democratic deliberation. Core values include lifelong learning, communications and education, and political participation. Efforts are concentrated in three areas: (1) use of media and technology to expand and improve citizen participation in the electoral process, especially presidential elections; (2) study and development of interactive communications technologies, including multimedia, electronic publishing, and computer networks, that enhance lifelong learning; and (3) development of telecommunications policy that responds to the challenges of new media and preserves the public interest.

***Interests in Information Technology***: Projects range from the design and demonstration of software for broad participation in policy forums to the development of an authoring tool for use in interactive storytelling. Recently, the foundation has focused on the potential social, political, and economic benefits of instituting low-cost, universal electronic mail in the United States. Related projects include an analysis of sociological factors affecting the use and impact of e-mail on the Internet, the development of a national dialog on universal e-mail, and a study of the extent to which e-mail can facilitate communication among government agencies and the publics they serve.

**The MCI Foundation**
**1200 South Hayes Street, 10th Floor**
**Arlington, VA 22202**
**703-415-6927**
**http://www.mci.com**

***Mission and Values:*** MCI's Corporate Community Partnerships, which encompasses The MCI Foundation, seeks to empower individuals and enhance communities through dynamic education and technology programs. Core values include education, teaching, and youth. MCI develops and provides access to standards-based Internet curriculum materials for grades K-12 in core academic disciplines, including science, economics, English, history, philosophy, and foreign languages. Resources include special World Wide Web sites, customized search engines, and teacher training materials.

***Interests in Information Technology:*** In an effort to enhance the learning process through technology, MCI provides schools with advanced end-to-end solutions, including Internet access, networking equipment, and personal computers. Other technology projects include the development of an interactive museum network and a multimedia tour of the Civil War; the use of distance learning techniques to disseminate the best science teaching practices; and a study of alternative points of Internet access, such as libraries and museums.

**The Andrew W. Mellon Foundation**
**140 East 62nd Street**
**New York, NY 10021**
**212-838-8400**
**http://www.mellon.org**

***Mission and Values:*** The purpose of The Andrew W. Mellon Foundation is to "aid and promote such religious, charitable, scientific, literary, and educational purposes as may be in the furtherance of the public welfare or tend to promote the well-doing or well-being of mankind." The foundation makes grants to institutions of higher education, cultural affairs, performing arts, population, conservation and the environment, and in public affairs.

***Interests in Information Technology:*** Since 1994 the foundation has run a Libraries, Technology, and Scholarly Communication program that supports "natural experiments" in the use of technology in a particular aspect of electronic publishing or library research. The goal is to compare differences in patterns of scholarly use and in the costs of electronic and traditional methods of conducting business. Some 30 projects in a variety of fields have been funded, and preliminary results are being reported at conferences and in forthcoming publications. In addition, the foundation has supported projects in Eastern Europe, Latin America, and South Africa on library automation and on the use of technology for preserving and accessing archival and other research materials. The foundation also supports a Cost-Effective Uses of Technology in Teaching program that supports demonstration projects, primarily at large universities, of multimedia courses that can reduce costs while maintaining or increasing educational quality. Among the other projects funded by the foundation werethe early stages of JSTOR (see above), a project on electronic monographs in area studies at the University of California Press, an electronic journals project at the MIT Press, and the Making of America project at Cornell University and the University of Michigan.

**The Morino Institute**
**1801 Robert Fulton Drive, Suite 550**
**Reston, VA 20191**
**703-620-8971**
**http://www.morino.org**

***Mission and Values:*** The Morino Institute helps communities understand and adapt to the potential rewards and threats of the communications revolution. Focus areas include education, health care, government, and economic opportunity. Strategic areas of investment include youth advocacy and services and "entrepreneurship of the new age" to benefit children and communities. Efforts in social networking and community services are designed to promote awareness of, and education about, the new communications media.

***Interests in Information Technology:*** The institute is a charter sponsor of a "netpreneur" program, which provides a physical and virtual support network for Internet entrepreneurs and their stakeholders in the Washington, D.C., area. Based on experiences with this program, the institute is developing models that can be applied to other communities, especially in the creation of new opportunities for youth. The institute also supports public access (community) networks.

**The Rockefeller Foundation**
**420 Fifth Avenue**
**New York, NY 10018-2702**
**212-852-8450**
**http://www.rockfound.org**

***Mission and Values:*** The Rockefeller Foundation seeks to identify and target the root causes of human suffering and need. The foundation is defining and pursuing a path toward environmentally sustainable development consistent with individual rights and equitable sharing of the world's resources. Program areas include the arts and humanities, equal opportunity and school reform, agricultural sciences, health sciences, population sciences, global environment, and African initiatives such as education for women. The foundation also supports activities in international security and international philanthropy.

***Interests in Information Technology:*** The foundation does not currently support a program in information technology but is interested in seeing the Internet become a global public space for discourse building democracy; using information technology as a resource for sustainable development; and building the U.S. infrastructure for electronic interactive art to help develop creative capital in music, visual arts, and other fields. Possible models for the arts infrastructure include new electronics arts laboratories in Germany, Austria, and Japan. In the United States, existing facilities are either private or university based and therefore are not open to the broader creative community. As part of its work in developing countries, the foundation is supporting the creation of an electronic library of the leading agricultural science journals for distribution in the developing world, initially on CD-ROM. The foundation also provides technical assistance in the use of CD-ROM and Internet information sources to its grantees in Eastern and Southern Africa.

**The Survivors of the Shoah Visual History Foundation**
**Post Office Box 3168**
**Los Angeles, CA 90078-3168**
**818-777-7802**
**http://www.vhf.org**

***Mission and Values:*** The Survivors of the Shoah Visual History Foundation is dedicated to videotaping and archiving interviews of Holocaust survivors around the world. The goal is to make the comprehensive collection of testimonies available for research, education, and public awareness, in particular for use in teaching racial, ethnic, and cultural tolerance in public schools throughout the nation. More than 41,000 testimonies (interviews of 1 to 5 hours each) have been collected in 30 languages in 47 countries; the foundation expects to have 50,000 interviews by the end of the first phase of the project. The collection is now being distributed to five repositories and eventually will be made available through secured networks to museums, educational institutions, and nonprofit organizations as well as in documentaries, books, and CD-ROMs. Eventually the foundation hopes to digitize and catalog records of other historical events. In comparison to institutions such as universities and libraries that have well-established roles and methods for helping society, the Shoah Foundation has a unique structure and mission and has not established conventional guidelines for sharing its wealth of accumulated knowledge. The foundation is deeply committed to developing ways of establishing its content, technology, and methodologies as a common, shared resource.

***Interests in Information Technology***. The foundation's activities depend on information technology, from the video cameras used to tape the interviews, to the digital technology used for cataloging and archiving, to the networks and interactive systems now in development. Many research, social, educational, and technology issues need to be address to attain the goal of affordable dissemination of the materials. Sophisticated analytical tools must be developed to make the Shoah Foundation's collection readily available for socially beneficial research, such as studying the recovery processes of child survivors of the Holocaust to assist the children of today's Yugoslavia.

# APPENDIX G

## SOURCES OF ADDITIONAL INFORMATION

*Affinity groups.* Several dozen affinity groups are affiliated with the Council on Foundations, ranging from the Funders Committee for Citizen Participation to Grantmakers in Health. Contact Council on Foundations for details. http://www.cof.org or (202) 466-6512.

Benton Foundation, Washington, D.C. Best practices toolkit-tools to help nonprofits make effective use of communications and information technologies:
http://www.benton.org/Practice/Toolkit/

Council on Foundations, Washington, D.C. Membership association of grantmaking foundations and corporations. Links to various resources. Publishes booklet that lists most private foundations. http://www.cof.org or (202) 466-6512.

*Data Mining and Knowledge Discovery: An International Journal.*
http://www.research.microsoft.com/datamine

Digital Government Program Announcement. http://www.nsf.gov/pubs/1998/nsf98121/nsf98121.htm

Digital Libraries Initiative home page. http://dli.grainger.uiuc.edu/national.htm

Digital Libraries Initiative - Phase 2 home page. http://www.nsf.gov/home/crssprgm/dli/start.htm

*Digital Libraries: Report of the Santa Fe Planning Workshop on Distributed Knowledge Work Environments*. http://www.si.umich.edu/SantaFe/

Federal Geographic Data Committee. Resource for database design. http://www.fgdc.gov

Foundation Center. Nonprofit information clearinghouse of foundation-related information.
http://www.fdncenter.org

Integrated Media Systems Center at the University of Southern California (supported by NSF, city, county, state, and the entertainment industry). http://imsc.usc.edu.

Knowledge and Distributed Intelligence home page and proposal submission. http://www.nsf.gov/kdi

KDI Brochure. NSF 98-60.

Lightworks Technology Foundation. See their "Digital Milk Carton" for missing children and other activities. http://www.lightworks.org.

National Coordination Office for Computing, Information, and Communications. Committee of the White House National Science and Technology Council. http://www.ccic.gov

*National Guide to Funding for Information Technology*. First Edition. Elizabeth H. Rich, Editor. The Foundation Center, 1997.

National Library of Medicine home page.  http://www.nlm.gov

National Science Foundation home page.  http://www.nsf.gov
Biological Sciences Directorate.  http://www.nsf.gov/bio/
Computer and Information Science and Engineering Directorate.
http://www.cise.nsf.gov/general/welcome.html
Education and Human Resources Directorate.  http://www.ehr.nsf.gov/division.htm
Engineering Directorate.  http://www.nsf.gov/home/eng/start.htm
Geosciences Directorate.  http://www.nsf.gov/home/geo/start.htm
Mathematics and Physical Sciences Directorate.  http://www.nsf.gov/mps/general.htm
Social and Behavioral Sciences Directorate.  http://www.nsf.gov/sbe/sbeovrvw.htm

National Science Foundation Custom News Service.  http://www.nsf.gov/home/cns

Next Generation Internet.  http://www.ngi.gov

Philanthropy Journal Online.  http://www.philanthropy-journal.org

Potomac KnowledgeWay Netpreneur Program.  Provides a support network to encourage netpreneurs and their stakeholders to communicate, partner, and exchange knowledge.  http://www.netpreneur.org

RaDiUS.  "Research and Development in the United States."  http://www.rand.org/radius

Web Accessibility Initiative at Massachusetts Institute of Technology, international program office headed by Judy Brewer. http://www.w3.org/WAI/

Southern Utah University Library Web.  Links to a number of private foundations and related non-profit associations.  http://www.li.suu.edu/library/grants/private.htm

University of Michigan Web site for the NSF data analysis demonstration project using the General Social Survey.  http://www.icpsr.umich.edu/gss/