Digital Libraries and Education
Working Meeting, January 4-6, 1999
National Science Foundation

Contents

Introduction

This meeting brought together leaders from selected Digital Library Initiative Phase I projects, from projects funded as planning testbeds and applications to undergraduate education under Digital Libraries Phase II, and others who have been working on projects related to digital libraries and education. The meeting began with dinner Monday evening January 11, 1999 and concluded at noon Wednesday, January 13.

During this critical start-up phase of designing digital libraries to meet the needs of education, the goal of this meeting was to identify key aspects that could be enhanced by collaboration among projects working in this area. The meeting was also expected to generate recommendations that will inform future efforts by clarifying the infrastructure elements and kinds of standards needed to ensure quality, access, usability, reliability, stability, and interoperability.

The meeting began Monday evening, January 4 with dinner and a keynote address by Thomas A. Kalil, Senior Director to the National Economic Council with responsibility for science and technology issues. The NEC is a White House organization created by President Clinton to coordinate economic policy. In addition to his role in shaping the Administration's National Information Infrastructure agenda, the speaker is also the U.S. National Coordinator for the G-7 Global Information Society pilot projects. He also served as an advisor to the Clinton-Gore campaign on technology and competitiveness issues, and helped organize the Little Rock Economic Summit. A summary of the slides from the keynote address are in Appendix A.

Tuesday morning following brief introductory and logistical remarks by NSF staff, Gary Marchionini, University of North Carolina at Chapel Hill, gave an overview of the state-of-the-art in digital libraries. Slides from this talk are in Appendix B. This talk provided the basis for one of the threads that permeated the meeting – clarifying the state-of-the-art with regard to an action agenda for the development of a national digital library for science, mathematics, engineering, and technology education.

The second and final plenary talk was given by Bill Arms of the Center for National Research Initiatives and the chairman of the July 1998 SMETE-Lib workshop. The report of that workshop is available electronically at http://www.dlib.org/smete/public/report.html. The slides from this talk are in Appendix C. This talk placed the current meeting in context and laid the basis for the subsequent sessions.

The main part of the meeting was devoted to a series of breakout sessions and plenary sessions organized around three broad topics.

Topics

1. Issues related to collections
   - Quality and evaluation
   - Reusability and usability – interoperability of objects
   - Metadata, cataloging, and controlled vocabulatries – interoperaibility of descriptions
   - Community and collaboration
   - Intellectual property

2. Issues related to "SMETE-Lib Central" the body that would be responsible for the overall coordination and maintenance of the library
   - Clarify essential federal government
   - Organization/Structure/Design of the central organization
   - Incentive structure that focuses on essential user needs and services
   - Business model that supports sustainability
   - Models to integrate collections across different dimensions

3. Issues related to building and sustaining a user-community.
   - Needs assessment
   - How to build communities
   - Evaluation of the library
   - Assessment of student learning
   - User support structure
   - Dissemination and public awareness

The following three pages include the reports from the breakout groups for each topic as modified in the light of the plenary discussions.

Issues Related to Collections

- Quality and evaluation
- Reusability and usability – interoperability of objects
- Metadata, cataloging, and controlled vocabulatries – interoperaibility of descriptions
- Community and Collaboration
- Intellectual property

A national digital library can be a powerful force helping to integrate SMET education across disciplinary, institutional, and temporal dimensions. In order to realize this potential, reusability and interoperability are key requirements. The group noted works-in-progress like the ESCOT (Educational Software Components of Tomorrow) project (http://www.nsf.gov/cgi-bin/showaward?award=9804930), the Instructional Management Systems (IMS) metadata project (http://www.imsproject.org/metadata.html), and the work on interoperability of the Digital Library Initiative projects. The group suggested the possibility of using currently funded projects as a testbed for mechanisms for interoperability.

This group discussed various aspects of the initial collections making up the library. Their overall recommendations were to build it now – lay an open framework supporting the larger vision and at the same time work toward an initial critical mass. Both depth and comprehensiveness of initial coverage are important. The initial emphasis should be determined in large part by the primary stakeholders – learners at all levels. The group also noted the importance of involving industry and other government agencies. They noted a number of Web sites for education – for example, the site http://www.gene.com/ae/ maintained by Genentech and NASA's Web sites. The group also recommended the use of dissemination grants or supplements to existing NSF grants to add resources developed by NSF supported projects to the library's collections. This was a recurring theme – the role that a national digital library for SMET education could play in multiplying the impact of projects funded by NSF other agencies and foundations.

Building on this theme, the group expressed concern that intellectual property rights were a key issue. There was particular concern that some projects resulted in products that were in limbo – always about to be published. The group stressed the importance of availability either through commercialization or "open source." Participants recommended several ways in which NSF might encourage this including requiring this issue to be specifically addressed in final reports and making further funding conditional on wide availability of products from prior work. This theme was discussed in the closing plenary session and met with wide agreement although a few people were concerned about pressure for premature publication.

The group stressed the importance of mechanisms to help users find high quality and appropriate resources. It noted some of the mechanisms developed under the Digital Libraries Initiative Phase I – for example, the search engine Googol (http://www.google.com/) which is based on an analysis of links or connections. One participant noted that this particular search engine is biased against recent additions to the Web. The group noted the importance of taxonomies, controlled vocabularies, and metadata and discussed the possibility of using IMS metadata in federated searches or searches initiated through a meta-portal. There was general agreement about the need to find a pragmatic, cost-effective middle ground regarding metadata, controlled vocabularies, and taxonomies. The group emphasized that an effective national digital library involved much more than using the usual Web-based search engines in a domain made up of selected distributed collections. As one example, the group noted the importance of both disciplinary and cross-disciplinary taxonomies for educational resources.

Evaluation of library resources and mechanisms to facilitate annotation and the association of commentary to resources were viewed as important contributors toward the goal of wide and effective use of quality resources. The group also emphasized the importance of studying the library's impact and the ways in which it is used.

Mechanisms for distributed collaborative work with shared resources and tools were considered as potentially important. Reusability and granularity were viewed as important contributors supporting customization in various ways including producing new resources made up of smaller components.

Issues Related to SMETE-Lib Central

- Clarify essential federal role
- Organization/ Structure/ Design of the central organization
- Incentive structure that focuses on essential user needs/services
- Business model that supports sustainability
- Models to integrate collections across different dimensions

Because of the enormous scope of effort required to create and maintain a digital library for education, the group stressed that a federal role was essential to insure that the library would serve all constituencies along the lifelong learning spectrum. The current federal involvement in start-up projects to produce tools and testbeds was lauded, but the group felt that additional funds were needed to establish and maintain the central coordinating function of the library until it reached maturity.

Currently the central function is completely distributed on an ad hoc basis. There are a few standards emerging and a few testbeds being developed. What is needed is to carefully examine the previous infrastructure design and organization for comparable large projects such as the supercomputer centers, the Internet, the National Science Balloon Facility, and the National Center for Atmospheric Research. Federal agencies should collaborate to develop an RFP to solicit competing models for the design and structure of the infrastrucure of "SMETE-LIB" Central in order to arrive at the best model to serve a digital library focused on education in its broadest sense.

Such a model must take into account an incentive structure that will focus on essential user needs and services. Incentive structures now in place are based upon traditional marketplace forces such as the commercial publishers or the academic research reward system as represented by the university tenure process and academic publishers. New incentive models need to be developed based upon a careful requirements analysis of what incentives will assure the flow of necessary services to users.

While it is recommended that federal support provide the start-up funding, there eventually needs to be developed a business model that supports sustainability of the digital library as it moves into a stable, mature state. Examples of this ongoing stability and self-sustenance include the basic Internet backbone with its plethora of Internet service providers and the emerging electronic marketplace. Examples of business models that might be adapted include those used by commercial and academic publishers. Any business model for SMETE-LIB Central must take into account issues related to security, privacy, and intellectual privacy rights. These models must provide benefit to both users and producers.

Finally, any successful model for SMETE-LIB Central must have a robust strategy to integrate collections across multiple dimensions. Currently most collections are discipline-based and any attempts to integrate across collections are ad hoc and very distributed. Some of this work has been done by professional societies. Much research has been done to develop various tools and services, but there have been few attempts to consolidate all of the tools and services or to apply them broadly. To provide data on the magnitude of this very large task a meta-analysis of the state-of-the-art of digital library tools and services needs to be conducted. Work needs to start immediately to begin to scale the digital library by integrating existing testbeds, both vertically within a discipline, and horizontally across disciplines.

Note: An immediate action item undertaken by the attendees at the meeting was to propose a workshop and website to be developed for the ACM DL99 conference to be held at Berkeley on August 11-14, 1999. Alice Agogino agreed to chair the committee to develop the workshop and website. Ed Fox agreed to host the website at his website (http;//fox.cs.vt.edu/DL99). The purpose of the website was to begin a repository of information about ongoing digital library research projects.

Issues Related to Building and Sustaining a User Community

- Needs assessment
- How to build communities
- Evaluation of the library
- Assessment of student learning
- User support structure
- Dissemination and public awareness

Participants in this discussion section focused on needs and support that should be created to sustain the Digital Library. The issues related above were compiled from dialogue ranging from the nature of the digital library, to the needs of the varied users, and the mechanisms by which the scientific community can best evaluate the organization and support structure of the library to ascertain usability of the library.

The first topic listed was that of needs assessment. The group discussed the state of the art of current library holdings, such as NPACI, publisher and professional societies. The involvement of NSF as foci for new interactions was mentioned. Ensuing discussion covered the amount of NSF involvement in the short, midterm and long-term. Potential users spanned all age and education groups (K-12, community colleges, 4-year colleges/universities, graduate research universities, and lifelong learning). Subsets of individuals in this group were identified as students, faculty, professionals, and other.

The second topic concerned the question of how to build communities of individuals to interface with the digital library. The community should consist of providers (authors and support individuals) and users. It was agreed that the community structure be multidimensional in order to service the multifaceted user community. Incentives to both the providers and users must be inherent within the system. The system must have a dedicated support system. Lastly, there must be benefits (short and long-term) to the providers and users in order to ensure the library is used and is allowed to evolve through the dynamic provider/user interface.

The evaluation of the library was the third topic discussed by the group. This issue is critical in that it enables the providers to build and sustain the community. The metrics of this assessment were agreed upon as the usability of the library material and the quality of the holding. Hence, a feedback mechanism is a most important issue in the planning and design of the digital library.

A related topic concerns assessment, which was the fourth issue of the group. Online tools for the evaluation of student learning are needed in the digital library to assess the use of the library. Additionally community (user) feedback is an important issue. From these issues, the group stressed the importance of having tools to measure how the digital library experience was incorporated into the learning experience and tools to allow the quantitative use of the library.

The fifth issue raised by the group centered on the dissemination and public awareness/relations. It was recommended that providers look at current professional organizations (such as the American Chemical Society, ACS) for the methods they use to disseminate their current electronic holdings and to advertise their service to the community. Issues of dissemination were more vigorously discussed, with the topics being: face to face vs. online communication for dissemination, public outreach as a vehicle to promote dissemination, and the use of modern public-relation tools for dissemination.

The last issue identified by the group was the user support structures. Topics of this issue concerned the tangible benefits (time value and multifaceted nature of the library), customization and personalization of the user interface to the digital library, the utilization and enhancement of the holdings (by local campus resources, librarians, and academicians). Support of non-traditional groups (defined by discipline, ethnicity, or education level) by this interface was deemed most important.

Three Cross-Cutting Themes

Three cross-cutting themes emerged during the meeting.

- There was general concern that results from some projects funded by NSF and other agencies existed in a kind of limbo – never published but never released for general use. Many of the workshop participants expressed their belief that NSF and other agencies should strongly encourage investigators to make their work widely available either through commercial publication or through "open source." In particular, this consideration should play a strong role in funding decisions for investigators whose results from prior grants were not widely available in some form.

- Many of the participants articulated an expansive view of the library while others emphasized the importance of a large initial collection and pointed out the value of legacy material and "low-hanging fruit." By the end of the meeting there was general agreement that the foundation and infrastructure for the library should be both open and ambitious, so that it would support the most expansive conception of the library, and that at the same time there should be substantial investment in a large initial collection and services that would have an immediate impact.

- There was considerable discussion of the scope of the library. As originally conceived, the library would begin with resources for science, mathematics, engineering, and technology education at the undergraduate level. This initial focus was seen to be both manageable and central to the broader SMET educational enterprise. Nonetheless there is no natural boundary separating the undergraduate level from the graduate level, from the high school, middle school, and elementary school levels, or from lifelong learning. Indeed, one of the most attractive features of a national digital library for SMET education is its potential for making connections across institutional boundaries. Given our nation's priorities in view of the recent TIMMS report and the need for so many new mathematics and science teachers at the K-12 level, it made sense to many participants to expand the library's initial focus to include at least the high school and middle school levels and to place a strong emphasis on teacher preparation.

  As with the previous issue, the key is an infrastructure that will support a library with the widest possible scope coupled with initial collections and services that will have a more focused and manageable immediate impact. The anticipated distributed nature of the library's collections and services supports this approach. Different players will be able to concentrate their efforts on particular parts of the SMET educational enterprise.

Appendix A: Slides from keynote address by Thomas A. Kalil

A Digital Library for Science and Math Education

Tom Kalil
The White House
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January 4, 1999

Policy Context

1. President's Educational Technology Initiative
   -Connect all classrooms to the Internet by 2000
   -Train teachers to use technology effectively in classroom
   -Increase the number of multimedia computers in the classroom
   -Encourage the development of high-quality content

2. Life-long Learning
   -Learning Anytime Anywhere
   -Distance Learning Demonstration program
   -Government as "model user" of technology-based training

Goals for a Science and Math Digital Library

1. Improve student performance
2. Get more students excited about science and math
3. Increase the quantity, quality and comprehensiveness of Internet-based science and math educational resources
4. Make these resources easy to discover and retrieve for students, parents, and teachers
5. Ensure that these resources are available over time

Appendix A: Slides from keynote address by Thomas A. Kalil

Rationale for a Science and Math Digital Library

1. Student performance in math and science is poor and needs to be improved (TIMSS)
2. Today's Internet lacks the cataloging, organization, archiving, collections management, etc. of a library
3. The effort to connect every classroom to the Internet will be of limited value without high-quality content
4. A digital library can be a resource for all Americans (marginal cost of dissemination is almost zero)

What's in a digital library?

Examples

1. Courseware
   - Multimedia
   - Modeling and simulation
   - Intelligent Tutoring Systems
   - Case-based reasoning
2. Learning objects
3. Hypertextbooks
4. Primary/reference material
5. Lectures
6. Lesson plans
7. Access to remote scientific instruments
8. Project-based learning
9. Tools (e.g. Biology WorkBench)
10. Tele-mentoring

What services does a digital library provide?

Examples

1. Search
2. Navigation
3. Archiving
4. Location-independent naming
5. Meta-data
6. "Peer review"
7. Recommender systems
8. Annotation
9. Selective Dissemination of Information
10. Federation
11. Interoperability
12. "Trails"
13. Copyright management

Appendix A: Slides from keynote address by Thomas A. Kalil

Issues

1. What are some concrete, easy-to-understand goals for a science and math digital library?
2. Does "digital library" obscure the social dimension of learning?
3. How do we successfully leverage the "small efforts of the many?"
4. How do we move from "hot-lists" to "wish-lists"?
5. How can the federal government leverage additional resources from universities, state and local government, foundations, the private sector?
6. What are some exemplary projects that we can build on - e.g.
   -MathForum
   -Access Excellence
   -Educational Object Economy
   -HandsOn Universe
   -California Digital Library
   -Virtual Department of Geography

Appendix B: Slides from overview of digital libraries by Gary Marchionini

A Digital Library Overview
Gary Marchionini
University of North Carolina at Chapel Hill
www.ils.unc.edu/~march

Digital Library R&D

- **Motivations (economic and social)**

Technology Push
Information Production
Global competition & collaboration
Management, reuse, standardization

Digital Library R&D

- **Support**

–DARPA, NSF, NASA support

–30 years of library automation

Digital Library Design Space: Content

- **Selection and acquisition**

–Technical: digitization, transfer, storage

–Community: rights, costs, security

–Examples: Library of Congress, NDLTD, ACM DL

- **Multimedia (includes code)**

–Technical: compression, bandwidth, storage, QoS, signal processing

–Community: rights, costs, standards

–Examples: MESL, Informedia, Blobworld, QBIC, Alexandria, BLC, Perseus, Linux community

- **Indexing and metadata**

–Technical: IR algorithms, natural language processing, signal processing, tagging schemes and scripts

–Community: standards, classification paradigm

–Examples: CNRI, Library of Congress, WWW search engines

- **Maintenance**

–Technical: backups/archives, version control, link management

–Community: dispensation, authority

–Examples: ? (Alexa?)

Appendix B: Slides from overview of digital libraries by Gary Marchionini

Digital Library Design Space: Services

- **Query**
  - **Technical: NL user interface, results display**
  - **Community: costs, privacy**
  - **Examples: WWW search engines, Library of Congress Thomas**

- **Selection**
  - **Technical: advanced interfaces, visualization**
  - **Community: costs, privacy, universal access**
  - **Examples: Yahoo, WWW hyperlinks, BLC**

- **Consortia, clearinghouses, portals, channels**
  - **Technical: interoperability, networking**
  - **Community: standards (naming, cultural, local/global), rights, quality control**
  - **Examples: Eisenhower NCMS, AskERIC, Think Quest**

- **Filtering/SDI**
  - **Technical: IR algorithms, visualization (mining), collaborative filtering**
  - **Community: costs, privacy, security**

- **Reference (elicitation and answering)**
  - **Technical: natural language understanding, network interaction/collaboration**
  - **Community: privacy, costs**
  - **Examples: ?FAQs?, ERIC aska, AgNIC, AFP**

Sharium

- **A virtual workspace with rich content and powerful tools where people can work independently or collaborate with each other to learn and solve information problems. A collaborative problem solving environment.**
  - **Organized around resources and tools**
  - **Encourages contributions and participation**
  - **Is sustainable**

Appendix C: Slides from talk by Bill Arms

NSF SMETE Library

Building the SMETE Library: Getting Started

William Y. Arms

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The SMETE Library Project

1996 Vision articulated by NSF's Division of Undergraduate Education

1997 National Research Council workshop

1998 Preliminary grants through Digital Libraries Initiative 2

1998 SMETE-Lib workshop

1999+

Implementation???

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Goals for the Meeting

- To identify key aspects that could be enhanced by collaboration among projects working in this area.
  (e.g., the development of testbeds)
- To inform future efforts and proposals to NSF by clarifying the elements of the library infrastructure that need to be developed to ensure:
  quality
  usability
  reliability
  stability
  interoperability

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Breakout Sessions

1. Identify wish lists of library services and infrastructure.
2. Discuss the state-of-the-art regarding the needs identified during the first set (organized by broad topic).
3. Articulate priorities and an action agenda.

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Assumptions

Questions Discussed at Previous Workshops

and

Provisional Answers

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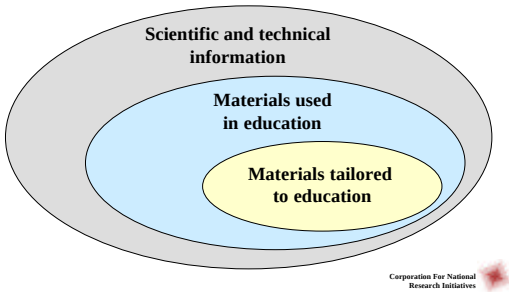
Collections and Services



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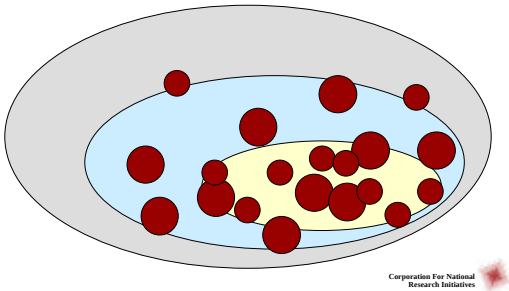
Appendix C: Slides from talk by Bill Arms

Core Partners



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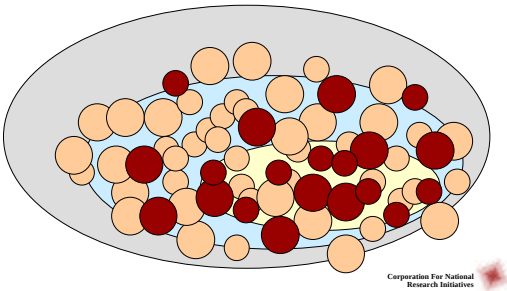
All Partners



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Collection Development Policy

The SMETE Library partners could:

- concentrate on educational materials
- *be a general purpose science library*
- concentrate on open access materials
- include formally published materials, preprints, web sites and similar materials
- be a long term archive

The SMETE Library must have a very comprehensive collections development policy

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Audience

The SMETE Library could:

- concentrate on the needs of science teachers
- serve students directly
- emphasize independent learners

The SMETE Library should aim to serve every one of these communities and more.

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Location

The SMETE Library might:

- *have a large computer system and collect materials*
- be a federation of libraries each with a specialized collection
- be a virtual library, providing access to collections maintained by independent organizations

The SMETE Library should emphasize services, not collections. It should be a virtual library coordinating a large federation of partners.

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Information Discovery and Quality of Materials

The SMETE Library could:

- help people find information
- provide catalogs and indexes
- review educational materials and validate them for scientific and educational content

The users need all of these services.

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Appendix C: Slides from talk by Bill Arms

Unanswered Questions

1. The SMETE Library could:
   facilitate new kinds of collaboration

How would this benefit education?

2. The SMETE Library could:
   provide access to curriculum materials

But would people use them?

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Fundamental Question: Leverage

How can the SMETE Library be more than the sum of its parts?

Which separate activities can SMETE can bring together?

Which existing, fragmented activities can be combined as the initial nucleus of SMETE?

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Leverage

How can the SMETE Library be more than the sum of its parts?

Which separate activities can SMETE can bring together?

Which existing, fragmented activities can be combined as the initial nucleus of SMETE?

By working together as partners.

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Partners

Where to Start: Collections

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Scientific information

Soon, all scientific and engineering information will be available online:

- Journals, reports, papers, standards, patents
- Data sets, instruments, sensors
- Computer programs, simulations, designs
- Maps, images, films
- **...** etc., etc., etc.

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Online Archives

Major scientific archives

- Physics E-print Archive
- ICPSR - social science data sets
- Netlib - Mathematical software
- Genome database
- NASA images and archives

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Digital Libraries Developments

Digital Libraries Testbeds

- NCSTRL (Networked Computer Science Technical Reference Library)
- DLI-1 Testbeds

NSF DUE Projects

- Curriculum projects
- DLI-2 Testbeds

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Partners

Where to Start: Services

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The Instructor's Wish List

To discover materials and services:

- Good science
- Comprehensible to students -- effective for teaching
- Stable -- will not change or disappear

Access to collections and services that are provided by many independent organizations:

- No uniform catalog or index to everything
- Mixture of for-profit and open access information

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Approaches to Indexing and Cataloguing

Conventional cataloguing and indexing: Skilled professionals, following quality guidelines.

Web spiders and gatherers: Programs that gather information and build indexes (e.g., Infoseek, Harvest).

Metadata in publishing: Addition of metadata by the creator to aid automatic indexing (e.g., Dublin Core, IMS).

Content extraction: Indexing using structured text, speech recognition, or image content.

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Where to Start: Technology

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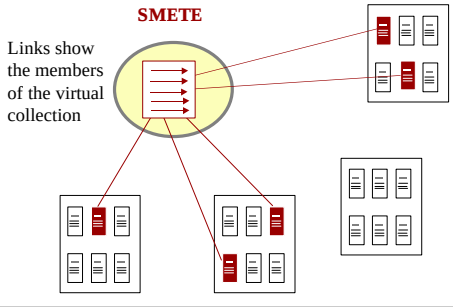
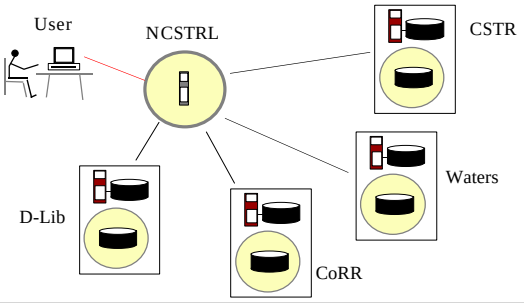
SMETE Library: Virtual Collections



Appendix C: Slides from talk by Bill Arms

SMETE Library: Portals



Where to Start: the NSF

The SMETE Library needs the NSF to succeed:

- Prestige and visibility
- Funding for Core Partners and central coordination
- Associated research programs

Guidelines and service standards for creators of scientific and technical information!!!

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Breakout Sessions

1. Identify wish lists of library services and infrastructure.
2. Discuss the state-of-the-art regarding the needs identified during the first set (organized by broad topic).
3. Articulate priorities and an action agenda.

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Breakout Groups

We want your ideas!!!

Please address the general topic, but ...
... you are not constrained

Prepare a short report for the whole group

Some important topics are out of scope (international issues, intellectual property)

Remember - our task is to make suggestions to the NSF, not to direct them

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Long Term

What will make the SMETE Library a permanent part of the educational landscape?

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Appendix D: List of participants

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