International Technology Research Institute
World Technology (WTEC) Division

WTEC Panel Report on

Digital Information Organization in Japan

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February 1999

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WTEC PANEL ON DIGITAL INFORMATION ORGANIZATION IN JAPAN

Sponsored by the National Science Foundation and the Defense Advanced Research Projects Agency
of the United States government

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WTEC at Loyola College (previously known as the Japanese Technology Evaluation Center, JTEC) provides assessments of foreign research and development in selected technologies under a cooperative agreement with the National Science Foundation (NSF). Loyola's International Technology Research Institute (ITRI), R.D. Shelton, Director, is the umbrella organization for WTEC. Paul Herer, Senior Advisor for Planning and Technology Evaluation at NSF's Engineering Directorate, is NSF Program Director for WTEC. Several other U.S. government agencies provide support for the program through NSF.

WTEC's mission is to inform U.S. scientists, engineers, and policymakers of global trends in science and technology in a manner that is timely, credible, relevant, efficient, and useful. WTEC's role is central to the government's effort to measure its performance in science and technology. Panels of typically six technical experts conduct WTEC assessments. Panelists are leading authorities in their field, technically active, and knowledgeable about U.S. and foreign research programs. As part of the assessment process, panels visit and carry out extensive discussions with foreign scientists and engineers in their labs.

The ITRI staff at Loyola College helps select topics, recruits expert panelists, arranges study visits to foreign laboratories, organizes workshop presentations, and finally, edits and disseminates the final reports.

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ISBN 1-883712-52-1
This document was sponsored by the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA) of the U.S. Government under NSF Cooperative Agreement ENG-9707092, awarded to the International Technology Research Institute at Loyola College in Maryland. The government has certain rights to this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the United States government, the authors' parent institutions, or Loyola College.

ABSTRACT

This report reviews the status of Japanese hardware, systems and applications for digital information organization (DIO) with a particular emphasis on digital libraries. Specific topics include technological development in both hardware and software; practical DIO applications; cooperation among government, industry and universities; and economic and policy issues. The report includes site reports for visits conducted by the panel members to leading research laboratories and universities in Japan. The panel's conclusions include the following: (1) DIO systems in the United States and Japan are based on common, integrated technologies to provide a spectrum of services; (2) Japan is producing extremely fast large-capacity hardware/software research systems; (3) Japan leads the United States in digital display development by about two years; (4) Japanese libraries are digitizing catalogs on a grand scale; (5) distributed digital libraries will revolutionize education and learning; (6) Japan has a clearly articulated national information infrastructure policy that views DIO as critical to "an advanced information society." These and other conclusions are reviewed in detail in the panel's executive summary.

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 The ISBN number for this report is 1-883712-52-1. This report is distributed by the National Technical Information Service (NTIS) of the U.S. Department of Commerce as NTIS report # PB99-128019. A list of available WTEC reports is included on the inside back cover of this report.

FOREWORD

Timely information on scientific and engineering developments occurring in laboratories around the world provides a critical input to maintaining the economic and technological strength of the United States. Moreover, sharing this information quickly with other countries can greatly enhance the productivity of scientists and engineers. These are some of the reasons why the National Science Foundation (NSF) has been involved in funding science and technology assessments comparing the United States and foreign countries since the early 1980s. A substantial number of these studies have been conducted by the World Technology (WTEC) Division managed by Loyola College through a cooperative agreement with the National Science Foundation.

The purpose of the WTEC activity is to assess research and development efforts in other countries in specific areas of technology, to compare these efforts and their results to U.S. research in the same areas, and to identify opportunities for international collaboration in precompetitive research.

Many U.S. organizations support substantial data gathering and analysis efforts focusing on nations such as Japan. But often the results of these studies are not widely available. At the same time, government and privately sponsored studies that are in the public domain tend to be "input" studies. They enumerate inputs to the research and development process, such as monetary expenditures, personnel data, and facilities, but do not provide an assessment of the quality or quantity of the outputs obtained. Studies of the outputs of the research and development process are more difficult to perform because they require a subjective analysis performed by individuals who are experts in the relevant scientific and technical fields. The NSF staff includes professionals with expertise in a wide range of disciplines. These individuals provide the expertise needed to assemble panels of experts who can perform competent, unbiased reviews of research and development activities. Specific technologies such as telecommunications, biotechnology, and nanotechnology are selected for study by government agencies that have an interest in obtaining the results of an assessment and are able to contribute to its funding. A typical WTEC assessment is sponsored by several agencies.

In the first few years of this activity, most of the studies focused on Japan, reflecting interest in that nation's growing economic prowess. Then, the program was called JTEC (Japanese Technology Evaluation Center). Beginning in 1990, we began to broaden the geographic focus of the studies. As interest in the European Community (now the European Union) grew, we added Europe as an area of study. With the breakup of the former Soviet Union, we began organizing visits to previously restricted research sites opening up there. Most recently, studies have begun to focus also on emerging science and technology capabilities in Asian countries such as the People's Republic of China.

In the past several years, we also have begun to substantially expand our efforts to disseminate information. Attendance at WTEC workshops (in which panels present preliminary findings) has increased, especially industry participation. Representatives of U.S. industry now routinely number 50% or more of the total attendance, with a broad cross-section of government and academic representatives making up the remainder. Publications by WTEC panel members based on our studies have increased, as have the number of presentations by panelists at professional society meetings.

The WTEC program will continue to evolve in response to changing conditions. New global information networks and electronic information management systems provide opportunities to improve both the content and timeliness of WTEC reports. We are now disseminating the results of WTEC studies via the Internet. Twenty-four of the most recent WTEC final reports are now available on the World Wide Web (http://itri.loyola.edu) or via anonymous FTP (ftp.wtec.loyola.edu/pub/). Viewgraphs from several recent workshops are also on the Web server.

As we seek to refine the WTEC activity, improving the methodology and enhancing the impact, program organizers and participants will continue to operate from the same basic premise that has been behind the program from its inception, i.e., improved awareness of international developments can significantly enhance the scope and effectiveness of international collaboration and thus benefit the United States and all its international partners in collaborative research and development efforts.

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INTRODUCTION

Digital information organization (DIO) refers to methods of rendering large amounts of information into digital form so it can be stored, retrieved and manipulated by computer. An example of digital information organization is the digital library, a storehouse of largely unstructured text documents that is useful only if it can be searched readily. Another example is the digital museum, which contains pictorial and three-dimensional objects that are much more difficult to digitize and search than text, and that are susceptible to scanning and optical character recognition (OCR). Many other requirements for DIO exist, including corporate databases, videotape collections, map information, census statistics and financial data.

The rapid rise in computer and Internet use has resulted in the creation of vast quantities of digital information being created and transmitted. For example, virtually all business documents are now created in digital form, either by computers directly (in the case of machine-generated forms) or by humans using word processing software. The fact that this material is digitized makes it amenable to automated storage and retrieval. The sheer volume of it, however, makes it imperative to develop suitable organizational techniques.

The very health of institutions depends on their ability to manage information effectively, whether for educational, research, business, military or governmental purposes. Therefore DIO is a critical technology for entities of all sizes, from small corporations to government departments and even entire nations.

DIO systems employ an amalgam of various technologies, including scanning, OCR, digital storage techniques, data compression, indexing and search algorithms, display devices and the Internet. These technologies must be integrated properly and scaled to enormous proportions to allow humans to deal effectively with the flood of digital information now being made available.

STUDY OBJECTIVES AND PROCESSES

The purpose of this WTEC study was to investigate Japanese hardware and systems for DIO, with a focus on digital libraries. The study was supported by the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA). The panel members were divided into two teams, one of which visited primarily academic and library sites, while the other focused on commercial organizations. The WTEC panel visited 18 sites during its one-week visit to Japan (March 23-27, 1998): nine corporations, five universities, three libraries and one museum.

The teams were composed of professionals from different disciplines who made observations in the following areas:

- technological developments in hardware and software
  - system architectures
  - fast search techniques
  - multilingual capabilities
  - multimedia systems
- practical DIO applications
- cooperation among government, industry and universities

- economic and policy issues
  - government funding
  - models for fee collection for use of digital materials
  - legal issues, particularly copyright

UNITED STATES - JAPAN COMPARISONS

The WTEC team was interested in comparing the relative progress of the United States and Japan on issues relating to DIO. The panel's conclusions are informal in nature only, as team members, after a literature review, visited 18 sites over a period of a single week during 1998 and cannot claim to be familiar with even a plurality of developments in the United States and Japan. However, some patterns emerged that are summarized in Table ES.1

Table ES.1
State of the Art of Digital Information Organization in Japan Compared to the United States

State of the Art of Digital Information Organization in Japan	Japan Status	Trend
Systems	0	⇑
Display technology	+	⇑
Virtual reality, immersive technology	+	⇑
Architecture	0	⇑
Digitization of content	+	
Utilization of digitized content	—	
Catalog accessibility	—	
Catalog scalability	0	
Text search	—	
Translingual search	0	
Image/video processing	—	
K-12 education using digital techniques	—	
Commercialization of digital libraries	+	⇑
Digital library policy	+	

The notation "+" means Japan is perceptibly beyond the United States in capability; "— " means Japan is perceptibly behind; "0" means no significant difference was observed and blank means no conclusion could be drawn. An upward arrow indicates that any observed difference is likely to increase in the future, or, if there is no difference, that Japan is believed to be improving over the United States.

For both the United States and Japan, the following issues must be addressed if digital library efforts are to progress expeditiously:

- digital library policy
- intellectual property rights
- scalability
- translingual and multiple character set capabilities
- architecture for global indexing, search and access
- sharing content; unless institutions are able and willing to share digital materials, a worldwide library can never be realized

CONCLUSIONS

Systems and Architecture

- DIO systems in the United States and Japan are based on common, integrated technologies to provide a spectrum of services such as information capture, cataloging (metadata), indexing, storage, search/query, retrieval, asset/rights management, security and distribution.
- Japanese businesses are reengineering their operations to take advantage of advances in information processing, which in turn drives the development of new architectures.
- Japan concentrates on customized system developments rather than off-the-shelf or reusable components.
- Japanese corporations are building hardware and system components specifically directed to capturing the DIO market, incorporating advanced security features such as digital watermarking, digital notaries and secure archivers.
- Mission-specific, well-funded digital library efforts are driving development of commercial systems and architectures. Many different systems and architectures are employed in Japan's digital libraries and museums, some of which are comprehensive and innovative.
- Japan's Next Generation Digital Library Project is developing a multi-tiered reference architecture for future distributed libraries that uses agent technology, messaging middleware and CORBA object management.

Text Processing

- Japan is producing extremely fast large-capacity hardware/software search systems.
- Japan attempts to support Chinese, Japanese and Korean (CJK) text retrieval. Cross-lingual retrieval, however, is limited.
- While Unicode is sometimes used, perceived deficiencies in its Asian language support lead to the use of specialized representations.
- The Japanese are successfully combining search and browsing technologies such as text clustering and thesaurus generation.
- Japan lacks significant information retrieval (IR) datasets.
- There is little sharing of IR technology in Japan between organizations, resulting in much reinvention.

Digital Imaging and Multimedia

- Japan leads the United States in digital display development by about two years.
- Japan is on a par with the United States in digital image acquisition.
- Japan lags behind the United States in Internet use by about two years.
- Entire businesses and business units in Japan are devoted to multimedia development. A major theme of this development is *kansei*, a Japanese term meaning roughly that the look and feel of the system must harmonize with the task being performed.
- Japan possesses advanced video storage and retrieval systems, including such functions as scene segmentation, face tracking, caption recognition, similarity matching and keyword-based retrieval.
- Japan leads in virtual reality and immersive experience environments.

Cataloging: Description, Access and Scalability

- Japanese libraries are digitizing catalogs on a grand scale: Kyoto University expects to have over a million items in its catalog by the year 2000.
- Japanese are more willing than Americans to handle and scan rare and fragile documents.
- Reluctance of publishers to make content available digitally, even for a fee, is a severe barrier to access.

- Digitization efforts in Japan are performed independently by different organizations; resources are rarely shared.
- Japan is participating in developing international metadata standards.
- Content production and metadata generation, which require substantial human effort, are inherently non-scalable.
- The cost of scanning and indexing is minimal compared with the cost of metadata creation.
- Keyword-based search methods do not scale well because the number of query hits increases with the size of the collection.

Education Using Digital Libraries

- Distributed digital libraries will revolutionize education and learning, particularly in the area of distance education.
- Digital libraries will provide the following:
  - resources for teaching and curriculum development
  - environments for learning and exploration
  - environments for publishing and broadcasting (digital journals)
- Japan has mandated and funded the development of all-digital libraries. Nara Institute of Science and Technology (NAIST) maintains an operational all-digital library.
- Japan is establishing centers that will focus on the creation of digital multimedia content.
- Japan is creating programs to train professional digital librarians. NAIST is discussing the possibility of establishing a graduate program for digital librarians.
- The impact of digital libraries on K-12 education in Japan seems to be minimal.

Policy, Intellectual Property and Economics

- Japan has a clearly articulated national information infrastructure policy that views DIO as crucial to an "advanced information society." The policy attempts to establish the following:
  - worldwide information access in each Japanese home
  - library networks
  - multimedia centers
  - high definition television (HDTV)
- Japan allows and promotes cooperation among different government agencies, universities and corporations.
- Japan's copyright system is amenable to the digitization and distribution of digital information for the following reasons:
  - multimedia copyright is more highly developed in Japan
  - fair use is broader in Japan than in the United States
  - Japanese law provides for extensive compulsory licensing
  - more licenses can be obtained from Japanese performing rights societies
  - Japan is more accepting of automated "meter-click" charging mechanisms

CHAPTER 1

INTRODUCTION

R.D. Shelton

BACKGROUND

Americans like to think that their nation is leading in all fields of science and technology. Indeed, President Clinton has charged the nation's science agencies with maintaining that lead. Those who assess the quality of research abroad, though, often find centers of excellence that challenge American science leadership.

So it is with digital libraries and their supporting technologies. Few here question U.S. leadership in most fields of information technology, despite decades of well-financed challenges abroad. In systems like digital libraries, the Library of Congress has pioneered electronic access to collections for decades, and the National Science Foundation/Defense Advanced Research Projects Agency/National Aeronautics and Space Agency Digital Libraries I initiative has recently produced highly visible results. It is easy for Americans to have the impression that other nations are merely following developments here. Because of the bad economic news from Asia, some believe that Japan is no longer challenging the United States for high technology leadership. As with other recent WTEC studies (Shelton and Holdridge 1997), however, this panel of American experts found in Japan exciting research and development projects and dazzling, complete systems in this field.

At a printing company in Tokyo, panelists were treated to a virtual reality tour of the Sistine Chapel, with closer views than any tourist can see in Rome. At a financial services company, the WTEC team saw a large firm totally integrated with electronic commerce, from data acquisition to delivery of products. At a new graduate school with model facilities and equipment, panelists saw a totally digital library; hardcopy acquisitions were discarded after scanning. At large companies that were developing enabling technologies, they saw many projects that were indeed following the American lead, but others that had unsurpassed technologies, particularly in fast text searches, image displays, and in three-dimensional image capture. Many other interesting examples can be found in this report.

In most fields, and particularly this one, the real question is not as much who wins as how well they play the game. Implementing Raj Reddy's vision of worldwide access to all authored works needs all the teamwork that can be mustered; everyone who wishes can be in the front lines of this revolution. Read on to find how the Japanese can help.

SCOPE OF STUDY

By design, this study provides a review of status and trends in digital libraries and their enabling technologies in Japan. The objectives are to compare research underway in Japan with that in the United States, to identify opportunities for collaboration, and to suggest ways to refine the thrust of U.S. research programs. The term "digital information organization" is meant to include digital libraries and related information access technologies and systems. Of special interest are Japanese infrastructure and policies to promote these new technologies; new Japanese experimental facilities established for the development and evaluation of new

information access technologies, including digital libraries; new search engine technologies; and human interaction technologies.

While the library provides a convenient metaphor, the sponsors, NSF and DARPA, were more broadly interested in technologies for computer-based information creation, access, and management that are under development to improve the transfer of information to and from information systems; in the ability to conduct efficient and effective searches of databases; and in the quality of content in those databases. These technologies can address problems such as information overload, insufficient speed of information processing, multi-language information, and intellectual rights protection. The recent large-scale Japanese experiments in electronic libraries, museums, and commerce were to be examined as means of integrating these technologies and delivering the results.

WTEC BACKGROUND

With core funding and management from the NSF Directorate for Engineering, the WTEC Division of ITRI (formerly JTEC) has conducted over 40 international technology assessments. Other agencies have also provided funding: DARPA, ONR, AFOSR, ARO, NASA, the Departments of Energy and Commerce, and other NSF directorates. Recently panels of WTEC experts have assessed Asian and European R&D in nanotechnology, superconductivity, high-density data storage, satellite communications, and electronic manufacturing. Final reports are available from the National Technical Information Service (NTIS), on a CD-ROM, and on the Web (Horning 1995).

APPROACH

NSF and DARPA defined the scope of the study in meetings in early 1997. WTEC then recruited a panel of U.S. experts, chaired by Raj Reddy, Dean of Computer Science at Carnegie Mellon University. The panel is shown in Table 1.1, along with others who helped with the research in Japan and in producing the results. Short vitas are in Appendices A and B.

Table 1.1
Panel Members, Sponsors (*) and Staff (**)

Raj Reddy	Carnegie Mellon University
Tryg Ager	IBM Almaden Research Center
Rama Chellapa	University of Maryland
Bruce Croft	University of Massachusetts
Beth Davis-Brown	Library of Congress
Jerry Mendel	University of Southern California
Michael Shamos	Carnegie Mellon University
Ronald Larsen *	DARPA
Lawrence Goldberg *	NSF
Duane Shelton **	ITRI
Hiroshi Morishita **	WTEC

The study was initiated at a kickoff meeting held in Arlington, Virginia in November 1997. WTEC staff then conducted a literature search, including a survey of possible sites prepared by David Kanhaner of ATIP. Cecil Uyehara worked with Hiroshi Morishita in Japan to make arrangements for the panel's study tour in Japan. WTEC established a Web site at the outset of the study to publicize it to the research community (Horning 1997).

During March 21-28, 1998, panelists visited the 18 sites shown in Table 1.2 by dividing the group into two teams. Complete systems were seen at the museum and universities, the National Diet Library, NACSIS,

NAIST, Nikkei, and Toppan. The other sites typically demonstrated a half-dozen projects of enabling technologies. Appendix C contains detailed reports from each location.

Table 1.2
Sites Visited in Japan

Advanced Telecommunications Research Institute (ATR)	University of Library and Information Science
Fujitsu	National Diet Library
Hitachi	National Ethnology Museum
IBM Japan	Nikkei
Keio University	NTT - Yokosuka
Kyoto University	Kyoto University Library
Matsushita	Toppan Printing
University of Tsukuba Library	NACSIS
Nara Institute of Science and Technology	Omron

The panel held a day-long workshop in Arlington, Virginia on May 12, 1998. More than 80 people attended, including representatives of the leading U.S. companies and Federal agencies concerned with this field. The panelists delivered presentations on the vision of all authored works online, the hardware and software architecture for delivering such vast databases, text search and retrieval systems, image databases issues, metadata methods for digital libraries, and the economic, policy, educational applications and intellectual property aspects of digital libraries. Two of the panelists were unable to be at the workshop, and Ronald Larsen and Lawrence Goldberg presented their materials. The slide presentations from the workshop are available on the Web (Tamburello 1998).

REPORT OUTLINE

This final report follows much the same plan as the workshop, but benefits from peer reviews of preliminary results. Chapter 2 presents Raj Reddy's vision of the digital library of the future, the kind of inspiration shared by many in Japan who are working to make this dream a reality. Jerry Mendel brings us back to earth with a description of digital libraries as they exist today, particularly for education applications (Chapter 3). Tryg Ager lays out the hardware and software architectures that provide the framework for the development efforts in Japan (Chapter 4). Bruce Croft and Rama Chellapa review the way the Japanese deal with text and image data (Chapters 5 and 6). Beth Davis-Brown covers the central issue of access, metadata, in Chapter 7. In the concluding Chapter 8, Michael Shamos presents the economic and intellectual property aspects of information access in Japan, and policy—what governments can do to provide the library of the future. Appendices A and B contain the vitas of the panelists and other team members, respectively, and Appendix C has the detailed trip reports from the 18 Japanese sites studied.

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CHAPTER 2

GLOBAL DIGITAL LIBRARIES: BUILDING THE INFRASTRUCTURE

Raj Reddy

INTRODUCTION

Building a digital library is a daunting challenge, involving a wide variety of technological, social and policy issues. One of the goals of this WTEC study was to compare the relative progress being made on these problems in the United States and Japan. To set the stage for the comparison and the chapters that follow, this chapter will put forward a futuristic vision of the digital library (and shared digital libraries) and lay out the obstacles to its realization. This will set the stage to compare the United States and Japan based on the panel's firsthand observations.

LIBRARY OF THE FUTURE

The library of the future will be digital and have the following features:

- contain all recorded knowledge online (billions of items)
- distributed, maintained globally
- accessible by:
  - any person
  - in any language
  - any time
  - anywhere on earth
  - via the Internet
- act as the information resource for the 21st Century

This notion of a digital library is radical; most current digital library efforts are aimed at building individual libraries to replace existing physical libraries that are burdened by financial and space constraints. However, the avowed digital library policy of Japan is that "each home will be able to access electronic libraries and electronic museums around the world via networks, allowing users to readily search and obtain worldwide information on books and art based on their own particular interests" (MITI 1994).

DIGITAL VS. TRADITIONAL LIBRARIES

The shift from traditional libraries to the digital is not merely a technological evolution, but requires a change in the paradigm by which people access and interact with information.

A traditional library is characterized by the following:

- emphasis on storage and preservation of physical items, particularly books and periodicals
- cataloging at a high level rather than one of detail, e.g., author and subject indexes as opposed to full text
- browsing based on physical proximity of related materials, e.g., books on sociology are near one another on the shelves
- passivity; information is physically assembled in one place; users must travel to the library to learn what is there and make use of it

By contrast, a digital library differs from the above in the following ways:

- emphasis on access to digitized materials wherever they may be located, with digitization eliminating the need to own or store a physical item
- cataloging down to individual words or glyphs
- browsing based on hyperlinks, keyword, or any defined measure of relatedness; materials on the same subject do not need to be near one another in any physical sense
- broadcast technology; users need not visit a digital library except electronically; for them the library exists at any place they can access it, e.g., home, school, office, or in a car

Everything Can Be Stored

The total number of different books produced since printing began does not exceed one billion. (The number of books now published annually is less than one million.) If an average book occupies 500 pages at 2,000 characters per page, then even without compression it can be stored comfortably in one megabyte. Therefore, one billion megabytes are sufficient to store all books. This is 10^{15} bytes, or one petabyte. At commercial prices of $20 per gigabyte, this amount of disk storage capacity could be purchased for $20 million. So it is certainly feasible to consider storing all books digitally.

Very Large Databases

A database of a billion objects, each of which occupies one megabyte, is large but not inconceivable. Once one is comfortable with sizes of this kind, it is feasible to imagine a thousand such databases, or to envision them all as portions of the same global collection. This amount of storage is sufficient to house not only all books, but all of the following:

- photographs
- legislative material, court decisions
- museum objects
- recorded music
- theatrical performances, including opera and ballet
- speeches
- movies and videotape

Distributed Holdings

When information is digitized and accessible over a network, it makes little sense to speak of its “location,” although it is technically resident on at least one storage device somewhere, and that device is connected to at least one computer. If the information is available at multiple mirror sites, it is even less meaningful to speak of it being in a “place.” While traditional libraries measure their size by number of books, periodicals and other items held, the relevant statistic for a digital library is the size of the corpus its users may access. This means that digital libraries will want to expand their “holdings” by sharing digital links with other libraries. Unfortunately, there seems to be very little sharing of this sort taking place at present.

How can we understand the unwillingness of libraries to share content? The question goes back to the old measure of the size of a traditional library—the number of books it holds. When a library expends funds to assemble digitized works, it loses a portion of its prestige (or thinks it does) by allowing other libraries to copy or access its data. Ultimately, however, *all* material should be accessible from *every* library.

Gore's Digital Earth

In 1998, Vice President Gore stated that "A new wave of technological innovation is allowing us to capture, store, process and display an unprecedented amount of information about our planet and a wide variety of environmental and cultural phenomena. … I believe we need a 'Digital Earth.' A multi-resolution, three-dimensional representation of the planet, into which we can embed vast quantities of geo-referenced data" (Gore 1998). He then called on scientists to create a digital map of the earth at a resolution of one meter. Such a project will require technical innovation beyond that required even for a digital library containing every book ever written. The area of the earth in square meters is about 5×10^{14}. Storing two megabytes of data per square meter (which would include terrain data, imaging, environmental and other pertinent information) will require 10^{18} bytes, an amount roughly equal to the amount of digital storage currently present on earth.

DIGITIZATION

Ultimately, everything that people are interested in accessing will have to be digitized. The reason is that digital searching will become so easy, inexpensive, fast and ubiquitous that users will not tolerate, or will not access, traditional materials. Capture requires a concerted, shared, worldwide effort. The cost of digitizing is not trivial, so it makes little sense for any work to be digitized more than once. Yet without any registry of digitized works, many books are digitized multiple times, while others are ignored.

Converting text, images and objects to digital form requires much more than digital photography or even high-resolution scanning and requires, instead, the following:

- initial input, either scanning or keyboarding
- conversion to one of a set of standard formats
- optical character recognition (OCR) to capture text characters for searching
- OCR correction (since OCR is inherently error prone)
- creation and input of metadata and cataloging information
- special techniques for non-textual materials, such as music, images, videotape, etc.

Policy issues, discussed below, will determine the resources made available for digitization and how they will be allocated.

PARADIGM SHIFT

If digital libraries are to become truly useful, they must assist users in making the transition from paper books to digital hypermedia. Many people report that they derive a high degree of comfort from books for the following reasons:

- Portability. Books can readily be carried, are compact, light in weight and comfortable to read. Anything you can't read in bed will never displace a book.
- Reliability. Reading books would still be possible even if every computer on earth were down.
- Familiarity with the medium. The pages of a book are easy to turn, the book can be opened to any page, and the linear hierarchical organization of the material is easy to grasp.
- Low cost.
- Ability to annotate. Comments and corrections can be written in a book; passages can be marked for emphasis or studying, and a book can be resold to recover costs.

DIGITAL LIBRARIANS

A move to electronic libraries will alter the fundamental role of librarians. Far less attention will be paid to acquisitions, cataloging and circulation, and much more to systems, online assistance, navigation assistance and conversion issues. Unless graduate programs for digital librarians are established to create trained personnel, the real risk exists that users, particularly young adults who grew up in a digital generation, will outstrip the ability of librarians to assist them.

THE ELECTRONIC BOOK

It will be impossible to displace paper books if reading digital ones is inconvenient. In fact it is likely that an electronic book will have to offer significantly more capability than a paper one to gain wide acceptance. Toward this end, several manufacturers are developing E-books which attempt to mimic the essential features of traditional books while providing huge advantages, such as the ability to store 1,000 electronic books in the space of one paper book and keep the user's place in each.

The worldwide ecological burden imposed by paper books is immense. Tremendous energy and human resources are required to grow and harvest trees, convert them to paper, print and bind books, transport them to warehouses, maintain bookstores and ship the books from the warehouses to the bookstores. The processes of making paper and ink release noxious chemicals, to say nothing of the fuel required to transport boxes of books all over the world. All of this is done merely to disseminate information that could be disseminated electronically with far greater speed and efficiency.

The chief technical barrier to E-books at present is that they do not capture the familiar feel of paper volumes. When this problem is solved, we will then have to face the issue of how content is downloaded to them and paid for.

INTEROPERABILITY

Given that numerous libraries around the world will be developing digital collections, how will it be possible for a user of library A to access and view material housed in library B? The existence of numerous digital libraries will make it essential to share digitized items and ensure that cataloging, searching and retrieval tools at each one can be used readily with materials from others.

Formats and Standards

While standards may have the effect of inhibiting innovation, they are essential to interoperability. Agreement must be achieved on such fundamental issues as how text is to be stored. Is it straight ASCII, Microsoft Word, HTML, SGML, XML or something else? What kind of compression will be used? If text is compressed, how will searching be done? How are images, music and videotape to be represented? If agreement is not reached, at least the number of different ways in which works are digitized should be reduced to a number small enough to allow each library to support them.

Digital libraries must also have a second set of intake standards, going not to technology but to quality and reliability, which are discussed later on. Archivists question the permanence of digital materials since they note that electronic documents can be modified readily and the media on which they reside become obsolete at least once each decade. The question then is how an ever-expanding corpus of information will be converted to new media and formats as these evolve.

Metadata

This term is often used to mean information *about* an item, rather than the information in the item itself. Examples include the author, title, date of acquisition, price paid, donor, etc. It is particularly critical to capture metadata that is not present in or derivable from the item. For example, the author's date of birth is often not printed in a book but can be important in distinguishing among authors with similar names

(particularly parents and children). Libraries may "share" content by simply providing links, but uniform access to the content requires uniform metadata and a procedure for generating and storing it economically. It is of little avail to exchange documents at light speed if they must be held up for months until a human cataloger can prepare metadata.

Character Set Representations

This is not merely a question of different alphabets and writing systems, a major hurdle in itself, but also an issue of how characters are represented. For example, there are several widely differing mappings of Chinese characters into ASCII. There is some appeal to having a worldwide universal standard, such as Unicode, but the notion of attempting to list all of the world's glyphs and freeze them in a standard reduces flexibility and tends to overlook obscure or variant writing systems and restrict the development of new ones. Possibly a standard should be developed that permits new character sets so long as the definition of the glyphs and the representation mapping is maintained in an accessible location.

SCALABILITY: THE BILLION-USER PROBLEM

A major problem encountered in digital library development is scalability—the expansion of system capabilities by many orders of magnitude. For example, a Web site, even one with huge capacity, may be choked if many people access it at the same time. Assuming that before long approximately a billion people will be able to connect to the Internet, if only one percent of them are interested in a topic (a number that is far too low for subjects of global concern such as the death of Princess Diana), that is a collection of 10 million people. If a server requires 100 milliseconds to grant access to a Web page, then the population would have to wait 12 days for everyone to see the same page. Therefore, technology that seems instantaneous when used on a small scale may become impossibly cumbersome when expanded.

One can imagine speeding up access to a page by adding more servers in response to anticipated demand, but even this numerical solution does not scale. If the problem is delivery of an HDTV movie (which takes 10 seconds to download at 10 gigabits per second), distributing the film to even one million people (a tenth of a percent of anticipated net users and fewer than the attendance at a major film during its first weekend of release), would require 120 days. Increasing the number of servers by an order of magnitude would not make the delay even remotely tolerable.

Bandwidth scalability is largely a hardware and networking problem. Keyword searching presents a problem of an entirely different sort. The commercial Web searchers now index approximately 50 million documents. A search can easily return 1,000 hits. This is a number small enough that a user could consider glancing at all of them to find what he wants. If the corpus being searched contained 50 billion pages (less than the number of pages in all books), a search might return a million hits, which would instead require a lifetime of effort to review. Therefore, building a digital library index, particularly one to be shared among many libraries, is not simply a matter of building a large one. Access methods, screening and navigation tools must also be provided.

Even if a library has a few million books, its staff members can be generally familiar with the nature and extent of its holdings. A library with a billion books and several billion other items would be qualitatively different and probably beyond the ability of any person to master. The sheer volume of transactions, catalog records, new acquisitions and help requests would be overwhelming. This is particularly true if the library permits access by computer programs as well as humans. It is apparent then that new organizational concepts on a grand scale will be required if digital information systems are to scale properly.

SYSTEMS AND ARCHITECTURE

A digital library "system" is composed of multiple hardware and software components, including the following:

- scanners
- computers and servers
- storage devices
- media
- catalogs
- converters
- networks
- displays
- multimedia interfaces
- usage measurement software
- human processing procedures
- reference assistants

All of the above are interconnected through networks and gateway software and must be designed for scalability, interoperability and reliability. This is a daunting challenge, particularly since the technology in many of the areas is changing rapidly. A system that uses one speech recognition system for input must be designed so that the recognizer can be replaced with another very quickly. Otherwise, the digital library, potentially one of the most responsive and useful systems in the world, can become fossilized.

SEARCH

The problem of locating items in libraries is frequently referred to as "search," although that word tends to imply that one knows in advance what one is looking for, and possesses handles, indicators or index terms to serve as finding aids. This narrow view ignores the activity of browsing or even the higher-level function of becoming acquainted in general with a library's holdings. Browsing in a traditional library is a physical activity—it involves scanning shelves on which related works have been placed in proximity, and occasionally withdrawing them from the shelves for examination. Browsing in a digital library is a logical activity mediated by a computer. It does not require physical proximity in any sense; indeed, two consecutive items examined may be stored on different continents. The question, then, is how can a library user (not to say the library staff) become familiar with the whole of recorded human information in a way that makes it accessible and useful?

We adopt the term "navigation" to mean moving about in a digital collection. Search is a directed form of navigation in which the goal is defined in advance with reasonable clarity. The result of a search may be an item, a collection of items, or any part of an item, even down to a single glyph. Tools must be provided that enable users to move about at varying levels of granularity within the corpus.

The usual requirement for a search is that the user is looking for a specific piece of information or a summary of what is available about a certain topic. A common case is that the user wants the answer to a specific question, such as when the postcard was invented. Only rarely does such a question translate naturally into a keyword query. Such retrieval is indirect in the sense that the user wants to learn A, but formulates a query B, to which he receives a set of retrieved documents that must be scanned to determine whether the answer to A is among them. It would be far better simply to allow the user to ask question A instead of requiring him to convert it to some query language.

Non-Textual Matter

The existence of Web searchers proves that text can be searched without being indexed or cataloged. At least on a microscopic level, documents can be located purely by their content. Many documents consist of text plus other information such as mathematical equations, tables and drawings that themselves cannot be searched directly but can often be located by the presence of related text. Purely non-textual matter is very different. Although substantial progress is being made on video searching (through the use of extensive

captioning cues, speech recognition and other aids), content searching of music and visual materials is non-existent or in its infancy. The problem is further complicated by the existence of work that combines media in various ways.

Translingual Issues

Most library items, particularly in non-English-speaking countries, are not in English. The central translingual library question is how users may navigate through materials in foreign languages and make effective use of them. Translingual search is currently a research problem for which obvious solutions do not work. A keyword search cannot be made multilingual merely by translating the keywords one at a time. The number of possible translations of each word may be very large, so an explosion in the number of hits may result. This approach also takes no account of idiomatic uses, untranslatable words such as particles, and numerous other language-related phenomena.

An interim solution is the use of translation assistants—programs that offer dictionary entries or partial or suggested translations of text portions. These show great promise for users who are at least partially familiar with the language of the retrieved document.

Synthetic Text

A user who is looking for general information on a particular topic is constrained in traditional libraries to go to an encyclopedia (which may have no entry or an outdated one on the topic of interest) or to refer to books that are generally about the subject under consideration. The time necessary for the user to obtain an overview at the appropriate level may be large because of the volume of repetitive material obtained. Programs are needed that are able to scan hits with the particular query in mind and produce abstracts, summaries, translations or analyses of the retrieved material.

INFORMATION RELIABILITY

It seems inevitable that the class of works available through digital libraries will include electronic-only publications, ephemeral and unreviewed materials and even fabricated or counterfeit matter. The ease of publishing on the Internet combined with the absence of traditional methods for evaluating reliability makes it likely that library users will be retrieving works of questionable authenticity and value. Issues concerning the Internet and digital materials include:

- Reliability. How can a user (or an automated agent) evaluate the reliability of digital materials? What information must be maintained about the source of the item and its creator to facilitate a decision?
- Version control. How can changes made to a document be tracked and the appropriate catalog entries updated?
- Archiving. What assurance can there be that the digital materials will be retained somehow in their original form for an indefinite period?
- Authenticity. How can the genuineness of materials be assured?
- Reviews. The system should allow the user to scan reviews of the retrieved work and then add his own reviews or comments to a database.
- Citations. How may a user readily learn which works have cited the retrieved work, either favorably or unfavorably?

ECONOMICS AND POLICY

While a huge amount of material is in the public domain and may be freely assimilated into a digital library, the most valuable items are recent and protected by copyright. In order to induce copyright owners to allow their content to be accessed or downloaded from digital libraries, mechanisms need to be developed to compensate them appropriately. In the most extreme case, an author might himself produce but a single electronic copy of a work. In order to justify his effort, he might have to sell it for $100,000. Such a sale

would be impossible if the buyer were not able to charge for use of the material, and in fact charge enough to make a profit.

Fortunately, digital libraries theoretically permit precise measurement of the use made of content. A secure browser, for example, might prevent copying, printing or retransmission of material. Automated permission systems can be developed whereby users can pay directly for certain kinds of licenses. These in turn require metadata concerning the collection of rights the library has obtained for the item.

However, the implementation of charging requires another paradigm shift. The cost of building and maintaining traditional libraries is borne by governments, foundations and corporations, but hardly ever by individuals directly. Usage of materials is free, despite the high cost of maintenance. Note that authors receive substantial money on account of libraries, because currently each library that wants a book must purchase a copy of it, and the authors of popular books receive large royalties. In the digital world, the following are necessary to preserve this revenue stream:

1. centralized organizations finance
2. subscription fees
3. fees for individual use

POLICY

Digital library policy includes several areas:

- International cooperation. Many antiquities, national libraries and much television content are government-owned. Will governments share their materials with others? Can the world's nations cooperate to build a worldwide digital library?
- Government vs. private funding. How will digital libraries be funded?
- National priorities. Are digital libraries national priorities to be regarded as fundamental infrastructure such as roads, or must they compete with other projects for funds?
- Allocation of resources. Which works will be digitized first? Should priority be given to items that are decaying? How are budgets to be divided between software/hardware and research/development?
- Librarianship. How will educational programs for digital librarians develop?
- Copyright laws and conventions. Are the laws of various countries conducive to digital exchange of information? Can content holders prevent the use of materials in a digital age?

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CHAPTER 3

EDUCATION USING DIGITAL LIBRARIES

Jerry M. Mendel

INTRODUCTION

Is there any one among us today who does not believe that education and learning are lifelong pursuits? As one of our hosts in Japan commented "They [education and learning] will be the huge market for digital libraries when distributed digital libraries and information work technologies are available to content creators." Distributed digital libraries also have the potential to revolutionize education and learning, so there is a healthy symbiotic relationship among education and learning and digital libraries, a relationship that is in its infancy.

Upon returning to the United States, after visiting Japan as a member of the WTEC panel, this author undertook a modest literature search to learn more about U.S. efforts in education using digital libraries. It was found that a lot is happening in the United States, whereas, based on the panel's trip to Japan, it seems that not as much is happening there. This chapter first reviews what is happening in education using digital libraries in the United States, after which the same is done for Japan. The chapter then draws some conclusions.

EDUCATION USING DIGITAL LIBRARIES IN THE UNITED STATES

This section summarizes what was found in the literature search, and in discussions with some educators at the University of Southern California, by answering the following questions:

1. What are the roles that digital libraries can play in education?
2. What are some unique characteristics of online materials and some important reasons for excitement about digital libraries and education?
3. Will digital libraries mean education and learning as usual; or, can digital libraries change the ways in which people are educated?
4. Are there fundamental questions regarding guidelines and design standards for teaching and learning materials to support inquiry using digital libraries, or through other online resources?
5. What are the technical problems that need to be overcome to make education using digital libraries a reality?
6. Are there any cautionary messages?

While some would argue that the Web is not equivalent to digital libraries, it is generally agreed that the Web is and will be the deliverer of digital libraries to people; hence, at some point the distinction between digital libraries and the Web blurs. This is especially true when the definition of digital libraries is broadened to

include digitized materials not found in any "conventional" library, e.g., NASA's remote sensing records, student-generated articles that result from using already-existing digital libraries, etc. Hence, some of the following comments are taken from articles that focus a lot on the Web and digital libraries.

What Are the Roles That Digital Libraries Can Play In Education?

There seems to be general agreement that digital libraries can play three roles in education (e.g., Masullo and Mack 1996):

- as a resource for teaching (curriculum development)
- as an environment for learning (student experience)
- as an authoring space (again, in support of student experience)

What Are Some Unique Characteristics Of Online Materials and Some Important Reasons for Excitement About Digital Libraries and Education?

The University of Michigan Digital Library Web page (UMDL n.d.) and Wallace, et al. (1996) succinctly summarize the following six important features of digital libraries that make them significantly different from traditional libraries in ways which support student learners:

- content is current
- content can be from primary resources
- content is comprehensive
- resources are presented in various formats
- student can publish them online
- content is readily accessible

To this list can be added re-use of teaching resources. This is the feature being focused on by the EduPort project, whose goal is to support re-use of teaching resources by reflecting teachers' experiences with materials acquired from digital libraries (Masullo and Mack 1996). Masullo and Mack maintain that "real value added comes from reuse. Teachers do excellent work of bridging materials to create rich learning experiences. It is very difficult, however, to share the results with other teachers, and only a handful of students receive the benefits of unique exemplary teaching in each case. Opened and networked digital libraries offer that opportunity."

Hoadley and Bell (1996) maintain that "... structuring Web pages based on 'content' (through keywords or topics) and 'context' (e.g., social group who produced it, discussion that gave rise to the ideas) may prove to be one of the most important features digital libraries could afford. Currently, traditional libraries and social networks coexist, but are not the same, intersecting primarily through authors' names. In the future, these information networks and social networks may be more deeply integrated, allowing us not only to follow our favorite author, but trace works that have influenced him or her, institutions that an individual participates in, and so on."

Edelson and Gordin (1996) mention that "NASA ... has a number of ongoing efforts to make their extensive online databases of remote sensing data into a valuable resource available to education at all levels." They then ask the question, "*Why would* [this] *be good for education*?" Their answer includes:

- "Students could investigate authentic scientific questions using real, complex data.
- Students would have the opportunity to study their world in order to explore policy options.
- The activities that these resources support could help students to develop a view of science as inquiry unlike more conventional classroom activities.

- Resources such as this can provide students with a common ground that links them to the community of practicing scientists."

According to Edelson and Gordin, the "goal ... of the adaptation of expert resources for learners is: *Take resources that enable experts to extend their knowledge and turn them into resources that enable learners to develop some of the knowledge possessed by experts by performing personally meaningful tasks.*"

So we see there are many reasons to be excited about the interplay between digital libraries and education.

Will Digital Libraries Mean Education and Learning as Usual; or, Can Digital Libraries Change the Ways in Which People are Educated?

The National Research Council's 1996 report, *National Science Education Standards*, states that "Inquiry into authentic questions generated from student experiences is [should be] the central strategy for teaching science." Constructivists (Honbein 1996) maintain that this should be the basis for teaching just about everything. Wallace et al. (1996) state: "Digital libraries offer a unique and unprecedented resource through which teachers can facilitate student inquiry." In the recent National Research Council publication quoted above, "… emphasis on inquiry is pervasive. Yet, when it comes to textbooks and curricula as they exist today, the clear emphasis is on learning science content disconnected from experience. Although digital libraries can't change pedagogy or textbooks, they can make it possible for students to have access to scientific information and data which interests them, a fundamental requirement for authentic inquiry. Digital libraries can provide teachers with a feasible way to let students pursue their own interests within the bounds of the curriculum and without creating an enormous amount of extra work in providing students with materials to support their investigations."

The Wallace article explores the ways in which digital libraries can support inquiry learning. It concludes "... in themselves, digital libraries will not make a change in education without changes in the tasks students are asked to perform and in the support provided to students and teachers." The UMDL Web page (UMDL n.d.) also claims that online inquiry materials may also share the following important learning characteristics with inquiry based materials: authentic questions (i.e., the questions must be meaningful and important to the student for learning), flexible questions, and open-ended and divergent answers.

Soloway (1996) mentions that as of 1996, the National Research Council's new standards for science education resonate with those recently put forth by the American Association for the Advancement of Science, namely: "the emphasis in science classrooms needs to be on inquiry, rather than on didactic instruction and memorization; rather than being exposed to a broad range of content materials, students need to pursue a few science topics in depth." He then goes on to say that "... the still evolving concept of a *digital library* may well be the missing piece [for accomplishing this], bringing networked collections of digital resources (e.g., primary sources, current information, multimedia formats) together within a coherent and accessible framework. Still further, unlike their physical cousins, *digital* libraries afford students the highly motivating opportunity to publish their findings for all to review."

Although a lot of research into how digital libraries can be used in education is directed at science, there is also a substantial effort directed towards the humanities. Tally (1996) states that "the Library [of Congress] has asked [the] CCT [Center for Children and Technology] researchers and curriculum designers to help them understand what roles these kinds of online resources can play in history and social studies classrooms, and what kinds of support teachers and students need to use them well." He notes that "On-line historical archives invite teachers and students to confront new kinds of materials, new perspectives on historical events, and a new need for historical context. Ultimately, using these resources to advance a more dynamic, inquiry-based approach to history teaching and learning will require creative teachers to collaborate with each other—perhaps using the Web itself—and share lesson plans, teaching approaches, and assessment methods."

Humanities Web sites have been collected (http://edsitement.neh.fed.us) on "Top Humanities Web sites," where they are cataloged under four categories: literature, art history, foreign language, and history. Many of the Web sites that appear under each category are cross-listed in two or more categories. History, for example, had a list of 16 Web sites as of April 15, 1998, including one called *The Digital Classroom*,

established by the National Archives and Records Administration (NARA). Its stated purpose is "to encourage teachers of students at all levels to use archival documents in the classroom." It "… provides materials from NARA, methods for teaching with primary sources, and sample lesson plans."

Are There Fundamental Questions Regarding Guidelines and Design Standards for Teaching and Learning Materials to Support Inquiry Using Digital Libraries, or Through Other Online Resources?

According to the UMDC Web site "The University of Michigan Digital Library (UMDL) Project provides guidelines and design standards for teaching and learning materials to support science inquiry through on-line resources." (For additional discussions on the UMDL approaches to inquiry-based learning see Atkins et al. 1996). Although their work seems directed at public schools and public libraries, and science education, they raise questions that are so fundamental that this author believes they are applicable to all levels and types of education (K-12, higher education, and continuing education) and all types of libraries. The questions are grouped into four categories: structure of the online materials, student learning, teacher use, and implementation issues. Because of the fundamental nature of these questions, they are repeated, slightly modified, here (as given in UDML n.d.). In some of the questions parentheses have been added around the word "science." Doing this does not seem to change the fundamental nature of these questions.

Structure of the Online Materials

Digital resources provide students with unprecedented access to information, but unstructured material may result in information overload; hence, these questions must be considered:

1. How are the large amounts of information structured in the digital library in order for students to take the most advantage of it?
2. How can information searching be embedded as part of a learning environment to promote inquiry?
3. What kind of information is best represented in various media?
4. How do the media complement each other to help students learn?
5. What are the types of scaffolding that are most appropriate for digital library technology?
6. What are the issues in developing interfaces that implement such scaffolding strategies?
7. When should scaffolding be folded as student expertise in using the digital library increases?
8. How does one avoid the exponential learning curve typical of technology?
9. Because the digital library will be used as an integral part of classroom activities, what scaffolds are needed to make this use effective?
10. How are students enabled to publish their own documents in the digital library and share them with others?

Student Learning

One needs to study carefully the influence of using the digital library on student learning; hence, the following questions:

11. Does the use of online teaching materials help students develop deep understanding of (science) content and process?
12. What understanding of (science) concepts do students develop by using the digital library?
13. How does student motivation toward learning (science) change by using the digital library?
14. How does student thoughtfulness change by using the digital library?
15. How do students use online learning materials?
16. What types of artifacts are created and published on a digital library?

17. What types of interactions occur as a result of online publishing and what types of changes result?

Teacher Use

The use of digital resources has the potential to change classroom practice and the way in which teachers go about the practice of teaching; hence, the following questions:

18. How do teachers use online teaching and learning materials?
19. How do teachers make use of the various media and different parts of the digital library?
20. How does the digital library influence practice?
21. How can online inquiry be embedded as part of inquiry-based learning?
22. How does the use of online projects impact teaching?

Implementation Issues

Although the use of digital resources has the potential to change classrooms, past experience and research has shown that just giving teachers access to the materials or telling them how to use them is not enough. Teachers, too, need to be active learners in the process; hence, the following questions:

23. What initial supports do teachers need to use online resources?
24. What continued support is necessary for teachers to effectively use online materials?
25. What types of hardware configurations allow for effective use of online resources?

Again, these 25 questions have been taken from UMDL Web page (n.d.).

What are the Technical Problems that Need to be Overcome to Make Education Using Digital Libraries a Reality?

According to Masullo and Mack (1996), "... key problems are capturing ... material in digital form (e.g., digitized videos, scanned text, descriptions of videos and images), organizing it so it can be found, and developing some level of tools for re-using this material in new pedagogically relevant ways." Wallace et al. (1996) note that, "Current search engines and Web browsing software are not adequate for learning environments. Web browsers encourage breadth-first searches, and are often extremely frustrating for students." Tally (1996) states that "The most commonly discussed challenges of teaching with online resources are practical—access to good quality information, speed of downloading, the time necessary to find and make good classroom use of the material. All of these hurdles must be faced with electronic primary source archives."

Other chapters in this report focus on all these technical issues, but do so outside of the context of what is probably the most important application for digital libraries: education. Education has its own special needs, as captured by the 25 UMDL questions just given. Technical solutions for scanning texts, describing videos and images, etc., must therefore be driven by educational requirements.

Edelson and Gordin (1996) state that "The value of digital libraries is in the authentic activities that they can allow learners to engage in... To capitalize on their potential, these digital libraries need to be made accessible for learners through a variety of *bridging strategies*. ... supportive interfaces, activities design, resource selection and organization, and documentation ... designed to provide learners with enough of the hidden context and knowledge that experts bring to their tasks to enable students to use the digital resources as learning resources. These bridges require additional effort above and beyond the construction of experts' digital libraries, but they take the form of value-added support that leverages the initial investment. The addition of these bridges can transform these resources into invaluable resources for education, and can make digital libraries a common ground that provides a meaningful link between scientific researchers or other expert practitioners and the educational community. Creating such a common ground will increase the likelihood that the graduates of our educational system will be prepared to make sound decisions informed by results from the scientific community. ... The key to adapting digital libraries designed for experts is creating

a *bridge* between the learner's goals, abilities, and knowledge, and the requirements for productive use of the digital resources." Once again, the problems seem to involve a strong interplay between technology and education.

Any Cautionary Messages?

Wallace, et al. (1996) caution against using the digital libraries to answer very specific questions, because students become frustrated sifting through lots of material looking for a single piece of information; these can be answered more easily using an encyclopedia.

As an aside about encyclopedias, some are already available either online or in CD-ROMs, and incorporate text, audio, graphics and video. They serve a very useful purpose, in that they present "knowledge" as distinct from "information." They also come in different varieties for different age groups. Their possible drawback is that some group has made the decision about what is knowledge versus what is information, and the group's extracted knowledge may very well be presented from its biases or those of the publisher of the digital encyclopedia.

Digital libraries may someday contain source materials from which anyone could create a digital encyclopedia, although this may not be very practical. What may be more practical is for the companies that already have a digital encyclopedia to tap into the vast resources of digital libraries, making their existing products even better, by including links into television sound-bytes, news reports, journal articles, etc.

Hoadley and Bell (1996) note that "Multimedia representations did not lead students to cite more 'correct' scientific ideas, although it did encourage them to cite more ideas in general, which can be helpful in encouraging a group of students to brainstorm and consider alternative explanations for phenomenon."

No doubt, there are other cautionary messages that can be found in the literature, but the search performed did not find them. Certainly, one of the most important considerations is one already mentioned in Chapter 2 of this report by Raj Reddy: authenticity/veracity of material found on the Web.

EDUCATION USING DIGITAL LIBRARIES IN JAPAN

The panel did not meet with any Japanese K-12 educators, nor did it meet with any faculty from schools of education at Japanese universities. Also, no Japanese Web pages were checked to see if there are online journals comparable to *D-Lib Magazine*. Even if there were such journals, this author would not have been able to read them, since he does not read Japanese. So the reader of this chapter must take the comments made below, regarding the state of Japanese education and digital libraries, as perceptions of that state, perceptions gleaned from speaking with a very small number of people in Japan. To get a more thorough sense of education using digital libraries in Japan would require focusing on Japanese educators, either through another visit, or by collaboration with the most knowledgeable ones. In short, more work needs to be done.

In Japan the emphasis today appears to be in getting content online, with the main emphasis on rare books and manuscripts, theses and journal articles. University-level educational research is and will be possible, because university libraries will be the repositories of this information. Until sharing across digital libraries is possible, it is not likely that there will even be such research across universities. In the United States the concept of sharing is agreed upon; in Japan, it does not seem to be.

In the United States, there is also a big recognition of the interplay between education and the digital library. That same recognition does not appear to be so prevalent in Japan. Digital libraries do not appear to be making an impact in K-12 education. The Ministry of Education (MIE) is providing resources so that every elementary and middle school will have 20 computers, and every high school will have 40 computers; but the MIE is reluctant to provide resources for communications (e.g., Internet connections). This means that it is very problematic that students will be able to go online and make use of the digital libraries.

In Japan, it is very prestigious and important for a student to be admitted into an important university, such as Tokyo University or Kyoto University. So a market exists for companies to prepare students to take university entrance exams, for which students' parents will spend a lot of money. There is no market for K-12 students while they are in K-12, however, which is one of the reasons that Nikkei, a company that is very heavily involved with digital information, is not interested in this student population.

At Keio University, there is the Humanities Media Interface Project (HUMI project), which was launched in Spring 1996 with the aim, among others, of digitizing major rare books and manuscripts—Western, Japanese and Chinese—in the Keio collection, including the Keio Gutenberg Bible. The HUMI Project has been supported by the Ministry of Education, Science, Sports and Culture (*Monbusho*), the Information-Technology Promotion Agency (IPA), which is attached to the Ministry of International Trade and Industry, and Keio University. The library has a very large collection of rare books, including 8,000 Western rare books. The project managers seem to have a very progressive view of digitization of books, namely that, once digitized, the books can be examined or reassembled any way a person wants. The Keio Gutenberg Bible has played a very important role in the HUMI Project. The Bible was acquired not just for possession of an important article of Western cultural heritage, but because Keio University believes that modern research libraries should possess works significant enough to be digitized for the benefit of today's scholars. The university also wishes to promote the greater goal of preserving these treasures for posterity without further decay. For more discussions about the visit to Keio University, see the site report in Appendix C.

The HUMI Project is a clear indication that some very serious work is indeed occurring in Japan regarding education and digital libraries, and suggests that much more may indeed be occurring than we had the opportunity to observe directly. Prof. Naohito Okude (Keio University) sent this author some important observations about the digital library in education, in an e-mail message. Professor Okude's comments are paraphrased below, because not only are they somewhat visionary, but because they are also very optimistic about education using digital libraries:

> Contrary to the general assumption that hypermedia obliterates the past, digital technology is radically reconfiguring our understanding of history. Being digital in a research library requires designing a post-Gutenbergian research model for the humanities. Digital technology forces us to recognize that texts are not higher than images. Computers rid us of the assumption that sensory messages are incompatible with reflection. Once digitized, fleeting images become available to anyone who "reads" them on a graphics computer. Imaging becomes a rich and fascinating mode for communicating ideas.
>
> In order to conduct a professional image search within the humanities, serious training in visual proficiency is needed. The image search is an activity of focusing on cross-disciplinary problems in arts, graphics, film, video, media production and their different histories.
>
> Learning has always been a people-to-people process. Digital library technology will promote a computer-mediated people-to-people learning process. This technology will have to expand from its traditional areas, such as information retrieval and distance learning, to the new frontier of information work application to assist distributed learning and the process of inquiring using a networked system.
>
> Computer-human interface should be a central research agenda item for digital libraries. In addition to keyboards and mice, trackballs and joysticks, as well as gloves, helmets, glasses and body-suits, move an object on a computer screen. These multi-modal interfaces are not only immature in their development status, but they also are not intelligent. Future interfaces will be intelligent and will mediate communication between the researcher and the distributed computer network to make the latter more responsive to the former's wants and needs. New multi-modal intelligent interfaces will let the researcher span the continuum from passive reception of research data to active creation of new research results.
>
> Virtual reality (VR) technology is most appropriate for representation as well as research. Bit-mapped graphics-based supercomputers can run high-speed graphics and track human movements. Immersion, interactivity, and information intensity are the three main characteristics of VR

technology. In the next ten years we can expect a widespread and growing experience of VR in a variety of everyday educational and learning environments.

The real market for digital technology is not the "information market" but the "information work" market. The technologies for information work let a person or a computer program take in information, transform it, and send it out. Today's content creation technologies do not yet fulfill these functions.

When people and organizations all have computers, and all these computers are interconnected, they will sell and freely exchange information and information services. The digital libraries will then take the role of information managers in the age of the convergence of communication and computation, and new distribution technologies will emerge to link one digital library with other digital libraries, in order to effect digital data assistance. The role of the nineteenth-century library as the custodian of physically printed materials will remain but the digital libraries will also become distributed information managers of the links to other digital libraries. A grand distributed global digital library is the dream and the final goal of the digital libraries endeavor.

Each library will someday offer its collection in electronic form. To users, the collection of worldwide distributed libraries will look like one uniform library. To achieve interoperability of digital data at this level, enhancements of networking capabilities, interface design, and object-oriented databases are needed. Without this open architecture and deployment of distributed object-oriented technology, there is no future for the digital library to scholars and other people who want to use the libraries for their creative activities. Every library around the world should communicate with each other so as to contribute a consolidation of diverse human knowledge and experience.

Education and learning will be the huge market when the distributed digital libraries and the information work technologies are available to the content creators. Education and learning are lifelong pursuits. Within a few decades, people in Japan will come to the university at irregular times and will take more than four years to graduate. They will study for more years and will study more. This fragmented and discontinuous pattern is more of an expectation than the norm now, but students in the future will attend in broken times, and will often learn from more than one institution. This knowledge consumer market is the digital libraries' business domain.

CONCLUSIONS

As noted in the introduction to this chapter, distributed digital libraries may well revolutionize education and learning, but this will require resources, resources, and more resources.

Resources are needed to digitize vast amounts of materials. Hoadley and Bell (1996) state that "Education is often held up as a prime beneficiary of digital libraries. However, the obvious benefits, such as distance education or literally global text search, fall short of justifying either the lofty expectations for an educational revolution or the enormous cost of putting everything on-line." Perhaps, a demand-driven model should be used to establish priorities for what is digitized. These priorities could be established by professional educational societies and educational arms of technical societies. Then, educational representatives of higher-level National Academies could meet to prioritize across fields. Using this approach, there is a high likelihood that whatever is digitized would indeed be used by a large number of people, thereby justifying the large costs associated with digitization.

Resources are also needed to solve the myriad of open technical problems that have been discussed in other chapters of this report, but subject to the constraints of education. This, of course, means that the educational constraints are known. Unfortunately, that is not the case today. One must work through the 25 UMDL questions in order to establish all of the constraints. Resources are therefore needed to develop effective ways for teaching and learning using the digital libraries. If such resources are not made available or found, then it is indeed foolhardy to believe that digital libraries will make much of an impact, if any at all, on education.

Without computers available to students, it will not be possible for the digital libraries to make a significant impact on education. Today in the United States only 35% of all college students own a computer, and only 50% of all faculty do (Market View 1998). No doubt, the numbers of K-12 students and their teachers who own a computer are much smaller. Resources must be found to bring these percentages up to much higher values, or else digital libraries will not benefit all students. Instead, they will be an important benefit only to those who can afford to own and maintain a computer.

It seems that more resources are being directed at the myriad of problems associated with digital libraries in the United States than in Japan.

In conclusion, we may indeed be at the very beginning of a "dawning of an age of Aquarius" in education, because of digital libraries. The concept and its ramifications are breathtaking. Time will tell.

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CHAPTER 4

ARCHITECTURE AND SYSTEMS

Tryg Ager

INTRODUCTION

This chapter summarizes, compares, and evaluates the digital library architectures, systems and software components the WTEC team learned about in Japan. The baseline for comparison is a reference architecture derived from a set of core capabilities of digital libraries. The team was not charged to investigate digital library implementations in detail, so both architecture and systems will be described from a general or reference model standpoint. The team did find, however, that the concept of digital library is frequently explicit in Japan, both in the plans of technology providers, where numerous point solutions, components, and products were seen, and in operational information management approaches in businesses, universities, and museums. The WTEC teams found many different architectural approaches and system designs. In this chapter, a few examples are discussed in order to develop the general findings. Not all sites the WTEC panel visited are represented, but most of the main themes observed on the trip are covered. The sites that will be covered are the following:

- Nara Institute of Science and Technology (NAIST)
- Nihon Nikkei
- National Museum of Ethnology
- IBM Global Digital Library
- Fujitsu Multimedia Library Vision
- Japan's National Digital Library II Project

PRINCIPLES OF DIGITAL LIBRARIES

The purpose of a digital library is to provide coherent organization and convenient access to typically large amounts of digital information. The following principles provide working definitions of a digital library from both a conceptual and a practical standpoint:

- A digital library is an integrated set of services for capturing, cataloging, storing, searching, protecting, and retrieving information.
- Digital library services bring order where data floods and information mismanagement have caused much critical information to be incoherent, unavailable, or lost.
- Digital library architecture emphasizes organization, acquisition, preservation, and utilization of information.

- Digital library systems are realizations of an architecture in a specific hardware, networking, and software situation.

Core Capabilities of Digital Library Systems

Digital library systems compose a family of automated systems that together provide a comprehensive capability to manage the digital content of an enterprise. It is useful to divide the capabilities of digital library systems into the following areas:

- capture or creation of content
- indexing and cataloging (metadata)
- storage
- search and query
- asset and property rights protection
- retrieval and distribution

Content exists in multiple sizes, formats, and media, each with accompanying technical challenges. Content may be structured or unstructured. It may have exact, precise meaning; or it may be fundamentally ambiguous. Content may directly or indirectly support a business process or function.

A digital library architecture shows how capabilities are realized and related, and does this at several levels. Digital library architectures show how business processes or functions are enhanced; they show how technology components fit together and how, in detail, components interoperate with each other.

Such functions and relationships, when reduced to a particular software and hardware implementation, lead to operational digital library systems.

Digital Libraries and Traditional Libraries

Digital library functions, insofar as they purport to organize information, may be compared with traditional library functions. Consider digitization, which technically is the conversion of analog to digital formats. A common human artifact, such as a bound book, loses value when simply scanned into bits. In a library context, where organization, access, protection, and preservation are important business functions, digitization technologies are starting points for a complicated set of computational processes that in the first instance reconstruct the cultural, conventional, and intuitive significance, structure, and external relationships that defined the original artifact. Additionally, digitization and other processes may be able to add value and support certain fiduciary responsibilities that resemble functions of traditional libraries.

In a similar way, other core capabilities of traditional libraries can be transposed to the digital domain. Cataloging is transposed to the generation of metadata, and is an area where much work needs to be done to develop automated, multidimensional indexing and cataloging procedures. Just as the public card catalog is a gateway to the holdings of a conventional library, search of content and metadata is the gateway to a digital library. Circulation in a conventional library transposes to network access, retrieval and delivery.

The fiduciary responsibilities of traditional libraries are related to issues of copyright protection and intellectual property rights. Table 4.1 relates digital library capabilities to well-known capabilities of traditional libraries. The point is that traditional libraries have established uniform business processes and highly interoperable data formats which support especially bibliographic catalogs, item ordering, and interlibrary loan. Although many of these procedures pre-date "digital" libraries, digital library design can benefit from the comparisons.

Table 4.1
Comparison of Digital and Traditional Library Capabilities

Digital Library Capability	Traditional Library Capability
Capture	Acquisitions and collection development
Catalog and Index	Cataloging rules and bibliographic control
Store	Stacks, inventory management and shelf lists
Search	Public card catalog
Protect	Patron privileges and circulation rules consistent with public law and policy
Retrieve	Loan management and interlibrary loans

Having made these comparisons, it must be emphasized that neither in the United States nor in Japan is the digital library regarded as a technology related to library automation or the provision of integrated library systems for operating traditional libraries. None of the digital library projects visited in Japan either utilized or were based on library automation technologies. On the contrary, the panel saw digital library technologies, which very strikingly enabled the digital library capabilities enumerated in this chapter, creating new lines of business in both public and private endeavors.

DIGITAL LIBRARY ARCHITECTURE

In the following paragraphs an architectural approach to the digital library will be developed, which is based on taking the fundamental capabilities, introduced above, as the fundamental requirements the architecture must satisfy. I begin with the following notional architecture for digital libraries:

- A digital library approach to information management depends fundamentally upon a distinction between data and metadata. Metadata provide external classifying and organizing relations for data that may be unstructured, complex, or very large.

- Middleware services such as search, asset protection, and retrieval processes depend on metadata. Since metadata refers to data, which may be stored in separate hierarchical storage subsystems, integrity of reference must be maintained between metadata and data.

Figure 4.1 illustrates these fundamental distinctions between data management and metadata management, and between ingestion and utilization of content.

Operational Architecture

Operational architecture is an information management system represented in terms of the business processes it supports, and how information related to conduct of the business processes passes through the system's components.

The example shown in Figure 4.2 is an enterprise that conducts training by utilizing an extensive computer-based simulation system. The operational (business) processes, most obvious in the example, depend on the timely and well-organized capture of training information as it happens, and both contemporaneous and retrospective search and retrieval of information from a training event. Although the information is generated in several different enterprise domains (eight in the example), effective utilization of information often depends on cross-domain searches and retrievals. Therefore, digital library services must provide information interoperability in middleware.

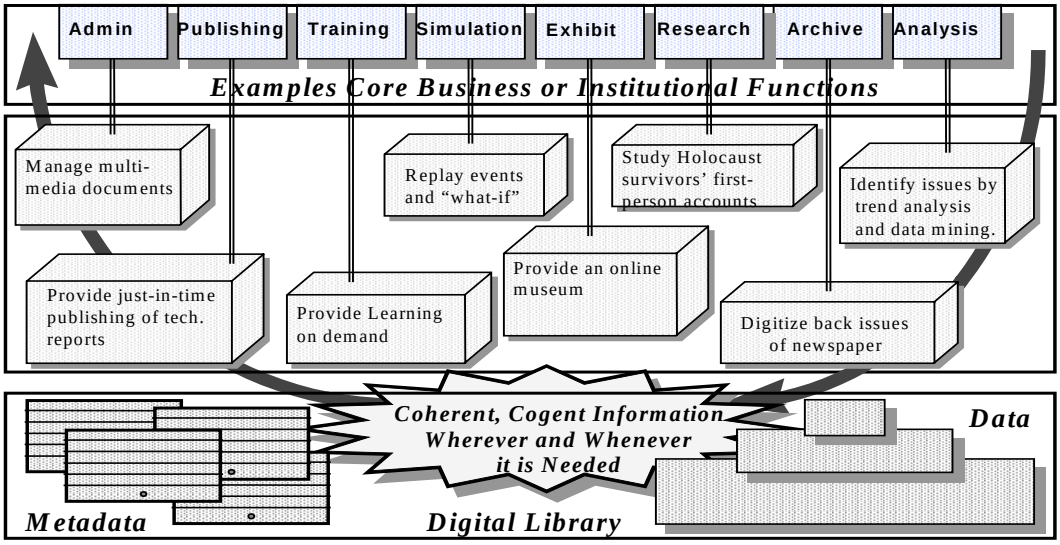

Fig. 4.1. Notational architecture—building blocks of information to enhance existing functions and enable new operational capabilities.

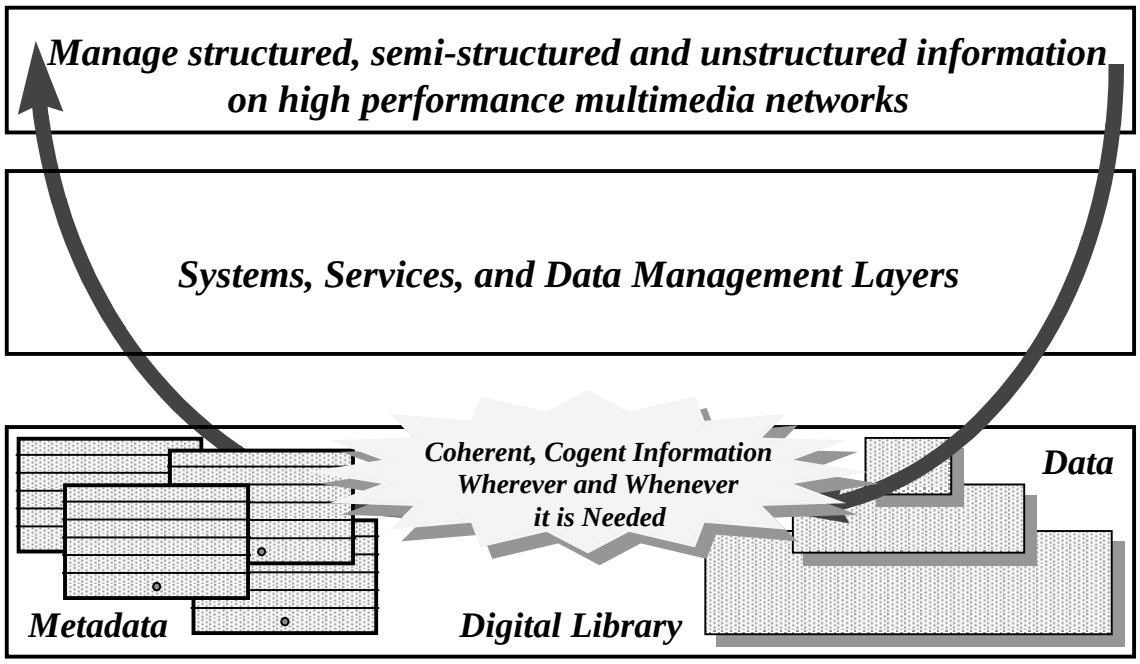

Fig. 4.2. Operational architecture.

Technical Architecture

A technical architecture breaks down operational (business) processes into functional components and capabilities (Figure 4.3). Hardware and software implementations are still not resolved.

The utilization of digital library materials depends on the existence of metadata to give an efficient and accurate view of content. Metadata must be created as content is added to the digital library. Metadata and data must be bound together logically, and there must be a robust underlying technology to manage the

logical connection through time, across platforms, and over geographical separations, all on a networked, distributed system.

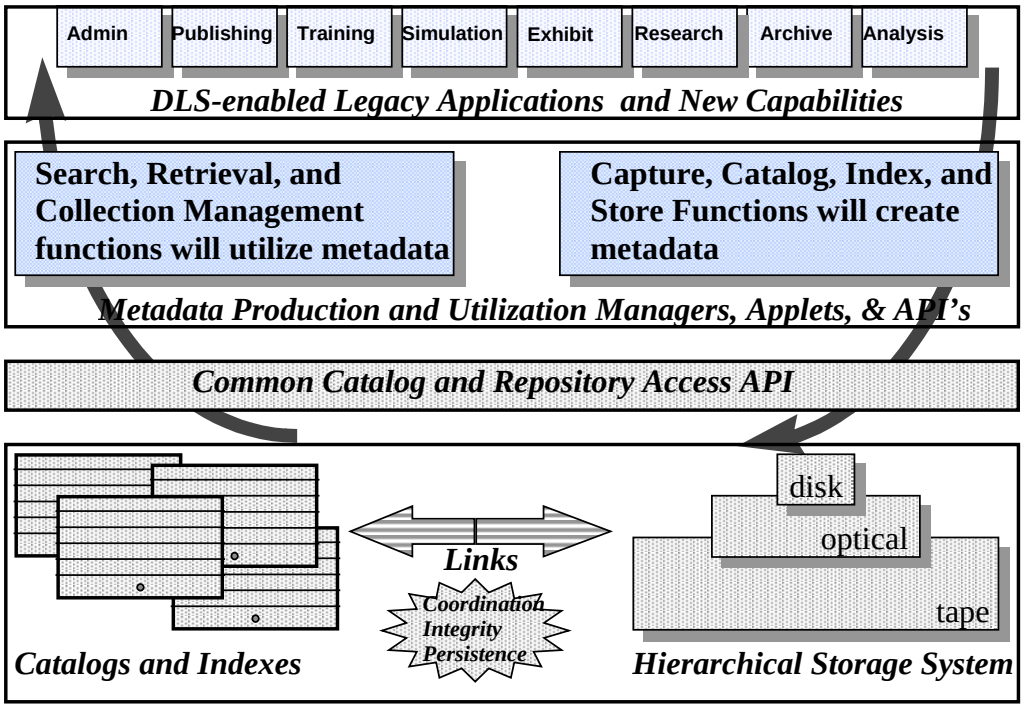

Fig. 4.3. Technical architecture.

Systems Architecture

A systems architecture shows the technology enablers and their inter-relationships. In Figure 4.4, the digital library is a centralized subsystem that interacts with a variety of data producers and consumers within a complex distributed system.

A fully detailed systems architecture resolves into software and hardware systems. Desirable systems properties such as scalability and extensibility can be taken into account at the systems architecture level. The systems architecture is rationalized relative to the operational and technical architectures.

THE DIGITAL LIBRARY IN JAPAN

This section will show how specific examples of digital libraries in Japan align with the design principles and the reference model sketched. It will try to represent each case on its own terms, leaving general comparisons and evaluations until the end of the chapter.

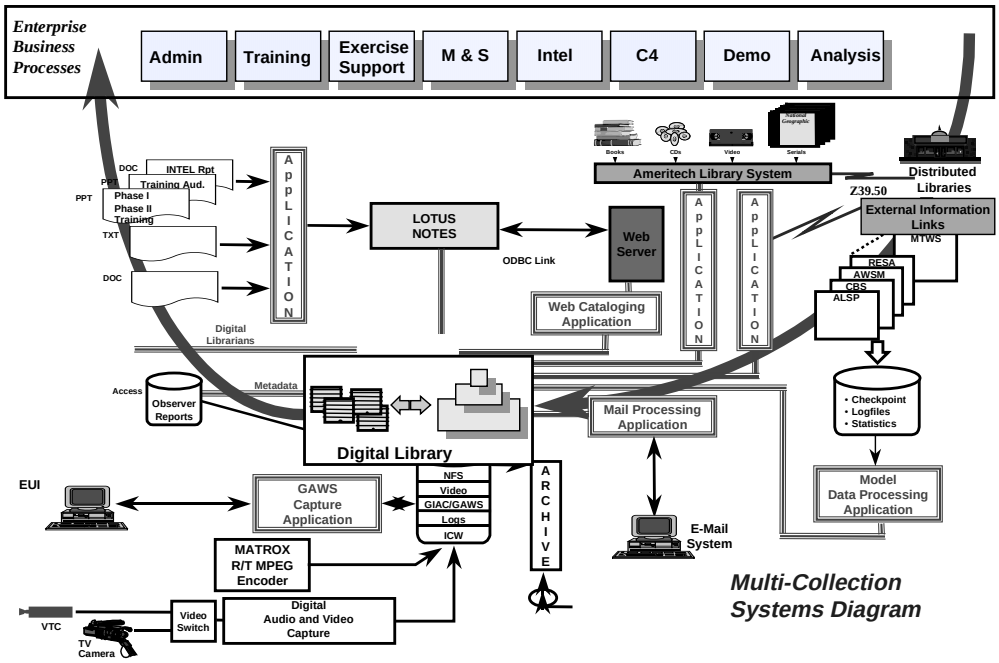

Fig. 4.4. Systems architecture.

Nara Institute of Science and Technology

This section begins with the digital library at the Nara Institute of Science and Technology (NAIST). NAIST's digital library is functional today and exhibits all the characteristics of the generic digital library reference architecture. The presence and management of both data and metadata is especially apparent in the NAIST technical and operational architectures (see Figure 4.5). The reader is directed to the site visit reports (Appendix C) for descriptive information about NAIST.

Capture and Catalog

The acquisition or capture process at NAIST is based on local conversion of print materials to digital form. Semi-automated means are used to prepare journals for scanning. For journals, article-level bibliographic data are produced; the articles are scanned and passed through optical character recognition systems for both English and Japanese texts. NAIST uses external cataloging services from NACSIS, a national service, which provides bibliographic records for many Japanese libraries.

Store

NAIST conceptualizes storage as a multimedia database, but clearly separates the "primary content" from metadata, which, as the NAIST concept of operations diagram (Fig. 4.5) indicates, are a mixture of bibliographic, presentation, inventory, and navigation data.

Protect

NAIST does not use technologies beyond user login to protect content. NAIST relies on publisher agreements to manage copyright issues.

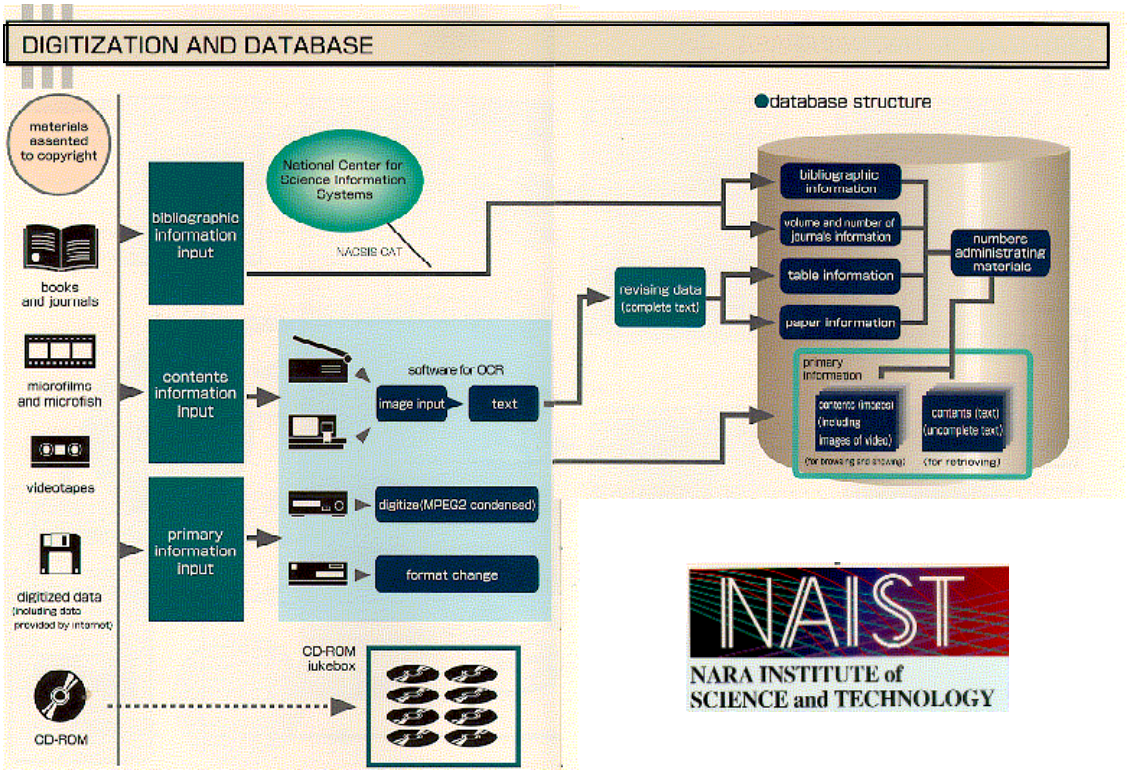

Fig. 4.5. Operational concept: NAIST University Digital Library.

Search and Distribution

The NAIST interface for query and retrieval is mainly Web-based, but there are specialized video presentation and editing workstations.

NAIST's digital library mission subsumes traditional research library missions, and practically all library capabilities are partially or fully realized with digital technologies. NAIST includes all core capabilities of a digital library and was the most complete example of a digital library that we saw.

From an architectural standpoint, NAIST's digital library aligns with the reference model, with emphasis on multimedia as the content rather than an abstract content type such as "library holdings" or "library objects." Implementation is largely through integration of off-the-shelf components running on commercially available systems, servers, and networks.

NAIST's systems include five main subsystems and interconnections to campus and external networks (Figure 4.6):

- The input system includes capabilities to digitize materials, especially journals and technical literature. There are color and monochrome scanners, digital cameras, and microform conversion equipment, and capability to convert already digitized materials for storage and retrieval in the NAIST digital library.
- A video subsystem supports special conversion and delivery requirements for quality of service for video ingestion and playback. Commercial (SGI Challenge XL) equipment is used.
- The main storage subsystem is controlled by an SGI Challenge XL. A hierarchical storage system is used with hard disk, optical, and tape capacity.

- The retrieval subsystem includes World Wide Web serving, and some special client-server capabilities that utilize SGI Indy workstations.
- A business support subsystem manages the administrative computing for the digital library.

NAIST adopts mainline technologies and builds most digital library services upon a readily available commercial base. The panel did not find, however, that the NAIST digital library, or any other Japanese example was either built upon or extended the capabilities of conventional, commercial automated library systems. NAIST's operational concept is very advanced. Remarkably, NAIST's system implementation is very conventional.

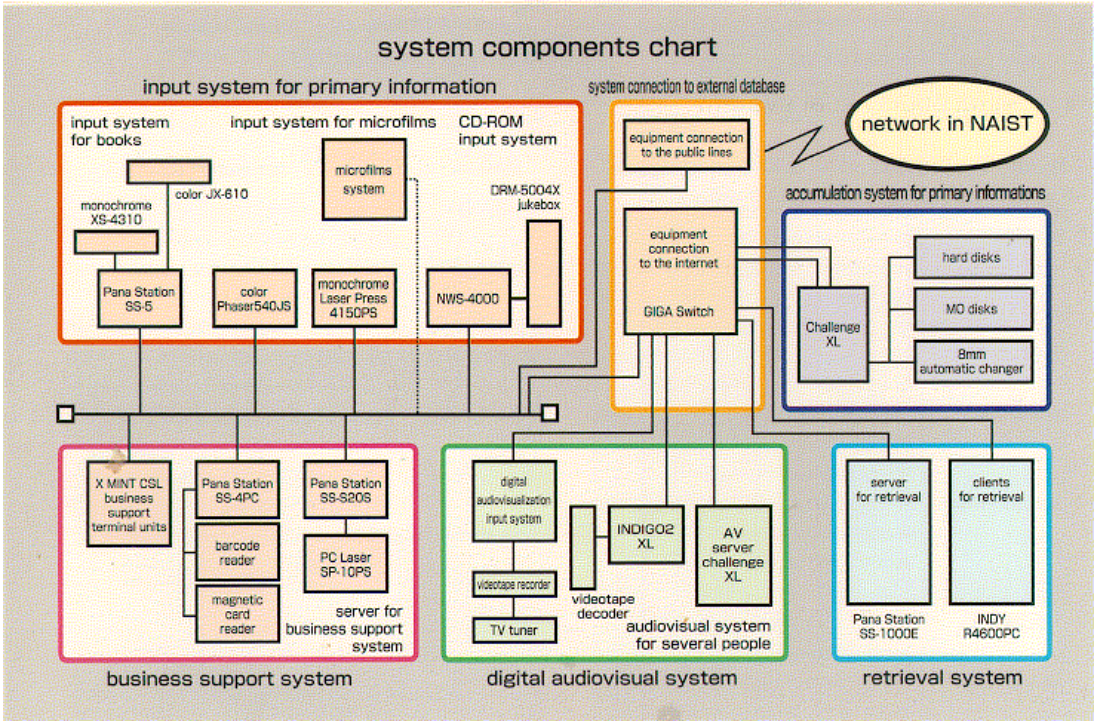

Fig. 4.6. Systems concept: NAIST University Digital Library.

Nikkei (Nihon Keizai Shimbun)

Nikkei demonstrates how digital library technologies provide support for new and expanded lines of business where information management is central to core business functions. Nikkei's systems illustrate the following principles:

- Nikkei has designed and built a comprehensive system for organizing digital information.
- The architecture and system design are driven by business processes.
- Well-managed digital information permits creation of new lines of business
- The recent history of Nikkei online services illustrates commercially viable scaling and market segmentation

The reader is directed to the site visit report (Appendix C) for further details about the scope of Nikkei's newspaper and information businesses.

The Nikkei concept of operations is shown in Figure 4.7, taken from a 1997 corporate overview. News gathering corresponds to the acquisition function of a digital library, but in the Nikkei situation, one sees that capture technologies, such as scanning, are secondary. Instead, the emphasis is on information gathering by

a worldwide staff of reporters. The Nikkei automated systems are sharply focused on converting information into information-intensive products and services that are distributed via print, broadcast, and online media.

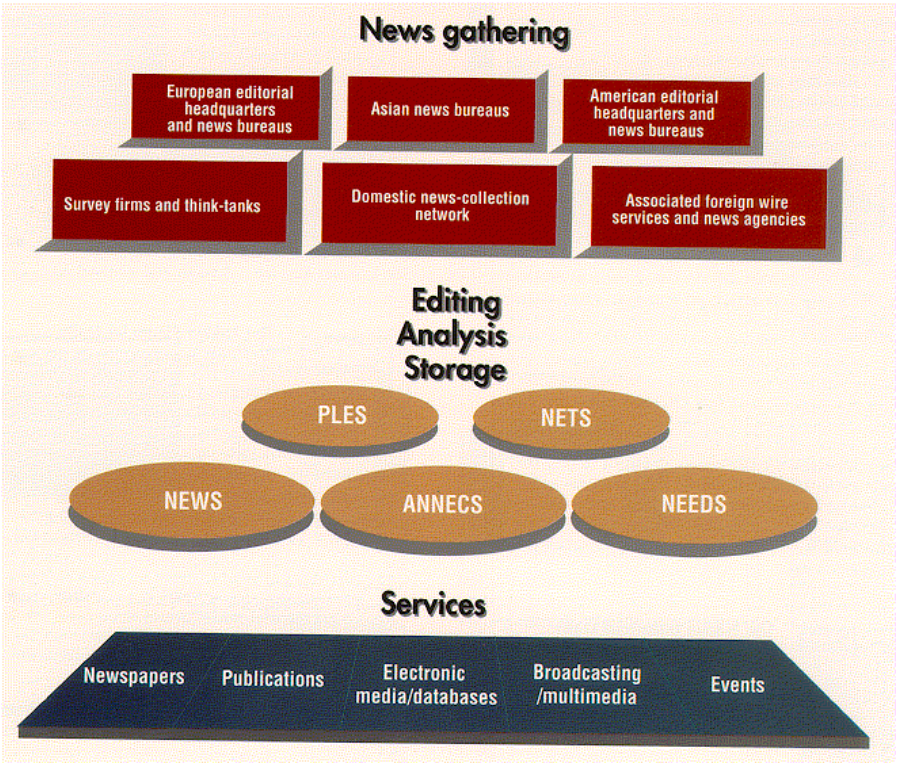

Fig. 4.7. Nikkei operational concept.

The operational concept diagram (Figure 4.7) shows Nikkei's fundamental information acquisition resource: a worldwide team of reporters and news-gathering offices (the blocks at the top).

The ovals represent automated information management systems that are very good examples of the application of digital library approaches to a commercial information service. The systems shown are an editorial system, a publishing system, and three network-based businesses that distribute various blends of information, most of which has passed through the editing and production processes.

Nikkei has mastered the problem of building a system for management of digital information that can very easily adapt to new technologies (e.g., Internet). This achievement appears to derive from an operational architecture that is explicitly designed to re-purpose and leverage information that is derived from or complementary to the newspaper production system. But in leveraging its core capabilities, Nikkei is pursuing new lines of business, such as being the Japanese supplier of AOL.

PLES

PLES is the PaperLess Editing System that prepares material for publication (Figure 4.8). PLES processes the information produced by the worldwide staff of 1,400 reporters, data gathered from wire services, and other internal archival and current information resources. Interestingly, it uses a text-to-speech system for copyediting. It is believed that multi-modal editing (both listening and reading) is more accurate than simply reading copy. PLES also includes a complete graphics input system, including scanners and digital format conversions. PLES corresponds to the capture and catalog capabilities in the digital library reference architectures discussed at the beginning of this chapter. The PLES subsystem provides inputs to the computer-based newspaper production subsystem, ANNECS, shown in Figure 4.9.

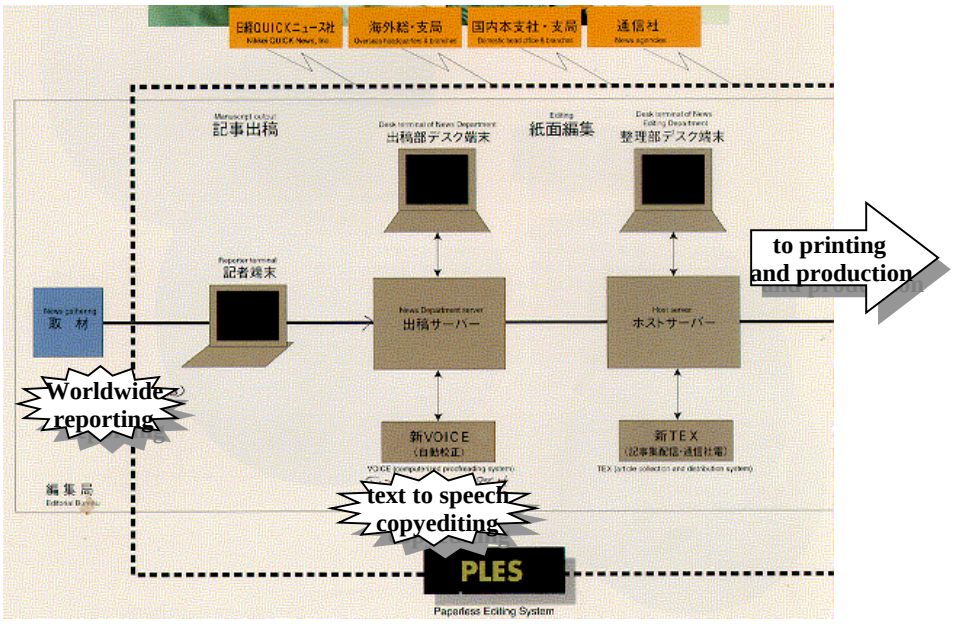

Fig. 4.8. Paperless editing (PLES).

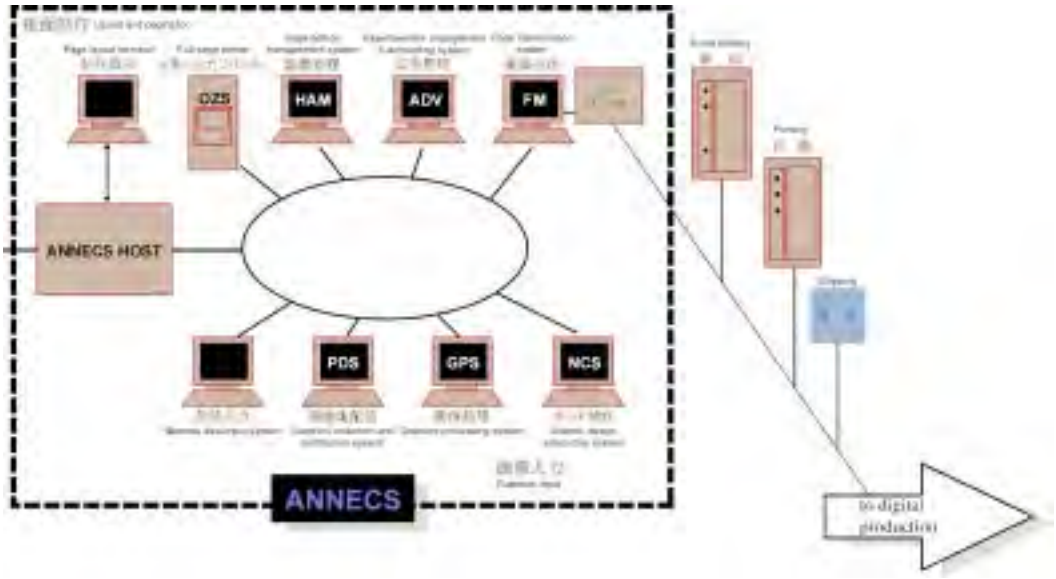

Fig. 4.9. Newspaper production (ANNECS).

ANNECS

ANNECS is the computer-based publishing system. Not only does it perform typesetting and layout, but also routes its data to other Nikkei businesses (Figure 4.9). Nikkei's approach to leveraging and reuse of information works because they have digital information which can inter-operate with a variety of systems, and which can be effectively reused in other lines of business besides publishing. One of the features of the digital library reference models discussed at the beginning of this chapter is data interoperability. Nikkei's approach depends on data interoperability. Accordingly, data that support newspaper production are passed along to subsystems that support online services and broadcast media.

Figure 4.10 shows how capture and production facilities for news gathering and newspaper publishing pay off for Nikkei by supporting additional lines of business.

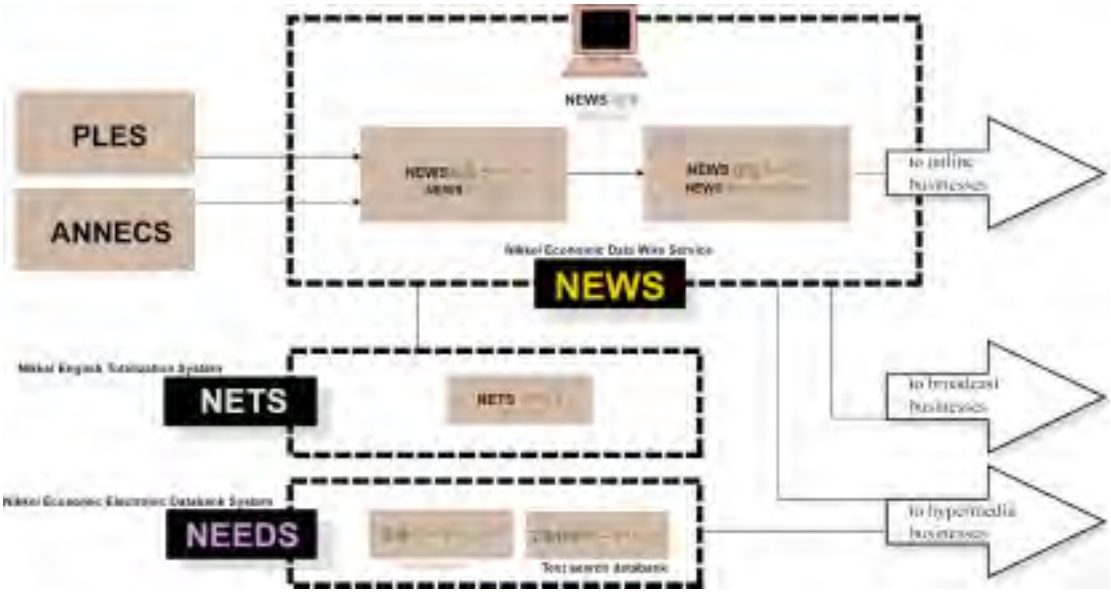

Fig. 4.10. Wire services and databases (NEWS, NETS and NEEDS).

NEWS is a distribution system (Nikkei Economic Data Wire Service) that feeds broadcast and online services.

NETS is a system to convert information originally in Japanese into English for resale or inclusion in Nikkei English-language products.

NEEDS is a database service and text search and retrieval system.

All of the above services that organize and manage digital information feed additional products and lines of business based on digital content, as shown in Figure 4.11.

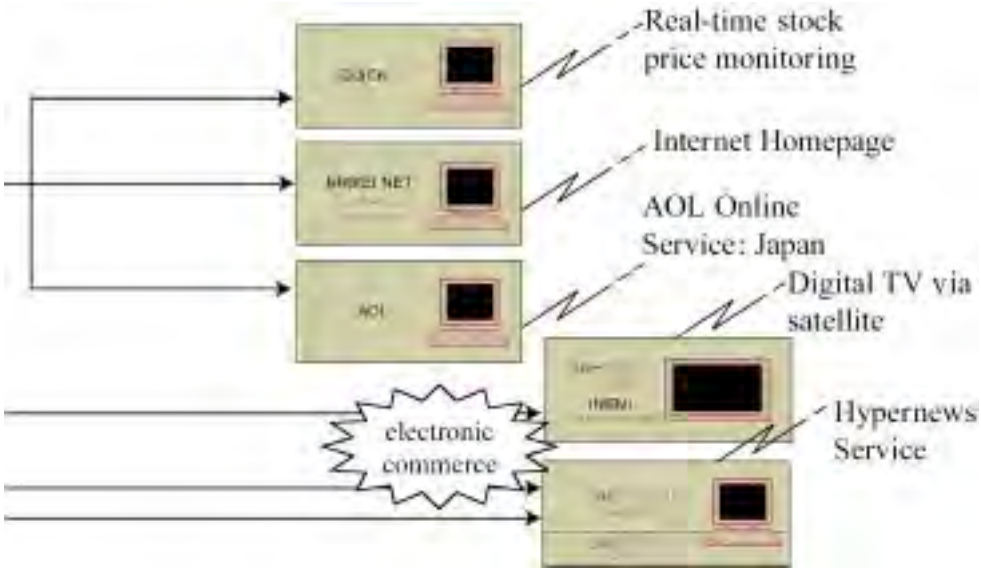

Fig. 4.11. New business based on organized digital information.

QUICK is a customizable, personalizable online product that delivers high-end business information to select customers.

NIKKEI NET is an Internet, Web-based news service that charges users.

AOL services in Japan are provided by Nikkei. Nikkei information in Japanese is a value-added product for Japanese AOL customers.

NSN is an all-business television channel that is broadcast using digital satellite technologies.

Nikkei Telecom is another Internet service that features a hyper-linked online newspaper format that offers search and retrieval for specialized business information such as corporate strategies and management news items.

Nikkei illustrates very clearly how interoperability in data and middleware can leverage information assets into many lines of business with different market targets, different selections of information, and different application-level interfaces and capabilities. The architectural and systems approaches seen in Nikkei information systems are the clearest and most advanced examples of digital library approaches to the organization of information for commercial purposes that the panel saw in Japan.

National Museum of Ethnology

The National Museum of Ethnology is a leader in utilizing technology for many aspects of museum operations, which are detailed in the site report (Appendix C). The museum is a good example of systems and architecture because all technologies at the museum are specifically designed and implemented to automate or enhance internal museum procedures.

The museum utilizes 3D imaging and measurement technologies to partially automate the acquisition process. Figure 4.12 shows one of the scanners and also gives a sense of the exhibition space at the museum. Digital library technologies are extending the capabilities of the museum, and over more than two decades, an elaborate local system to support museum functions has evolved, which features the following:

- digital library technology used to manage holdings of a museum
- support for:
  - online asset management
  - multimedia support for exhibition
  - indexing, cataloging, and search of scholarship
  - virtual collections for Internet communities
- example of a local museum solution

The museum's current systems design places technologies for individual museum functional capabilities such as video exhibits, kiosks, scholarship, asset management, and Internet on a high performance local network (Figure 4.13). This system is not designed as a single unified or comprehensive museum system. In that sense the design is conservative. However, the scale of the system relative to the museum's overall mission is very impressive, because nearly everything at the museum is strongly supported by technologies that map clearly to the digital library reference models.

Fig. 4.12. National Museum of Ethnology: operational concept.

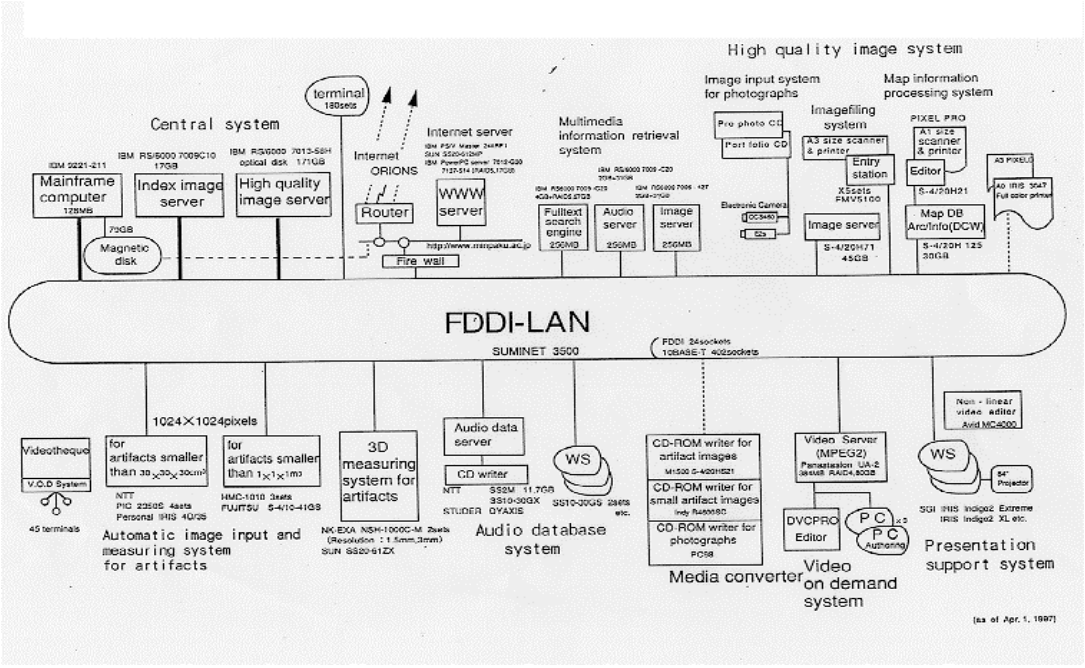

Fig. 4.13. National Museum of Ethnology: systems concept.

IBM Tokyo Research Global Digital Museum

One of the visions of digital library is global virtual collections. Working with the National Ethnographic Museum and the British Museum, IBM's Tokyo Research Laboratory has designed and implemented a global virtual museum focused on problems of K-12 museum education. The virtual museum includes the following characteristics:

- features architecture and system for worldwide virtual museum
- creates shared abstractions of collections that are managed differently
- focuses on K-12 museum education as a line of business

One of the problems a virtual collection must address is a data architecture that makes the different legacy systems of the various museums interoperable in the virtual collection space. The Global Museum Project defines data abstractions and user-level operations that allow teachers to create virtual collections for instructional purposes, and students to annotate, select, and present their own personal collections (Figure 4.14).

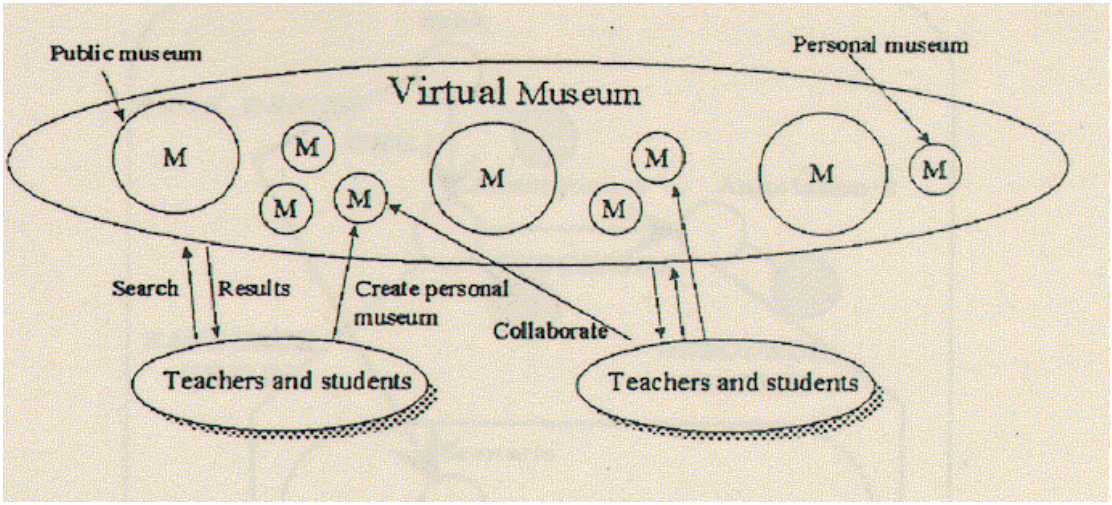

Fig. 4.14. IBM Tokyo Global Museum: operational concept.

Fujitsu Multimedia Library

Japan's technology providers are very focused on multimedia systems. Fujitsu's vision represents some of the architectural and systems issues that must be faced in order to build full-service, scaleable multimedia digital libraries, as indicated below:

- vision of modern system for scaleable multimedia management
- representative of technology companies seeking to provide core technologies at middleware level

Figure 4.15 summarizes challenges for digital library technology providers. From the top down, heterogeneous media requires changes in search and storage subsystems. Improvements in database technology for managing metadata must be complemented by advances in multimedia object stores.

Multimedia distribution raises quality of service issues and requires resource management at the systems level.

Finally, many device improvements will drive the multimedia library, especially devices that extend information management to new areas of internetworking, consumer electronics, home devices, and collaborative workspaces.

Japan's Second Generation Digital Library Project

In Japan, a second national digital library project is underway, funded by the Ministry of International Trade and Industry (MITI), and conducted by the Information Technology Promotion Agency (IPA) and Japan Information Processing Development Center (JIPDEC).

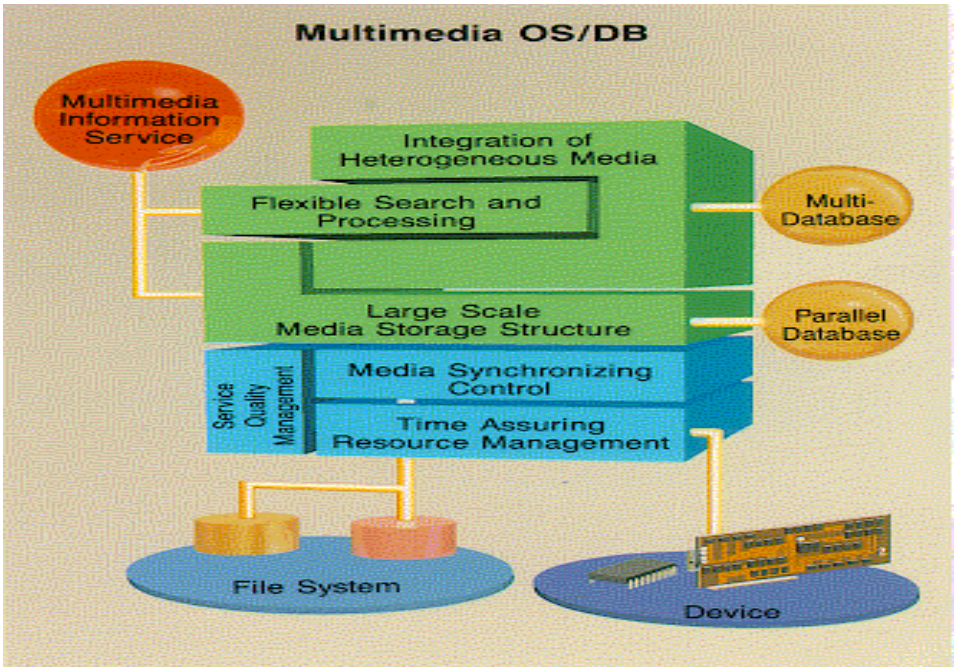

Fig. 4.15. Fujitsu: concept.

The purpose is to develop a reference architecture that will drive development and utilization of advanced technologies for information management. Only an overview of a preliminary version of the next generation architecture is considered here. The following bullets highlight main themes of the project:

- operate a private and public consortium
- build scaleable, distributed multimedia information management systems
- use advanced, standards-based technologies
- proceed as a consensus project (U.S. DLI-2 is competitive)

The reference model reflects modern multi-tier distributed systems architectures (Figure 4.16). It features messaging middleware, agent technology, multimedia databases, mobile agents, and CORBA distributed object management. The project is practical, and the plan calls for a prototype system in the next two years.

Up-to-date information may be found at the Next Generation Digital Library Web site, http://www.dlib.jipdec.or.jp.

Figure 4.17 is representative of the project's approach, indicating utilization of the three-tier model, CORBA, and Internet standards.

FINDINGS

The following represent key elements of digital library systems in Japan:

- Advanced, mission-specific, and compelling digital library systems are operational in some Japanese public institutions and commercial enterprises.
- Technology companies are exploring advanced digital library components and computing paradigms. Commercial emphasis is on custom integrations.
- Replicable solutions, services, and outsourcing were not observed except as envisioned by the Second Generation Digital Library project.

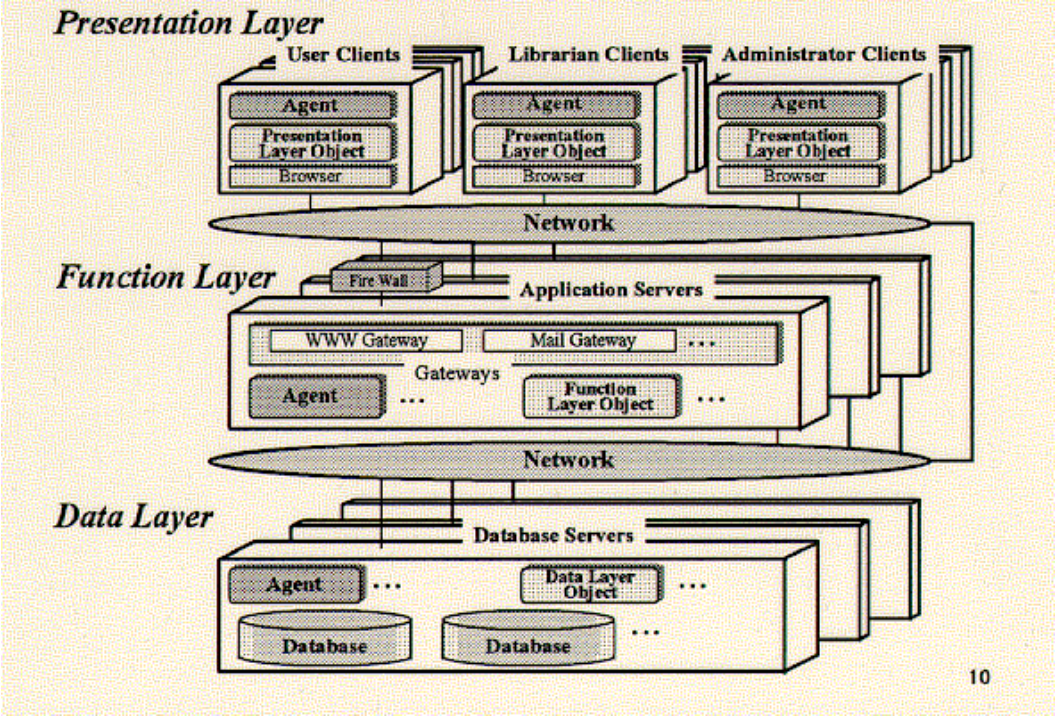

Fig. 4.16. Reference model for basic architecture (Japanese DLII initiative).

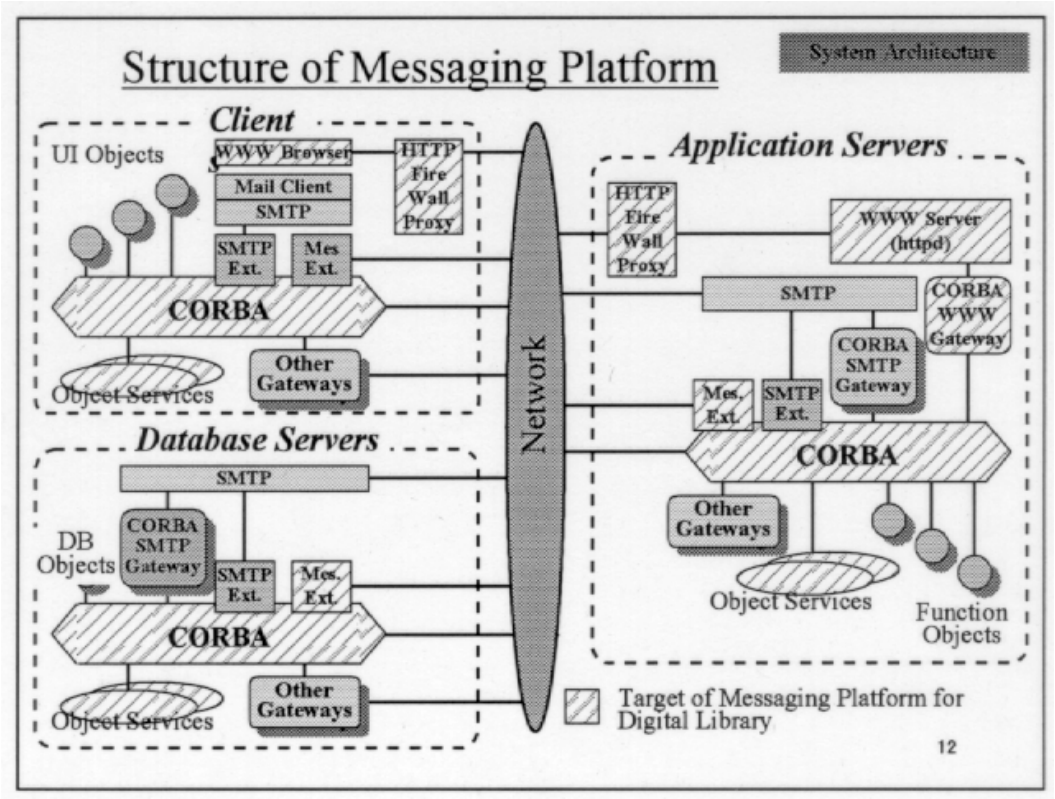

Fig. 4.17. Structure of messaging platform (Japanese DLII project).

- Japanese businesses and public institutions are engaged in a second-generation digital library project with a comprehensive architecture.
- Most libraries and museums do demonstration projects, while some are aggressive "early adopters" of digital library approaches.

The following points summarize the findings of the trip regarding systems and architecture:

- Advanced, mission-specific digital library systems are driving certain public institutions and commercial enterprises forward. These systems are usually part of a business process reengineering effort caused by rapid changes in the nature of information creation, consumption, and distribution technologies that affect core business functions and create new business opportunities. In these cases, architecture and systems are driven by business processes.
- Individually, technology companies are doing exploratory work on components for integration into current systems, but also looking forward to new computing paradigms that imply fundamental changes in systems, particularly with respect to information access and distribution. In these cases, it is clear that the interest is in providing advanced core technologies that support many information technology market segments.
- Cooperatively, Japanese business and institutions are engaged in a second-generation digital library project, which does provide a comprehensive architectural and systems point of reference. This is CORBA-based, takes advantage of advances in networking, features metadata management and many flavors of search and query.
- Libraries and museums, whose approach to information management in many ways inspires the technologies we saw, are split between those that are doing interesting, but limited demonstration or exploratory projects, and those that are aggressive "early adopters" with comprehensive visions and commitments to change the ways information is acquired, managed, and utilized in their environments. The library and museum sector featured many digitization projects, and offered numerous insights into the capture and cataloging subcomponents of an overall digital library system.

COMPARISONS

A comparison of digital library systems and capabilities in Japan and the United States suggests the following:

- In the United States and Japan, digital libraries are custom integrations with emphasis on a common set of core capabilities.
- In the United States and Japan, compelling examples of digital library systems and architecture solve specific business problems.
- Scaling of digital library capacity depends on internationally shared data, metadata, and distributed systems standards.
- For the next decade, the digital libraries will be based on common core technologies designed, implemented, and integrated to support certain business processes.
- Japan and the United States are comparable regarding architectures and systems as such.
- Japanese technology companies stress mainline multimedia middleware, while U.S. startup companies are more innovative.

CHAPTER 5

TEXT

W. Bruce Croft

BACKGROUND

Much of the information in digital library or digital information organization applications is in the form of text. Even when the application focuses on multimedia objects such as images, video or audio, these objects are primarily described using text or words and phrases from controlled vocabularies such as the Library of Congress Subject Headings. Compared to the data stored in traditional database systems, text is relatively unstructured and has less well-defined semantics. Consequently, the processes of *indexing* (both manual and automatic) and *retrieving* textual information are fundamental to digital library applications. *Information retrieval* (*IR*) is an area of both computer and information science that studies these processes.

Research on effective and efficient automatic techniques for IR has been underway in the United States and Europe since the 1960s (Sparck, Jones and Willett 1997). Dramatic improvements in disk storage technology and then the growth of Internet information access led to a significant increase in IR research activity in the 1990s. The U.S. government has also provided substantial funding in this area through efforts such as the DARPA TIPSTER project and NSF Digital Library Initiative. The TIPSTER project focused on the development of new techniques for text retrieval, filtering and extraction. The TREC annual evaluation conference was started by DARPA in conjunction with TIPSTER and is now run by the National Institute of Standards and Technology. TREC has resulted in standard text collections and evaluation methodologies that have increased both the size of the text-related research community and the number of new results.

In recent years, the IR research community in the United States has broadened its interests beyond retrieval to include new areas such as filtering, distributed and scalable IR, cross-lingual IR, information extraction, summarization, visualization, text data mining, and event detection.

In Japan, information retrieval research has not been a major focus of computer and information scientists until much more recently. Because of the relative difficulty of indexing Japanese text, much of the earlier work in Japan focused on hardware and software techniques to support exact matching of Boolean combinations of text strings. The first studies on the effectiveness of ranking techniques with Japanese text databases were not done until the 1990s (e.g., Ogawa et al. 1993) and some of those were done in the United States as part of the TIPSTER project (Fujii and Croft 1993). The advent of the Internet, the visibility of the U.S. government initiatives, and the general commercial interest in text search has changed this situation considerably. Many industry laboratories and university groups are working on a range of technologies for text. In addition, an increasing number of papers from Japan are submitted to the major IR conferences, new conferences focusing on Asian language issues have been started (e.g., IRAL 1997), and government initiatives exist in areas such as digital libraries.

IR RESEARCH IN JAPAN

Japanese IR research covers basically the same areas as in the United States, although there is more emphasis on indexing techniques appropriate for Japanese and other major Asian languages (especially Chinese and Korean). Indexing issues that are common concerns include the following:

Dealing With Different Character Encodings

There are a number of standard two-byte character encodings for Japanese and Chinese (e.g., JIS and GB). Unicode is a developing standard that addresses most of the problems in this area.

Input Methods for Japanese and Other Languages

Segmentation of Japanese into "Words"

A number of techniques based on dictionaries have been proposed to identify the words and phrases in Japanese text for indexing. Some of these techniques are now available commercially and achieve high accuracy rates.

Morphological Analysis

The identification and normalization of inflected word forms is less important for Japanese than for some languages, and techniques have been developed to do this as part of segmentation.

N-gram Indexing

To avoid the segmentation process, many researchers have proposed indexing Japanese (and Chinese) using pairs (bigrams) or trigrams of characters. Experimental results with this technique have shown that retrieval based on n-gram indexing is approximately as effective as retrieval based on segmented words.

The Use of Controlled Vocabularies and Ontologies for Indexing

As more work is done in this area, the language-dependent indexing issues are becoming less important. Full text indexing for Japanese is now relatively straightforward, and the focus of Japanese IR researchers is increasingly on the core issues of *effectiveness* and *efficiency*. Some of the specific research areas mentioned during the WTEC industrial and university visits were as follows:

- retrieval models (i.e., how to rank)
- text representation (e.g., concepts vs. words)
- query expansion (using corpus analysis and thesauri to add related words to the query)
- relevance feedback (using learning to improve retrieval)
- summarization (e.g., of documents and groups of documents to support browsing and text data mining)
- interfaces (different perspectives on the database or retrieved information)
- scalability (how to achieve fast indexing and query processing times as databases become much larger)

There was also significant interest in multilingual systems. The major focus here was on supporting the major Asian languages in one system, and to a lesser extent, supporting English. There is some work being done on cross-lingual retrieval (asking questions in one language and retrieving documents in many languages), but it is currently more of an interest rather than an active research topic. Machine translation was mentioned frequently and is considered an important part of a multilingual digital library application. The primary focus in this area was on translation from English to Japanese, particularly for Internet applications. Other Asian language and English translation pairs also exist or are being developed.

A number of digital library applications based on libraries were discussed during the WTEC visit, and these applications typically made use of traditional indexing approaches with controlled vocabularies, manual indexing and catalogs for searching. The issues involved with creating and searching online public access

catalogs (OPACS) as text databases are essentially the same as those studied in the United States. As an extension of this approach, metadata standards for information on the Internet (such as the Dublin Core) are being developed and debated in the international community. Japanese information scientists are part of that debate.

OVERVIEW OF TEXT RESEARCH AT SITES VISITED BY WTEC

All of the sites visited were dealing with text in some form, but a smaller number were actually doing research in text indexing and retrieval or related techniques. These sites were as follows:

- University of Library and Information Science, Tsukuba
- National Center for Science Information Systems (NACSIS)
- HUMI Project, Keio University
- NTT Multi-Media System Laboratory Group
- OMRON Multi-Media Information Technology Research Center
- Advanced Telecommunication Research Institute (ATR)
- Fujitsu
- IBM Tokyo Research Laboratory
- Matsushita Multimedia Systems Research Laboratory
- Hitachi Central Research Laboratory
- Nara Institute of Science and Technology (NAIST)

SUMMARY

In this section, the overall impression of the text and IR research being done in Japan is summarized, and then it is compared to the work being done in the United States.

The first observation is that the Japanese community of computer and information scientists working in the IR and text-related areas is smaller than the comparable communities in the United States and Europe. As a result, Japanese research in these areas tends to follow directions and initiatives begun in the United States. Individual projects are of good quality and are producing interesting technology, but progress has been somewhat impeded by a lack of a Japanese version of TREC or equivalent test collections. Although the value of recall/precision measurements is hotly debated in the IR community, there is no doubt that the culture of experiment and comparison in IR and TREC has led to significant improvements in both the understanding and performance of text access techniques. There have been some efforts to develop test collections for Japanese and this has resulted in a recent Call for Participation for IREX (Japanese Information Retrieval and Extraction Exercise, http://cs.nyu.edu/cs/projects/proteus/irex). IREX is organized by a committee of people from Japanese companies and universities, and is modeled on the TIPSTER and TREC programs. In addition, because TREC has made Chinese collections available, there have been a large number of recent papers on Chinese text retrieval.

Text-related research in Japan covers essentially the same areas as the United States, although there continues to be a strong emphasis on indexing techniques and speed. The differences that arose from the language-dependent aspects of Japanese text are rapidly disappearing.

Japanese companies appear to be focusing on developing the best commercial Asian language search systems for applications in Japanese, Chinese and Korean. There is, however, considerable competition even in this area in that considerable research and development of Chinese IR is underway in China, Singapore, Taiwan and Hong Kong, and Korea has a substantially longer history of IR research than Japan. One general criticism is that there seems to be too much reinvention of basic IR technology in Japan. Nearly every group visited was developing its own search engine (or engines). Licensing of U.S. search engines with Japanese

capability such as Verity or Infoseek is limited but may increase as it is demonstrated that search technology is essentially language-independent.

Current Japanese research and text search techniques do not offer significant benefits for English applications. The research is complementary to that being done in the United States, and the results tend to be incremental in nature. As the community of researchers in this area increases, however, we may expect to see more innovation and exploration of new ideas.

A number of groups in Japan are studying information visualization, architectures for scalable IR systems, and the application of natural language processing (NLP) techniques to IR. These are areas that could have a significant impact on the development of text-based systems. For example, the use of NLP techniques for IR has been studied in the United States for some time because of the obvious potential benefits of a system that "understands" the query better than a word-based system. Despite those potential benefits, research using quantitative evaluation based on test collections such as TREC has never demonstrated any retrieval effectiveness improvements from NLP. On the other hand, there is some evidence that language-based techniques may work better in Japanese than in English (Fujii 1997), and this may lead to a better understanding of text retrieval in general. Information visualization is another area where the opportunity exists for substantial innovation and synergy between Japanese research groups. An example of a visualization interface being developed and deployed by IBM Japan is shown in Figure 5.1.

In conclusion, the WTEC panelists' view was that text-related research in Japan has been lagging behind that of the United States and Europe, but that substantial recent investments by companies and universities in this area mean that this gap is rapidly narrowing. One should expect to see substantially more new techniques and research directions originating in Japan in the near future.

Fig. 5.1. IBM information outlining: search, extraction, categorization, and abstraction.

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CHAPTER 6

DIGITAL IMAGE AND VIDEO LIBRARIES: ACQUISITION, RETRIEVAL AND RENDERING

Rama Chellappa

SUMMARY

This chapter presents an evaluation of technology efforts in the broad area of digital image and video libraries in Japan. Major issues in this area are acquisition, storage, retrieval, manipulation, displays, interfaces, networking and providing protection to digital content. The study panel saw examples of competitive research and development in most of these areas and advances in display- and acquisition-related efforts.

INTRODUCTION

With the availability of video cameras, 3D scanners and high resolution display devices and virtual reality (VR) tools, the concept of a digital library has expanded from traditional text-based systems to more general text, voice, digital image and video-based systems. For example, one can now acquire and view rare objects housed in a remote museum or take a virtual tour of a medieval castle or the Taj Mahal by combining synthetic and real digital contents with VR tools. By incorporating computer vision techniques, one can also enhance the "telepresence" feeling of the viewer, making him/her appear to be among the people visiting the museum.

Figure 6.1 illustrates the modules of a digital image and video library (DIVL). In such a system, digital content could be extracted from rare books, statues, and aesthetic architectures such as the Taj Mahal or the pyramids. Key components involved in the creation, operation and usage of a DIVL are acquisition, cataloging, storage, retrieval, manipulation, user interfaces and system integration. Both in the United States and Japan, excellent examples of ongoing work in each of these areas can be found. For a description of related efforts in the United States, the reader is referred to summaries of just-completed efforts at the University of California, Berkeley, Stanford, the University of Michigan, the University of Illinois, the University of California, Santa Barbara and Carnegie Mellon University, under the sponsorship of the Digital Library (DL) Initiative, supported by DARPA, NSF and NASA. These and other related efforts are summarized in several DL conferences and journal issues (DLII n.d., ACM 1997a, ACM 1997b, AAAI 1997, IEEE 1998).

This chapter summarizes the panel's observations of ongoing research and technology efforts in Japan in various areas relevant to DIVL. Specifically, it presents an evaluation of what the panel observed in acquisition, cataloging, retrieval, and virtual reality presentations. Related efforts on electronic commerce and networked DL are also presented. Most of these efforts are being carried out by industrial organizations that view multimedia as a key technology for the 21st century. Digital library oriented issues are being investigated by universities and libraries planning to operate in the digital mode. This chapter covers

ongoing efforts in DIVL. Digital library related issues, text-based indexing, and search are covered in Chapter 5.

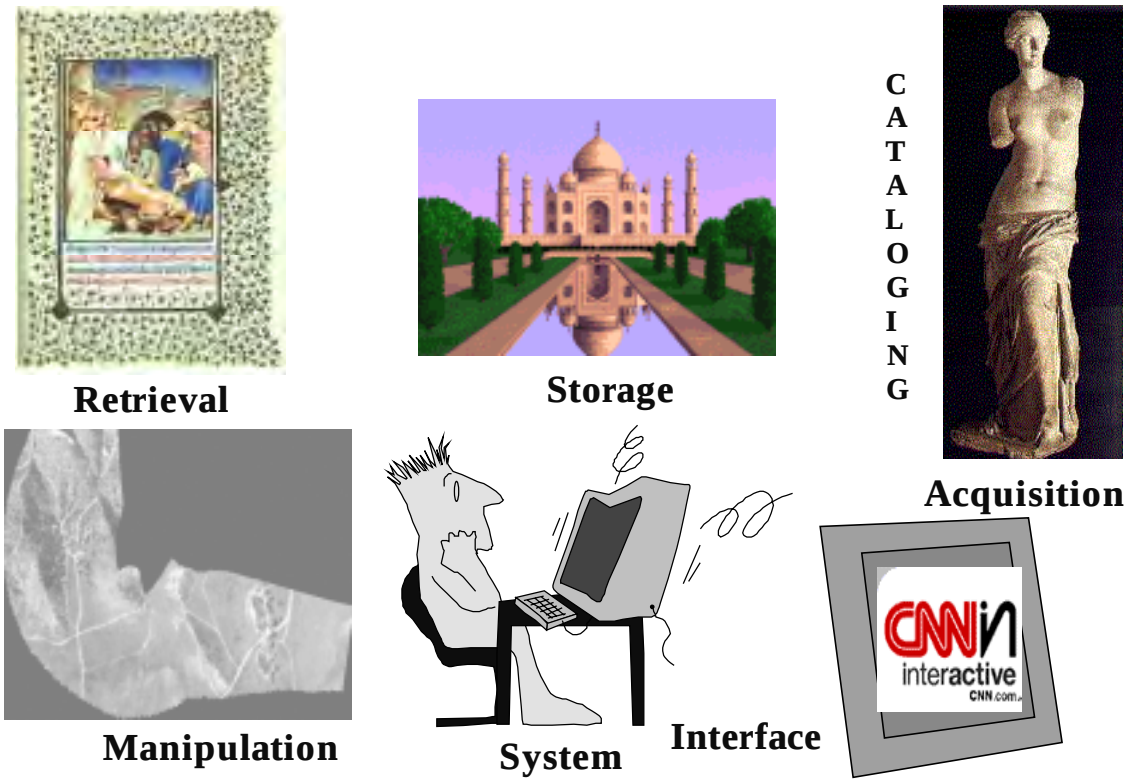

Fig. 6.1. Digital image video library.

ACQUISITION

Visual and 3D information present in the world surrounding us can be acquired in numerous ways. They include devices such as high-quality still cameras, video cameras, depth sensors (Kanade 1994, Michelangelo Project n.d.) multicamera arrangements (Narayana et al. 1998) and omni-directional sensors (Nalwa 1996, Nayar 1996). Different acquisition systems can be used for digitizing different objects. Rare books are digitized using a still camera set in a fixed position, whereas an object such as a statue is imaged from several different viewpoints. Issues that need to be resolved as part of acquisition are image resolution, cost, acquisition time, revisiting the acquisition process, the number of vantage views, synthesis of views from directions not included in the scanning and mixing of synthetic and real content.

The panel saw examples of acquisition of digital content at three sites: Keio University, the National Diet Library, and the National Museum of Ethnology. At Keio University, the emphasis is on digitizing rare books and manuscripts—Western, Japanese and Chinese. The Keio University Library has a large collection of rare books, one of its prized possessions being a Gutenberg Bible.

Keio University uses three different cameras for digitizing rare books, illustrations and photographs. A high-speed digital camera, an NTT-Olympus prototype, is used to digitize an entire book very quickly. It takes about five sec/page capture and display a single page. Figure 6.2 illustrates one of the camera setups at Keio University. Illustrations in the rare books are scanned using a high-quality camera that takes about two minutes/page. A third scanner, Kodak professional PCD scanner 4045, is also available for scanning photographs.

Fig. 6.2. Camera setup for scanning rare books.

The National Diet Library (NDL) has one of the largest collections of digitized rare books, documents and children's books in the world. The NDL out-sources digitization work to private companies and does not possess any acquisition devices.

The National Museum of Ethnology has an operational setup using three 3D scanners that can handle 100 objects per day in an "assembly line" fashion. These scanners can image objects that vary in sizes from 40 cm to 100 cm and can also produce measurements such as height, width and depth. Although dense imaging of 3D objects is possible (at 1/2-degree increments from all directions), typically five images from front, back, left, right and top are collected.

It is the panel's impression that the Japanese sites have shown operational capabilities in acquiring a wide range of artifacts, rare books and illustrations. There is a general appreciation for preserving rare books and other objects, and the Japanese even seem to be willing to subject their rare collections to repeated scanning to keep pace with improving acquisition technology. Keio University researchers cite the superior lighting system used for imaging the rare books. This "cold lighting" system assists in the preservation of the books rather than causing them to deteriorate.

One or two 2D images of pages from a rare book are often enough to create the necessary digital content. For 3D objects such as statues, many more images from different directions are required for virtual reality presentation. Although facilities for acquiring images at 1/2-degree increments from all directions are available in the National Museum of Ethnology, few images are collected in operation. One of the ways in which the paucity of data can be handled is by developing techniques for synthesizing new views from existing ones (Levoy and Hanrahan 1996). Such capabilities were not in evidence at the museum.

Another important issue in the acquisition process is cataloging. Different levels of capabilities were demonstrated. The National Ethnology Museum has the most streamlined cataloging scheme for 3D objects.

On the other hand, the National Diet Library, although it has millions of pages imaged, does not yet have a cataloging mechanism in place.

CONTENT-BASED RETRIEVAL

Text and content-based retrieval of video is a critical component of a DIVL for automatic indexing and retrieval. This is one of the most active research areas in the United States; published papers and prototype software systems are too numerous to list here. Good overviews of recent efforts can be seen in DLII n.d., ACM 1997a, ACM 1997b, AAAI 1997, and IEEE 1998. More detailed discussions of text-related search can be found in Chapter 5. Several Japanese companies are also actively involved in this area. Two demonstrations in the image area were shown by NTT researchers. One involves reading the Japanese captions from TV broadcasts so that topic- or concept-based video retrieval can be accomplished. Key algorithmic steps involved are detection of frames that contain text, extraction of text regions, character segmentation and recognition. Details of these steps can be found in Kurakaka, Kuwano and Odaka (1997). The other demonstration was of ExSight, a multimedia retrieval system using object-based image matching and keyword-based retrieval (Yamamuro et al. 1998). Unlike pixel- or impression-based approaches, object-based approaches such as ExSight search over a large database using content. The steps involved include automatic object extraction, feature extraction (color, shape, etc.) and high-speed similarity matching. Query fusion (as a union of image objects) and high-speed browsing are provided as Java applets. Potential commercialization applications are in electronic commerce, digital museums (show all the pictures of a boy with a dog), and digital photo albums. Although primarily image-content driven, the system can accommodate keyword-based retrieval. A functional diagram of ExSight is shown in Figure. 6.3.

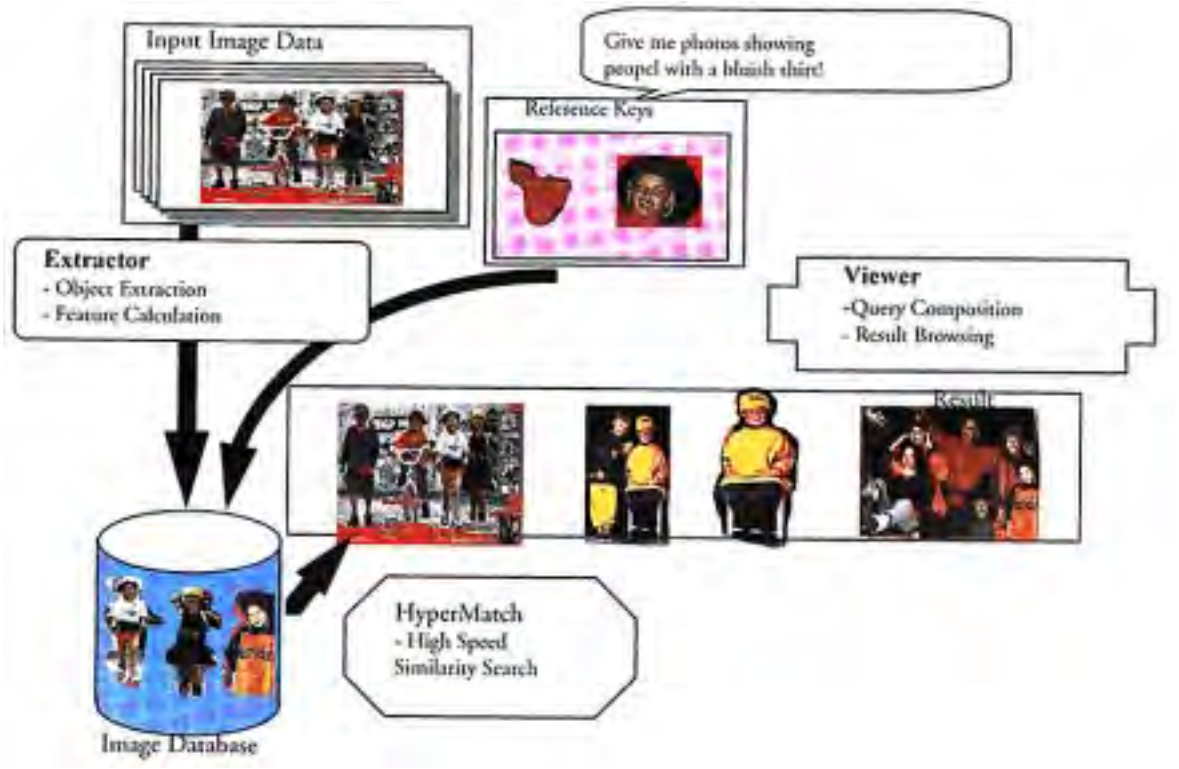

Fig. 6.3. Functional diagram of ExSight (NTT).

When audio books and video are collected and bound as digital objects, it is critical to provide user-friendly interfaces to access them. In the CyberShelf project, books created from HTML documents are accessible using a book metaphor description language. Another interesting demonstration was an image mosaicking system that produces a panoramic view from a sequence of translating images. User-friendly interfaces to

the mosaicking algorithms have been provided. Details of the mosaicking algorithms are found in Akutsu et al. 1995 and in Taniguchi et al. 1997.

OTHER RELATED EFFORTS

Packaged Media

Toppan's entry into packaged multimedia includes CD-ROM and DVD products. In an area flooded by technical standards Toppan's efforts are aimed at improving product quality within the confines of the standards. For example, a troubling aspect of MPEG encoding is that viewed motion pictures suffer from "jitter," in which the image jumps in position slightly from frame to frame. Toppan demonstrated a system to remove jitter from MPEG-encoded video. It also has techniques for improving the shading and tone of JPEG images to make them more realistic.

Networked Digital Library

The network library system being developed at NTT provides multimedia services based on a broadband ATM network. The network is served by hi-fi music, MPEG-1, MPEG-2 and digital library servers. Processing engines for voice recognition, search, Japanese/English translation and text-to-speech are provided. A key component in this network is a super-high definition display, at a resolution of 2048 x 2048 pixels, 24 bits/pixel operating at 60 frames/sec for video. The network library is being used for doctors' viewing of medical images, sightseeing tours, teleconferences and on-the-fly machine translation between Japanese and English.

Electronic Commerce Involving Images

Electronic commerce is viewed as being one of the promising opportunities in the 21st century. Major concerns in making this feasible are guaranteeing security, copyrights, and maintaining the timeline of transactions. The WTEC team saw two especially interesting demonstrations illustrating how electronic money can be securely moved around between interested parties and how copyrights can be protected in the sale and distribution of digital objects. In the demonstration of moving electronic money around, a smart card is used for making purchases from anywhere as long as one is connected to the network. When digital objects are marketed over the network, the sellers need to ensure that their copyrights are protected. NTT's InfoProtect project demonstrates the secure distribution of images. The owner of the digital content first creates a partial image (semi-disclosed) and its descrambling key. The descrambling key is registered with the system center and the partial image is transmitted to the potential buyer. The buyer decides to purchase by inspecting the scrambled image and buys the descrambling key via a secure key transmission protocol known as InfoKey developed at NTT. The key is used to descramble the image. The buyer ID is embedded using digital watermarking, providing protection against copyright violation.

Video Teleconference and Virtual Reality Systems

The high presence video teleconference system demonstrated at NTT is centered around two large projection displays (each 110 inches long along the diagonal). The resolution is four times that of high definition TV and enables interaction with life-sized humans. The quality of display performance was demonstrated using 2D monocular and stereo still images. The monocular images were viewed at a resolution of 6 million pixels/frame and the stereo pairs each had about 3 million pixels/image, giving excellent quality to the stereo images. Although this system as a whole is expensive, key components of the display technology have been commercialized. Using sound localization, an enhanced multimedia presentation is possible with applications to remote museums and education.

The WTEC team saw a demonstration of a virtual tour of the monastery at Sande Marco in Florence, Italy was shown at Keio University. The tour was displayed on three flat screens using back projection. About 1,000 photographs taken at the monastery were used with a 3D modeling package to create the tour. The building and surroundings were all synthesized, whereas the artwork was all photographed. This required 200 Mb of storage. On the virtual tour it is possible to zoom in on the many works of art. The tour is controlled using a joystick.

The team also saw Toppan's Virtual Reality Gallery, which consists of a portion of a spherical screen in an auditorium giving a horizontal visual range of 150 degrees, so the viewer is enveloped by the image being displayed by a digital projection system of resolution 3,500 x 1,000 lines. Toppan demonstrated a virtual reality tour through the Sistine Chapel that was created by taking still photographs from 50 different vantage points throughout the chapel, digitizing them and using them to create a 3D digital model. The viewer is able to move around within the chapel by means of a hand-held joystick. ATR demonstrated an agent interface that serves as a tour guide. This generic approach will be useful for exploring cyberspace. Other ongoing research efforts in this laboratory are communication by mental images including *kansei* processing, virtual reality, art and technology, including interactive environments, understanding of emotions from music and peoples' voices, and human communications science. This chapter will now briefly elaborate on the concept of *kansei* computing, which appears to be similar to the concept of affective computing put forward by Picard (1997).

Kansei is defined as computing that relates to, arises from, or is influenced by human characteristics such as sensibility, perception, affection or subjectivity. A national research project at ATR sponsored by the Ministry of Education during 1992-1995 gave impetus to giving computers human-like responsiveness. One of the media of *Kansei* information is the face, as it is able to express subtle emotions. There are two aspects to what is perceptible from a facial expression. One deals with image engineering issues of accurate, robust face recognition and expression algorithms. The other deals with human-science aspects of mimicking human information processing. For example, to respond to queries such as who looks similar here? or who is the most senior? one should incorporate ideas from human information processing. The emphasis of this group is on combining psychophysics and image engineering. This will guide the design of human computer interface (HCI) systems. For further information refer to the HCI report.

CONCLUSIONS

Just as in the United States, digital-library-related efforts are being pursued by Japanese universities, governmental institutions and industrial organizations, with strong interactions among these three sectors. In the DIVL area, industry is much more active, as the area is closely tied to multimedia technology.

The WTEC panelists feel that Japanese researchers and engineers are quite aware of related research and technology efforts underway in the United States. Largely due to the World Wide Web and exchanges of scholars, gaps in algorithm software/technology development are narrowing. Japanese industry appears to be quite aggressive in converting technology into marketable products. The companies also have a long-term view in many areas of DIVL. The concept of *kansei* computing, which the panel heard about at several sites, looks at making computing personal, with applications to HCI.

In terms of acquisition of digital content, the United States and Japan are about even. The Japanese seem to be more willing to subject their rare collections to repeated digitization than are Americans. However, this is not a technology-related issue.

For years, the Japanese have enjoyed a significant lead in display devices. The panel was impressed with several VR tours built using superior display technologies. The impact of this technology on small portable display devices is debatable.

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CHAPTER 7

CATALOGING AND METADATA CREATION IN DIGITAL INFORMATION ORGANIZATION: OLD CONCEPTS, NEW CHALLENGES

Beth Davis-Brown

INTRODUCTION

The promise of digital libraries implies the possibility of disseminating materials and information far beyond what has ever been imagined. Early digital library efforts, such as the Library of Congress' National Digital Library Program and the projects sponsored by the digital library I and II initiatives in the United States, showcase digital facsimiles of unique documents and artifacts previously available only to curators and scholars. In Japan, the National Diet Library, Kyoto University Library, the University of Tsukuba, and the University of Library and Information Science are actively planning to publish digital content on the World Wide Web (see site reports, Appendix C). One could view "digital information organization" as having two facets:

1. The creation of cataloging information to enable searching, discovery, and retrieval of information in digital format.
2. Accomplishing this task with methods that scale to effectively handle quantities of data exponentially larger than libraries have ever done. A key issue impacting the wide dissemination of digital information is the scalability of providing information (metadata) to structure and enable searching, navigation, and presentation of online documents. This paper will address some of the issues involved in creating cataloging and metadata, and discuss attributes of print documents and other analog formats that must be replicated in the electronic environment.

This author's participation in the WTEC study tour stemmed from experience in cataloging and classification and as manager of a team that digitizes historical legal materials for the Law Library of Congress and the National Digital Library Program. As the only "librarian" on the study tour, the author paid special attention to problems and issues concerning metadata creation and scalability of cataloging systems. These issues are just being articulated in both Japan and the United States, and call for thought and discussion. The goal of this chapter is to provide an introduction to factors that impact the growth of digital library technology and content from a practitioner's perspective.

On the surface, provision of metadata to accompany digital objects does not seem difficult. Roughly speaking, many people think that all that must be done is to take existing cataloging information, convert it to the appropriate format, and link it to the digital images. The process is not that simple due to several factors. First of all, the conversion of a physical artifact implies not just putting information into a new format but the concomitant goal to display the information in a logical way. To do that, information in addition to the content must be produced or extracted to enable the structure and display of the data. If existing schemes for classification and indexing are used, human intellectual capital is necessary at some point in the process to apply thesaurus terms and enable other access points (catalog).

TRADITIONAL LIBRARY PRACTICES

Many libraries in the United States and in Japan have not yet cataloged all of their holdings, and may not have all of these records in machine-readable format. A shortage of staff, sometimes rocky transitions from manual to automated cataloging work flows, and the "information explosion," have created arrearages or backlogs in cataloging departments that most institutions do not publicize. The discipline of cataloging has devised methods and policies to describe physical artifacts such as books, periodicals, microforms, sound recordings, and maps. These descriptions are largely based on the physical "container" in which the information resides, and thus are considered format-based description. (For more on bibliographic description, see AACR2.) Intellectual description, that is, data about the subject of the information in the "container" and a classification number reflecting subject analysis, is created by catalogers. The Library of Congress develops and maintains a very large thesaurus of controlled subject headings with documentation of references and related terms (see LC Subject Headings). The Library of Congress also maintains the *LC Classification Schedule* and the *Dewey Decimal Classification Schedule*. Variants of these classification schemes are being used by libraries in Japan. The library community's cooperation in development of these systems has made possible interoperability and interchange of bibliographic information on a global basis. Cooperatively built databases of bibliographic information such as OCLC and RLIN in the United States, and NACSIS in Japan, provide economies of scale as libraries collectively create and share the world's bibliography.

A discussion of "granularity," or the level at which an item is described, is a conceptual key for understanding digital information organization. "Item level" cataloging is probably most familiar to readers as they use online library catalogs to find monographs and multimedia materials. That is, one cataloging record is made for one work. Archives and special collections often catalog at the "collection level," insofar as it is not feasible to individually describe every letter in a huge archive or assign meaningful classification numbers to millions of photographs. With indexed journal articles, the "item" to be cataloged might be the title of the journal along with an accounting of the individual issues, or holdings. Article-level indexing information gives further description of the intellectual content of "pieces" of each issue of the journal. Conversely, one catalog entry might exist only at the title level of the serial publication without the more in-depth indexing information. Clearly, the article-level indexing provides greater access and description; it is also more expensive and labor-intensive to create and maintain. The topic of granularity of description is important because the creation of cataloging data is one of the more expensive aspects of traditional library methods of providing access to materials.

The digital world requires this same cataloging data as well as information necessary to structure and present electronic documents. The library community is cooperating with professionals from the computer science, text encoding, and museum communities to develop the Dublin Core metadata standard, a fifteen-element set to describe digital resources (see Dublin Core Metadata). Generally, metadata as discussed in this context falls into three major categories.

Physical/Structural Metadata

Physical/structural metadata is information about the digital object and its relationship to other digital objects in a repository. Structural metadata might include file location on a server or in a repository; file format; file size; relationship to other files; sequence, or date of creation. For example, a sequence of 35 mm photographic negatives may have been imaged. To present the negatives in the order in which the photographer created them, information is needed to structure the images in the original sequence in addition to the format and size of the file, date of creation, and internal numbering scheme. To extend the analogy to books on library shelves would be data about the shelf number (physical location); number of pages (size); the fact that the pages are numbered (sequencing); and binding (defining the item). This indication is a logical way to structure these materials as well as a means to indicate provenance of the materials.

Intellectual Metadata

The term intellectual metadata refers to information that provides access to the subject or content of a digital object. Intellectual metadata can be thesaurus terms associated with a file or item; indexing achieved by full text search and retrieval as described in Dr. Croft's Chapter 5; classification according to standard schema;

and associations with related sources of intellectual data such as bibliographies, archival finding aids, or cataloging records. Again using the example of 35 mm negatives from a roll of film, intellectual metadata would consist of who created the images (photographer/author), controlled or uncontrolled vocabulary terms describing the images, and perhaps a classification number. The related data might be the photographer's captions or references to a work in which the images were published.

Rights and Permissions/Access Management Metadata

Rights and permission/access management metadata functionally describe the goal of the encoding of rights and permissions information at the computer file level for digital objects. For example, an archival collection of photographs may have been made available to researchers, one at a time, in a special collections reading room for many years. However, the literary trustee of that collection may nonetheless object to widespread dissemination of these images on the World Wide Web. Thus, rights and permissions data must be associated with each image to indicate its status for distribution.

As mentioned previously, the creation of metadata has traditionally been one of the most expensive aspects of making library materials available. At the Library of Congress, one of the key decision factors when selecting collections for digitization is whether or not cataloging information already exists for a collection, especially in terms of intellectual metadata. The costs of scanning and even having text keyed and proofed are minimal in comparison with paying subject experts and professional catalogers to describe materials according to standardized methodology. Strategies for minimal level cataloging and reducing cataloging access points abound, but the activity remains very expensive.

There are aspects of current library practices in the United States and Japan that impact the potential reality of a global digital library at many levels. The costs and complexity of creating appropriate data needed to present materials reformatted digitally have been discussed. Additionally, if this information is not created accurately and with future presentation needs in mind, the digital materials can be unusable. For example, if a book is mislabeled or misshelved in library stacks, it is still available by inspection by a deck attendant or users. Conversely, if a digital file is not linked correctly to its related bibliographic record, finding aid, or previous pages in a sequence, it is essentially irretrievable. Thus, data must be created and checked for quality at a high level to ensure usability (see LC RFP 96-18).

HANDLING AND PRESERVATION

One of the principal goals of digitally converting historical and rare materials is to preserve the knowledge contained in them long after the lifetime of the physical container. Ironically, the very act of scanning these materials can cause damage to the physical artifacts if care is not taken in handling and treatment. In the library community, there has always been talk of the tension between preservation and access. To preserve treasures, they must be safeguarded, kept away from light and stress, and used only under restricted circumstances. Digital libraries *seem* to provide a solution to this problem—the possibility of creating facsimile digital images and distributing them widely while sheltering the original artifact from prolonged abuse. Institutions such as Keio University's HUMI Project and the Tsukuba University Library exhibit admirable leadership to the library community by submitting their treasures to the scanning process. Tsukuba University Library and the National Diet Library have stated they plan to rescan materials repeatedly as greater storage space, high speed networks, and higher quality display technology allow for superior images. In the United States this idea has not been expressed due to preservation, cost, and labor considerations. To retain knowledge in materials published on paper and other unstable media, handling and preservation concerns are significant factors to face when considering the possibility of a global digital library.

DIGITAL BINDING

Dr. Rama Chellappa and this author coined the concept of “digital binding” during discussions and site visits in Japan. For a while, thought has been given as to how to expand the definition of metadata backwards, if you will, to physical artifacts, and aspects of their physicality that give us information about use. The fact

that a book is bound and that in Western languages should be read from left to right are implicit pieces of metadata. To present that same book in digital format, each file representing every page image and the beginning and end of the book must be coded in a way to allow for coherent display to the user. It is nice to allow the user to "turn" pages of a document, which requires encoded information indicating digital file sequence and document boundaries as they relate to the original artifact. As this illustration suggests, activities that are taken for granted with artifacts, such as knowing in which order the pages should be read and where the boundaries of the document lie, must be recreated and made explicit for digital presentation.

Other thoughts about the "digital binding" concept came in a session with President Makoto Nagao of Kyoto University. Professor Nagao developed Ariadne, a multimedia digital library system that was demonstrated publicly in October 1994 (Nagao n.d.). Nagao discussed the difference between traditional book publishing versus publishing on the Internet, stating that, "There are so many information creators besides professional publishers on the network, and some parts of information created by these creators are so important that the collection of these digital information content(s) is urgent for libraries (Nagao n.d.)." This led to the thought of other attributes of published materials that might be emulated in the "digital binding" arena to allow for the study of information that is naturally inherent in published materials and that indicates authorship, provides version control, and defines the document. For example, in libraries or bookstores, electronic or physical stamps on the artifact indicate ownership; the date of creation and printing is fixed and is usually expressed on the verso of the title page; the content is physically immutable because the item is bound or packaged together; and the status and reputation of the publisher provide verification and to some extent authentication of the information. One relies more on material printed by Oxford University Press than vanity publications from typewriters and photocopy machines. For "digital binding" to occur, would not these same authentication and verification features need to be replicated in an electronic environment? How then, might one recreate these aspects of "boundness" or "publishedness" in the electronic environment, assuming that the information is critically important? Both legal and technical aspects of this question are interesting to explore and potentially prototypical in this context.

Publishers function to collect fees from consumers of information, either through sales or database access fees. The publisher takes a risk and may be rewarded or penalized economically for the gamble of publishing an author's work. In the online climate, President Nagao suggests that "a digital library cannot exist without a charging mechanism to users" in order to charge and collect licensing or usage fees for digital books. Dr. Chellappa and this author hope to explore some of these issues further by prototyping technical means through which to provide a "digital binding" scheme from the perspective of multimedia and text materials.

INTEGRATION OF DIGITAL INFORMATION

How will digital information be integrated with materials represented in traditional resources, such as library catalogs, citations, and abstracts? As mentioned earlier in this article, many libraries have not yet cataloged all of their holdings at the title level. With a new world of digital information on the Internet, libraries are struggling with policies to determine how they will integrate these materials with older formats. For example, how does a user of a public library in Kyoto or in Washington, D.C. know that the Library of Congress offers THOMAS, an Internet resource of contemporary bills and acts of the U.S. Congress? The Internet cognoscenti claim, "people that use the WWW know how to find what they need with search engines. Cataloging is over." However, many "average" information seekers have only vague ideas of the resources on the WWW and how to go about finding them. It is for these users that the integration of descriptive information about digital materials into traditional means of information discovery is essential. This topic was addressed as early as 1994 at the Seminar on Cataloging Digital Documents held at University of Virginia and the Library of Congress (UVA and LC 1994). Follow-up meetings have continued to discuss these issues in the library community and have given rise to organizations such as the Digital Library Federation (LC 1995).

CONCLUSION

The practical implementation of processes to describe and access information can be complex. While the issues concerning description and access of information are not difficult to understand in a strictly intellectual

sense, coordinating the creation of cataloging and metadata in a production environment can be. Much of the data necessary to successfully retrieve and present digital information online is inherent in the conversion/creation process of that information. If files are not named properly or essential metadata are not captured at the time of image scanning or record creation, the material can be unusable without highly expensive manual intervention or reprogramming. The process of quality review, worthy of an article in itself, is an activity that is crucial at both ends of the digital content production cycle to verify that the digitally converted information is legible, clear, and properly labeled.

A final conclusion from what was seen in Japan and from what this author knows to be true in the United States is that digital content management on a large scale is a huge question impacting digital libraries in Japan and the United States. Traditional methods of description and access are not practical, affordable, or appropriate for large amounts of digital material. The library community has led admirably in terms of standardizing data formats and standards for description and access that make bibliographic records interoperable. In Rama Chellappa's Chapter 6 concerning image retrieval in Japan, and Bruce Croft's impressions regarding text (Chapter 5), there are some research agendas with the goal of achieving scalable solutions to content conversion and management problems. But until that time, digital information organization must continue to be studied, prototyped through projects such as the DLIB II initiative, and considered carefully by professionals in many disciplines.

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CHAPTER 8

JAPANESE DIGITAL INFORMATION: POLICY, INTELLECTUAL PROPERTY AND ECONOMICS

Michael Ian Shamos

INTRODUCTION

This chapter compares and contrasts the United States and Japan in these important respects:

- National policy. Is the government organized for and committed to digital library development on a large scale?
- Copyright. Is the copyright system structured to facilitate digital libraries while providing fair reward to content creators?
- Economic models. Are payment mechanisms in place that permit users to receive proprietary content and distribute revenue to content owners?

The conclusion is that in the first two areas Japan is significantly ahead of the United States. Japan is not perceived to lead in the area of economic models for reasons discussed below.

NATIONAL POLICY

Japanese digital library (DL) policy is shaped by many factors, including cultural values, issues of governmental organization and structure, economic questions (relating both to budgets and social choices), legal concerns (centered on copyright) and technology. Japan differs from the United States in that it has formulated and is implementing a national digital library policy. By contrast, while the United States has DL funding programs in place, these programs depend on organizations such as universities to seek funds through voluntary proposals.

The U.S. approach is a passive one in which the government makes research funding available and depends on organizations such as universities to come forward with voluntary proposals. While this approach virtually guarantees large number of applicants, it is unable to force DL development in a specific direction, and does not ensure that the appropriate government departments will even be involved.

Japan's DL policy is articulated in a document entitled *Program for Advanced Information Infrastructure* (May 1994) published by the Ministry for International Trade and Industry (MITI), referred to later as the "MITI report." The MITI report presents the DL issue as but one part of a far larger coordinated effort to augment the country's digital infrastructure. This involves strengthening digital telecommunications to facilitate use of the Internet and large-scale development of multimedia products and techniques, as well as focused work on electronic libraries.

Japan's DL objective is expressed in one sentence of the MITI report: "[I]n the medium and long term each home will be able to access electronic libraries and electronic museums around the world via networks, allowing users to readily search and obtain worldwide information on books and art based on their own particular interests." The Japanese are willing to take a long-term view and, as shall be seen later in the Economic Models section, to build infrastructure with no requirement for short-term cost justification. The Japanese DL goal is egalitarian ("each home") and international ("worldwide"), yet personalized ("own particular interests"). Japan avowedly wants to create "netizens"—people who inhabit the Internet, are familiar with its power and have the ability to use it effectively. The MITI report also makes it clear that Japan makes little distinction between digital libraries and digital museums.

Government Organization

It is one thing to have a national information infrastructure policy, but quite another to possess the organization, budget and will to carry it out. In Japan, the policy laid out in the MITI report is implemented by a number of agencies:

- MITI. Also administers protection for patents and industrial designs. Funds the Kansai Center[1], a program involving Kyoto University, Fujitsu, NTT and Kansai Power for rapid digitizing and delivery of information to homes and businesses. MITI is responsible for promoting cooperation between government and industry to build Japanese industries capable of competing in world markets.
- Ministry of Education, Science, Sports & Culture (Monbusho). Has responsibility for universities and museums, and has the power to mandate the establishment of digital libraries in institutions under its jurisdiction and has done so. It also includes the Agency for Cultural Affairs (ACA), one of whose branches administers copyright.
- Ministry of Posts and Telecommunications. Unlike in the United States, whose postal system is confined to the delivery of physical letters and packages, in Japan the oldest and newest methods of information delivery are overseen by the same ministry. It is also responsible for advanced telecommunications, and it controls high definition television (HDTV) and the country's Internet backbone.
- Other ministries. Various components of the advanced information infrastructure have been delegated to other ministries, such as the Ministry of Health and Welfare, which in charged with using information technology to improve the health of the population.
- National Diet Library (NDL). This is roughly the equivalent of the Library of Congress. However, the NDL has taken a leadership position in digitization. The fact that the Diet's library is digitizing means that the Diet's members are in a position to appreciate the value of digital libraries and continue to fund them.
- Management and Coordination Agency. This agency is responsible for ensuring that the other agencies fulfill their proper role in national initiatives and that territorial disputes do not interfere with national priorities.

It is notable that copyright operations in Japan are run by the Ministry of Education. This means that copyright is subservient to educational needs, a principle that finds expression many times in the Japanese copyright laws. For example, no copyright owner may forbid the use of his material in a textbook approved by Monbusho. If the owner and author are unable to agree, the matter is referred to the ACA and a fair royalty is set. Provisions such as these place Japan in an excellent posture to allow use of copyrighted materials in digital libraries.

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[1] Kansai, the region surrounding Osaka, Kobe and Kyoto, is an area given to huge projects. The world's longest suspension bridge is nearby, and the area is served by Kansai Regional Airport, at $6 billion one of the most expensive in the world. An entire island was constructed in Osaka Bay out of landfill to house it.

The fact that Japan has a defined and funded digital information policy, combined with a governmental structure to carry it out, means that Japan is in a strong position to lead the United States in the area of digital information organization.

Multimedia

The Japanese place great emphasis on multimedia and regard it as the next "breakthrough" industry in which Japan can become a world leader. "Multimedia software possesses highly effective powers of expression, appealing to the human senses of vision and hearing through voice and video. It therefore constitutes a highly important form of support for contents and applications in an advanced information society." (MITI report). In furtherance of this vision, Japan has established regional multimedia centers and "inter-media factory cities" as foci for producing content to be distributed via "information parks" to be located all over Japan. The multimedia centers are charged with the following:

- supplying advanced multimedia equipment
- developing multimedia content
- fostering and training creative multimedia personnel
- interacting with the intellectual property rights system
- cultivating multimedia information literacy among the population

Japan's multimedia initiative is wide-ranging and well motivated. In particular, the need to acclimatize the country to the power of multimedia and the need to train professionals, from cognitive psychologists to programmers and multimedia artists, is fully recognized in Japan.

The effects of Japan's policy objectives were observed by the WTEC group. Matsushita has an entire building devoted to multimedia in which sales and marketing people work side by side with scientists and engineers to develop useful products. Toppan Printing has an entire division devoted to multimedia production, which it views as the printing industry of the 21st century. Nara Institute and the National Ethnological Museum are set up to allow users to retrieve information in a variety of media, including text display, sound and videodisk. Some of the most impressive observations were the emphasis on multimedia at Toppan Printing and the comprehensively digitized National Ethnological Museum.

Databases

Databases are at the core of any digital information effort. In the early 1990s, Japan perceived that it lagged behind other industrialized nations in database creation because of a tendency among corporations and government agencies not to share information. To remedy the problem, the Japanese government established a "New Industry Creation Database Center" to encourage the growth of commercial database business by providing government administrative information in electronic form.

Cooperation Among Industry, Government and Universities

Japan is often said to have a business advantage over the United States in that MITI is able to fund projects that could not take hold here if traditional capital sources were relied upon and also that the agency's very existence blurs the line between government and industry and even between competitors in the same industry. This view is correct. MITI has the ability to compel universities and corporations to work together, which often results in synergy that would otherwise not exist. Two such efforts were not viewed by the WTEC group. The first is being conducted by The Tokyo Institute of Technology, which operates the National Center for Overseas Periodicals in Science and Technology and has a digital library accessible over a campus-wide network. Another project is the Union Catalog Experiment, a consortium of about 20 libraries that are merging their catalogs into a single digital one that will serve the needs of all its members.

To summarize, the effect of Japan's digital information policy is that it positions the country to exploit emerging technology without having to wait for market forces to produce the necessary capital. It is able to

invest in emerging technologies before they are of proven profitability. The advantages to Japan, relative to the United States are as follows:

- In the United States, corporations rarely fund infrastructure unless they can immediately begin recouping any investment.
- In the United States, technological cooperation between business competitors is very difficult because of antitrust concerns.
- In the United States, academic institutions compete for scarce government funding through voluntary proposals; the agencies do not themselves create consortia.
- While U.S. funding agencies have well-articulated agendas, the nation as a whole does not have an overall digital library policy.

INTELLECTUAL PROPERTY

A central issue facing DL developers everywhere is what use can be made of copyrighted content. Can it be indexed, cataloged, summarized, displayed, distributed, translated, spoken, modified, colorized, morphed, compressed, archived, and mirrored? The general answer is that some of these actions are permissible without permission of the owner and others are not[2]. It is a separate question what technological mechanisms can be employed to allow that which permissible and render the remainder impossible.

If permission of the copyright owner is required to make particular use of a work, the question reduces to finding the owner, obtaining the permission and rendering any required payment. This process, when performed manually, is extraordinarily slow and is completely inconsistent with the notion of an online DL. Furthermore, the requested permission may be refused, or may be selectively granted to those who are friendly or sympathetic to the owner. If the ultimate goal is to facilitate the widespread online use of information, with due compensation to owners of content, a system in which certain permission may be refused is a stumbling block. The Japanese copyright system provides the basis for a solution to this problem.

Copyright in the United States primarily protects economic rights, that is, the right to derive income from one's works. The European system leans more heavily toward the protection of moral rights, those for which violation does not necessarily cause monetary damage but results in harm to the creator's reputation, the integrity of his work, or his right to be acknowledged as an author. The systems differ in their treatment of published works. Once an author has chosen to make his work available to the public, how much control may he retain over its use? In a system focused on economic rights, the control is designed to ensure that others do not profit unfairly from the work. He who creates and publishes gives up a measure of other types of control. There is an implied compact with society that in return for one's intellectual production, a limited monopoly is granted to exploit the work for profit. After a certain time, the rights of any author and owner dissolve, and the work enters the public domain, from which it may be freely used by all. The question in comparing economic and moral rights systems is what public uses are permitted from the time of publication until entry into the public domain. A moral rights system views the compact as more favorable to the author. He has greater control of the work as necessary to protect his reputation and that of the work.

In the DL context, if authors in an economic copyright system can be induced to grant licenses in return for monetary compensation only, an economic scheme must be devised to measure usage and direct the appropriate payment properly. However, the whole arrangement is legally feasible if technology can be developed to support it. A moral rights system imposes potentially insuperable barriers to DL since authors may simply refuse permission for non-economic reasons and the system will uphold their judgment. In such

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[2] In this chapter, the usual copyright distinction is made between the author of a work (its creator) and an owner of the copyright in a work (a party having the ability to enforce certain rights). The author and owner may be the same or different entities.

a case, unless a solution is found, a DL will have to be satisfied with only public-domain material and that for which express permission has been obtained.

Compulsory Licensing

Even in an economic rights system, the owner is able to set an unreasonable price for usage of his work. While this may mean that he derives no income because he finds no takers, the effect is that the public is deprived of the ability to use the work, which is the equivalent of a moral rights system. A solution is afforded by the notion of "compulsory licensing." This idea, already partially implemented in many countries, is that the author and owner cannot refuse permission for certain types of usage, but the user must pay an established fee that is not set by either the owner or user, but by an independent authority.

Compulsory licensing exists in the United States, but is extremely limited. It is confined to the making of phonorecords of nondramatic musical works.[3] In simple terms, if one wants to record a song the copyright owner cannot stop him, even if the performer can't sing a note. All one has to do is serve a notice on the copyright owner of an intention to invoke a compulsory license in his song. One then pays a fixed fee (based on the length of the recording) for every copy made. The fee is set by statute and does not vary based on the nature or popularity of the work recorded. Popularity enters into the picture indirectly; if the recording become a best seller, both the performer and the copyright owner will benefit.

Compulsory licensing is beneficial to DL because: (1) material can be made available to all at a fixed price known in advance; and (2) technological solutions exist to record licensees and secure payment. In the United States, the provision will have to be expanded to include various uses of all copyrighted works, not just phonorecords of musical works.

Unless a compulsory license in available, in the United States the copyright owner has an absolute right to prevent use of his property (subject to "fair use" exceptions, which ordinarily do not include commercial uses). The right does not have to be exercised reasonably or fairly—it is a property right entitled to slavish protection. The situation, as we shall see, is very different in Japan because of extensive compulsory licensing.

Performing Rights Societies

Suppose a radio station wants to play music all day long. (Playing music is not subject to compulsory license; that's restricted to making recordings.) It would be impossible for the station to negotiate with the copyright owner of every piece it might want to play. To solve this problem, the United States recognizes certain performing rights societies (such as BMI and ASCAP) that secure the performance rights to large collections of music and license them in toto to numerous licensees, such as radio stations, restaurants, nightclubs and the like. The royalties are pooled, and distributed to the copyright owners based on statistical estimates of usage.

Performing rights societies are beneficial to DL because (1) material is easily available through large catalogs that can be maintained online; and (2) precise measurement of usage is possible to permit accurate distribution of royalties.

The Japanese Copyright System

The Japanese copyright system is approximately 100 years old, less than half that of its U.S. counterpart. It deliberately combines features of both the U.S. and European systems and is much more refined than either in the area of modern technologies, such as software, databases and digital transmission. Japan is a party to

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[3] 17 U.S.C. §115. Retransmission of cable broadcasts is also sometimes referred to as a compulsory license, but is more akin to a telephone company tariff in that no authorization is given to exploit the work in any way but to carry it intact.

most major international copyright agreements, such as the Berne Convention, respecting the rights of foreign authors.

Under no circumstances should Japan be confused with certain other Asian countries that have only limited regard for copyright. Japan is even more respectful of copyright than the United States, and government DL policy is specifically crafted to acknowledge such rights. The MITI report states, "To prevent unlawful duplication, strict enforcement of the Copyright Law is necessary, as well as raising the awareness of all users regarding this issue, and proper management of software by enterprises and others so as to prevent illicit duplication by employees ..."

The Japanese culture esteems individual artistic creativity, a point that is reflected in its copyright laws. There is a prevailing Western misunderstanding that creativity is discouraged in Japan because it conflicts with group harmony and collective decision making. Some authors compound the error by using it to "explain" the gap in software development between the United States and Japan. If anything, the Japanese find art and creative expression in many directions that would be considered mundane in the United States. This is relevant to DLs because (1) DLs create new opportunities for individual expression and publishing; and (2) DLs make heavy use of multimedia, combining work from many sources (such as calligraphy) that are protected in Japan.

The Japanese system is richer than the U.S. system in the following ways that impact DLs:

- Japanese copyright law is strongly oriented toward DL technologies such as networking, databases and multimedia.
- Compulsory licensing is broader in Japan.
- There are far more performing rights societies in Japan.

Japanese Copyright Administration

In the United States, copyright is administered by the Library of Congress (LC), part of the legislative branch of government. Its principal role is to ensure that Congress has access to extensive holdings of research material for its deliberations and, to that extent, is archival in nature. Our statute provides for copyright registrants of published works to furnish the Copyright Office with two copies of the work, one of which will repose in the LC. The copyright system therefore provides a guaranteed flow of material into the LC.

The Japanese copyright system is administered by the Agency for Cultural Affairs (ACA) of the Ministry of Education, the same ministry that promotes DLs throughout Japan. The Japanese view the copyright system as an adjunct to education rather than as an archival or primarily legal function. This permits Japan to turn its copyright function and policies in the direction of DLs with much greater ease than in the United States, where an act of Congress is required to implement any significant policy change.

The ACA established a Special Office for Multimedia in 1992, and the National Diet Library has enacted new rights specifically addressing copyright in digitized and networked environments.

The Japanese Copyright Law

Japan greatly respects proprietary rights of all kinds, including intellectual property. The crime rate is low, which indicates a nearly universal regard for personal property. The author's own experience is that the Japanese are honest to a fault, and appropriation of the work of another is virtually unthinkable. This tone is reflected in the copyright system, which provides many avenues for obtaining use licenses and ensures equitable distribution of profits to creators.

Litigation is generally rare in Japan, and copyright cases more commonly involve difficult issues of law, such as what is copyrightable, rather than instances of piracy, which are severely punished as crimes. While

in the United States certain types of infringement may be prosecuted as crimes, in Japan any infringement of a copyright, moral right or neighboring right (discussed below) is subject to fine and imprisonment.

The Japanese copyright law is an expanded grafting of U.S. and European (moral rights) legislation, harmonized to a great extent with international conventions. It recognizes copyright and the moral rights of attribution and integrity, which last for the life of the author plus 50 years, as in the United States. Copyright in the United States comprises a bundle of five rights, which may be further subdivided or separately licensed by their owner: reproduction, preparation of derivative works, distribution, performance and display. Japanese copyright (*chosakuken*, literally, "authorship right") recognizes at least 12 separate rights, some of which have no counterpart in the United States. Furthermore, in Japan these rights are more finely divisible than they are here.

Japan provides for a statutory "right of publication" (*shuppanken*), which is separate from ownership of the work and imposes an obligation on the holder of the right to publish the work within three years from the date of grant, even in the absence of any agreement between the owner and the publisher. Other rights having no direct U.S. counterpart are the right of recitation and the right of the original author in the exploitation of a derivative work.

Japanese moral rights (*jinkakuken*) are also more extensive, including the right to edit subsequent publications of a work, terminate a right of publication under certain conditions and prevent use of a work in conflict with the author's beliefs.

Japan recognizes "neighboring rights," which possess only rough analogues in U.S. law. These are very modern and include the right of interactive transmission, a critical protection for Web developers, and the right of "making transmittable," which means transforming a work so that it can be broadcast or sent over networks. The category also includes the right of rebroadcasting and various cable and sound recording rights.

Japanese copyright law protects "databases which possess creativity in the selection or systematic organization of ... information," a fact of great significance to DLs. A database is defined as a computer-readable collection, which includes everything in a DL. The United States is now struggling with protection for databases, and even the present bill before Congress (H.R. 2652) has been found by the Justice Department to be unconstitutional because copyright in the United States is limited to works of authorship rather than products of industrious collection[4]. It is unclear whether extensive protection for databases or an absence thereof would do more to promote digital libraries. However, uncertainty over the matter is not likely to help.

Japanese copyright law is better suited to protection of interactive media displays. For example, in the United States the shape of the letters in a type font is not copyrightable[5]. In Japan, artistic calligraphy is copyrightable.

Japanese Compulsory Licensing

Compulsory licensing in Japan is extensive in ways that bode well for digital collections. A major digitization problem in the United States, for example, is raised by out-of-print works that are not so old as to be definitely out of copyright and whose copyright owner cannot be located. If one of these works is digitized and added to an electronic library, the operator risks being sued at any time, assessed damages and

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[4] "Memorandum for William P. Marshall, Associate White House Counsel, re: Constitutional Concerns Raised by the Collections of Information Antipiracy Act, H.R. 2652," from William Michael Treanor, Office of Legal Counsel, U.S. Department of Justice, dated July 28, 1998.

[5] Some digital type foundries have attempted to protect digital fonts as computer programs, but this would only prevent copying the digitized form of the font. It would not protect the appearance of the characters.

ordered by injunction to delete the work. Moreover, any computer on which the work is resident may be seized without notice. On the other hand, it is likely in many cases that either the copyright has expired or that the owner, even if he becomes aware of the use being made of the work, will interpose no objection. There is no safe procedure in the United States to make use of out-of-print materials except permission of the copyright owner.

The situation is different in Japan. If the copyright owner of a work cannot be located after diligent effort, the potential user need only to apply to the ACA for a compulsory license. A royalty rate will be set, and the user must pay the royalty to the ACA, where it will be held in the event the author surfaces. If so, the author may not prevent use of the work, but must be content with the established royalty. It is obvious that such a provision facilitates digital libraries because such material can be used without risk (but at some cost). In Japan, compulsory licensing applies to the following areas:

- textbook matter approved by the ACA
- broadcasting to schools
- examination questions
- nonprofit activities
- translation of works into Japanese
- missing owner (described above)
- public interest situations
- adaptations of computer programs

Author's Rights Organizations

These are the Japanese counterpart of performing rights societies in the United States. They are non-governmental organizations (NGOs) representing a significant component of the community of creators, usually divided by type of work, such as books, music, and the like. When no compulsory license is available under Japanese law, resort may be had to the author's rights organizations to secure bulk licenses. The set of such entities in Japan is much more populous than it is in the United States and includes the following:

- Japan Society for Rights of Authors, Composers and Publishers (JASRAC)
- Japan Federation for the Protection of Copyright of Literary Works
- Writers Guilds of Japan
- Copyright Research and Information Center (CRIC)
- Consortium of Copyright Societies on Multimedia Issues (CCM)
- Japan Art, Photograph and Graphic Design Copyright Organization (APG - Japan)
- Japan Video Software Association (JVA)
- Japan Reprographic Rights Center
- over 15 other such entities

Rights Clearance

In the event that no compulsory license is available and licensing is not managed by an author's rights organization, an individual negotiation with the copyright owner is required. In the United States, merely locating the copyright owner can be a formidable chore and sometimes requires legal counsel to conduct a search, which at best is unreliable.[6] In Japan, resort may be had to J-CIS, the Japan Copyright Information

[6] For example, in the United States, works may be anonymous or pseudonymous and can be registered for copyright under alternate titles not listed in the works themselves, all of which complicates searching.

Service, an organization that exists specifically to facilitate the licensing of copyrighted works, and one that has no counterpart in the United States

Fair Use

"Fair use" in the United States is an activity that would literally constitute copyright infringement if not for a legally recognized exception. In addition to a wide menu of compulsory licenses, there is a wider recognition of the fair use principle in Japan than in the United States. For example, personal use in Japan is almost always fair. The United States instead looks at the economic loss to the owner, and concludes that a use is usually not fair if it affects the demand for the original, which is not the test in Japan. Fair use, of course, promotes digital libraries to the extent they facilitate such uses.

Japanese Copyright Proposals to Enhance Digital Libraries

Prof. Makoto Nagao, now President of Kyoto University and the leading academic proponent of digital libraries in Japan, has put forward a proposal for modification of Japanese copyright law and policy to promote digital libraries (Nagao n.d.). It begins with the premise that authors and publishers must be paid for their works. Its salient points are:

- Authors owe a debt to past works and must contribute to future ones.
- Everyone has the right to use the work of another, but must pay for it (this is essentially a universal compulsory license).
- Permission of the author is required when a moral right is involved.
- The user must give credit to the source.
- The digital library serves as a publishing house for scholarly articles.

Prof. Nagao then delves into the problem of how to charge for the use of works, a topic discussed in the next section.

Summary

No one seriously suggests eliminating copyright to promote the digitization of information. The result would be a precipitous decline in professional writing. The U.S. stance on copyright is rather inflexible—any effort to expand the use of works is seen as a threat to revenue and hence a detriment to economic interests. In Japan, on the other hand, copyright is seen as a tool to serve society, education in particular. While the Japanese assiduously protect private interests, they regard financial compensation as sufficient and do not invest authors with the near-absolute power to control the source of that revenue. Japan therefore leads the United States significantly in the area of copyright policy and implementation as it applies to digital libraries.

ECONOMIC MODELS

The economic issues facing digital libraries are huge, but fall into a small number of categories:

1. how to pay for the cost of creating and operating them
2. how to pay for the necessary infrastructure (e.g., networks, Internet backbone, multimedia displays)
3. how to pay for content

Charging Structures

The first problem is how to assemble money to finance digital libraries. The second is how a portion of the surplus is to be distributed to content owners. The following are possible models for the financing of digital libraries:

- Microcharging. Because digital libraries are mediated by computer, it is possible to obtain precise data on each type of usage made of material. A charge can then be imposed on the user and paid directly to the content owner. While such a mechanism may have to deal with huge number of transactions each of very small size, it is not unprecedented. After all, telephone companies routinely measure usage, although they have the advantage of having billions of dollars in capital tied up in the measurement equipment and software. The real problem with microcharging is that it dampens consumer interest in material. If one has to pay for each screen one views, one is motivated to browse less. Instead of learning, which is the primary reason for using a DL, one must spend time worrying about how much the material will cost. An effective plan should eliminate this effect.
- The utility model. A first step away from microcharging is the electrical utility model. Each use is measured in "clickls" (to use a phrase coined by financial writer Andrew Tobias), and the user pays a monthly bill based on (but not necessarily proportional to) the number of clickls. As with an electric bill, discounts can be offered for higher usage and payments spread out over the year.
- Subscriptions: the HBO model. A problem with the utility model is that there is no cap on the potential cost of information. More use means higher fees. The solution used by Home Box Office is to charge a fixed rate per month for unlimited usage. Heavy users are subsidized by the occasional users, all of whom pay the same amount. Such a structure allows users to access content freely without worrying about costs, but generates very large revenues to be divided among content owners. How the division should be accomplished is a matter for separate debate.
- Public subsidy. A government may decide that access to information is so essential a component of ordinary life that it makes such access "free" to all citizens. The word "free" is in quotation marks because it of course is not free, but is paid for invisibly through taxes. An example is the U.S. Interstate Highway System, financed by the federal government through tax revenue. No charge is imposed (directly) on individual users because the system is thought to be so essential to U.S. daily life and commerce that tolls are regarded as detrimental.

Creation and Operation

It is difficult to assess the relative merits of the charging schemes discussed above because of a severe lack of real data. Japan is now engaged in a large-scale experiment to understand the economics of DLs. It's going to take time, however. When asked how much it costs to digitize a scientific journal, officials at the Nara Institute replied that they had no idea. This suggests that the Nara Institute of Science and Technology (NAIST) was given a mandate to implement a DL, largely ignoring the cost, with the idea that its economics would be studied later, once the technology has matured to a point that meaningful measurements can be taken. It is difficult to imagine a U.S. funding agency taking such an approach; more likely it would insist on an advance study to predict the savings to be realized.

Priorities

Which works are to be digitized first? If everything will ultimately be digitized, it is tempting to say that order does not matter, but digital libraries must achieve a critical mass in order to be useful, attract additional funds, and grow. The matter of prioritizing is difficult because of competing objectives. These objectives include:

- Offering essential materials. Users expect a DL to have what they want, or they will turn to other sources for it. This suggests that the best use of resources is to input the most commonly referenced books, such as dictionaries, almanacs and encyclopedias.
- Gathering the classics. The idea of a large library without Moby Dick is laughable. However, that novel can be found in every library and bookstore in the United States. It is unlikely that anyone would read it sitting at a CRT screen, so is it important to digitize it? The answer is yes. People expect libraries to offer certain items, and the decision to omit classics because they are available elsewhere is harmful because it represents the erroneous value judgment that introducing the essential works of a culture can be postponed.

- Preserving fragile materials. We cannot afford to wait until manuscripts decay beyond recognition before scanning them.
- Archiving one-of-a-kind items. Of certain critical materials, such as the Dead Sea Scrolls, only one copy exists, which means that only a selected few scholars are even able to access them, and then only under restricted conditions. At what rate should we be digitizing such items so they may be studied by the entire world?
- Avoiding duplication. With so much digitizing going on, it is important to eliminate wasteful duplication occasioned by the failure of institutions to exchange materials.

Paying For Content

It is axiomatic, and required by the legal system of all developed countries, that authors be paid for their work. With few exceptions, it is a pipe dream to imagine that even the inexpensive publishing outlet of the Internet will motivate authors to create and disseminate their works for free.

Professor Makoto Nagao's proposal is to allow the author of each work to set his own price for a menu of uses and allow market forces to operate as a natural regulator (Nagao n.d). He also asks the author to renounce any fee where only a small amount would be charged, thus avoiding the inconvenience and overhead of dealing with small numerical quantities. The notion of creating a free market is sound, since any attempt to subvert supply and demand is not likely to survive for long. However, there is no requirement that an owner allow his work into the marketplace at all, which is a significant obstacle. The recalcitrant owner can keep his work bottled up by setting an exorbitant price. It seems better to combine free negotiation with an appeal to an arbitration body if the owner and user cannot agree. Overall, it seems better to have a universal compulsory licensing scheme with fixed costs similar to the U.S. phonorecord provision.

SUMMARY

The best summary for this section is simply a quotation from the MITI report: "As described above, advanced information technology will disseminate rapidly in the industrial sector following the principle of economic rationality, if the economic effects are greater than the costs involved. However, the introduction of information technology to homes is attainable only if consumers become used to the new forms of service apart from the issue of cost. If the costs are reduced, advanced utilization of information in this area will be rapidly realized, with increased demand for services providing one-way transmission of images such as video-on-demand and home shopping, or services utilizing packaged media including CD-ROM."

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APPENDICES

APPENDIX A. PROFESSIONAL EXPERIENCE OF PANELISTS

Name: **Raj Reddy (Panel Chair)**

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Dr. Reddy is Dean of the School of Computer Science at Carnegie Mellon University and the Herbert A. Simon University Professor of Computer Science and Robotics. He began his academic career as an assistant professor at Stanford in 1966. He joined the Carnegie Mellon faculty as an associate professor of computer science in 1969, full professor in 1973, a university professor in 1984 and Simon University Professor in 1992. He served as the founding Director of the Robotics Institute from 1979 to 1991 and as Dean of the School of Computer Science since 1991. He received a BE degree (University of Madras, India, 1958), MTech degree (University of New South Wales, Australia, 1960), PhD (Computer Science, Stanford University, 1966).

His research interests include the study of human-computer interaction and artificial intelligence. His current research projects include speech recognition and understanding systems; collaboration on the Web; universal digital libraries; and learning on demand.

His professional honors include the following: Fellow of the Institute of Electrical and Electronics Engineers, Fellow of the Acoustical Society of America, Fellow of the American Association for Artificial Intelligence, Member of the National Academy of Engineering, and Member of the American Academy of Arts and Sciences. He was president of the American Association for AI from 1987 to 1989. He is a recipient of the IBM Research Ralph Gomory Fellow Award in 1991. Dr. Reddy was awarded the Legion of Honor by President Mitterand of France in 1984. He was a recipient of the ACM Turing Award in 1995. He was named a member of the President's Information Technology Advisory Committee (PITAC) in 1997.

Name: **Tryg Ager**

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Dr. Ager is the leader of Digital Library Pilots and Prototypes projects at the IBM Almaden Research Center, San Jose, CA. Recent projects include university electronic journal collections, a special collections project with the Library of Congress, integration of automated library systems with digital library, country-wide digital library systems, and digital libraries for training and analysis for the U.S. Department of Defense. Prior to joining IBM in 1994, he was a consultant for the Institute for Defense Analyses and helped plan and implement worldwide multimedia networking for the U.S. Department of Defense Dependents Schools, a K-12 school system for children of U.S. military personnel stationed abroad. From 1978 to 1994 he was Senior Research Scientist at the Institute for Mathematical Studies in the Social Sciences at Stanford University, working on many projects to create, test, and disseminate programs for computer-based instruction in logic and mathematics.

He graduated from St. Olaf College (BA) and received a PhD (philosophy) from the University of Pittsburgh.

Name: **Rama Chellappa**

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Dr. Chellappa is a professor of electrical engineering and an affiliate professor of computer science at the University of Maryland in College Park. He is also affiliated with the Center for Automation Research (Associate Director) and the Institute for Advanced Computer Studies. Prior to joining the University of Maryland, he was an associate professor and Director of the Signal and Image Processing Institute at the University of Southern California.

Several of his journal papers have been included in *Collected Works* published by IEEE Press, IEEE Computer Society Press and MIT Press. He has edited a collection of papers on digital image processing (published by IEEE Computer Society Press), co-authored a research monograph on artificial neural networks for computer vision (with Y.T. Zhou) published by Springer Verlag, and co-edited a book on Markov random fields (with A.K. Jain) published by Academic Press. He has served as an associate editor for the *IEEE Transactions on Signal Processing, Image Processing, Neural Networks,* and as a co-Editor-in-Chief of *Graphical Models and Image Proce*ssing, published by Academic Press. He is serving as an associate editor of *IEEE Transactions on Pattern Analysis and Machine Intelligence*. He has received several awards, including the 1985 NSF Presidential Young Investigator Award, a 1985 IBM Faculty Development Award, the 1991 Excellence in Teaching Award from the School of Engineering at USC, and the 1992 Best Industry Related Paper Award from the International Association of Pattern Recognition (with Q. Zheng). He has been recently elected as a Distinguished Research Fellow (1996-1998) at the University of Maryland. He is a Fellow of the IEEE and the International Association for Pattern Recognition. He has served as a general and technical program chair for several IEEE international and national conferences and workshops. His current research interests are image compression and automatic target recognition.

Name: **W. Bruce Croft**

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Dr. Croft is a Professor in the Department of Computer Science at the University of Massachusetts, Amherst, which he joined in 1979. In 1992, he became the Director of the NSF-State-Industry-University Collaborative Research Center for Intelligent Information Retrieval, which combines basic research with technology transfer to a variety of government and industry partners.

His research interests are information retrieval models, text representation techniques, the design and implementation of text retrieval and filtering systems, and user interfaces. He has published more than 100 articles on these subjects. This research is also being used in a number of operational retrieval systems. He was Chair of the ACM Special Interest Group on Information Retrieval from 1987 to 1991, and is an ACM Fellow. He is currently Editor-in-Chief of the *ACM Transactions on Information Systems* and an associate editor for *Information Processing and Management*. He has served on numerous program committees and has been involved in the organization of many workshops and conferences. He received the B.Sc. (Honors) degree in 1973, and an M.Sc. in computer science in 1974 from Monash University in Melbourne, Australia. His PhD in Computer Science is from the University of Cambridge, England in 1979.

Name: **Beth Davis-Brown**

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Ms. Davis-Brown has worked professionally in academic, technical, and special libraries since receiving the MSLS from the University of Tennessee in 1984. Since late 1994, she has been working with digital libraries at the Library of Congress. She also coordinated a three-day conference on "Cataloging Digital Documents" held at the Library and the University of Virginia. Since 1995, she has been the contact person for the LC National Digital Library Program (NDLP) specializing in issues of bibliographic control of digital materials, coordinating Library sponsorship of the Encoded Archival Description (EAD) development effort, and assisting in implementation of SGML encoded finding aids. In addition to these tasks, in January of 1997 she took over as Digital Conversion Project Coordinator for the Law Library of Congress. In this position, she supervises a team in an effort to convert and make available via the WWW over 350,000 page images from early congressional materials and over 668,000 kilobytes of encoded text. She also serves as co-Contracting Officer's Technical Representative on the paper scanning/SGML conversion contract for the entire NDLP. She also continues as co-chair of a Library-wide committee on implementation of the EAD and as a participant in issues concerning digital repository developments.

Name: **Jerry M. Mendel**

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Dr. Mendel received a PhD (1963) in electrical engineering from the Polytechnic Institute of Brooklyn, Brooklyn, NY. Currently he is Professor of Electrical Engineering and Associate Director of Education for the Integrated Media Systems Center (an NSF Engineering Research Center), at the University of Southern California at Los Angeles, where he has been since 1974. He has published over 360 technical papers and is author or editor of seven books, including *Lessons in Estimation Theory for Signal Processing, Communications and Control* (Prentice-Hall, 1995), *Maximum-Likelihood Deconvolution* (Springer-Verlag, 1990), *and A Prelude to Neural Networks: Adaptive and Learning Systems* (Prentice-Hall, 1994). He is also author of the *IEEE Individual Learning Program, Kalman Filtering, and Other Digital Estimation Techniques.* He served as Editor of the IEEE Control Systems Society's *IEEE Transactions on Automatic Control*. His present research interests include higher-order statistics applied to array signal processing; fuzzy logic applied to a wide range of problems that involve uncertainty, including prediction of nonlinear time series, modulation classification, and social science problems; and hysteretic neural networks with applications in optimization and identification of systems that include hysteresis.

Dr. Mendel is a Fellow of the IEEE, Distinguished Member of the IEEE Control Systems Society, member of the IEEE Signal Processing Society, the International Neural Networks Society, the European Association for Signal Processing, Tau Beta Pi, Pi Tau Sigma, and Sigma Xi, and a registered Professional Control Systems Engineer in California. He was President of the IEEE Control Systems Society in 1986. He received the Society of Exploration Geophysicist's 1976 Outstanding Presentation Award for a paper on the application of Kalman Filtering to deconvolution; the 1983 Best Transactions Paper Award for a paper on maximum-likelihood deconvolution in the *IEEE Transactions on Geoscience and Remote Sensing*; the 1992 Signal Processing Society Paper Award for a paper on identification of nonminimum phase systems using higher-order statistics in the *IEEE Transactions on Acoustics, Speech, and Signal Processing*; a Phi Kappa Phi book award for his 1983 research monograph on seismic deconvolution; a 1985 Burlington Northern Faculty Achievement Award; a 1984 IEEE Centennial Medal; and the 1993 Service Award from the School of Engineering at USC.

Name: **Michael Ian Shamos**

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Dr. Shamos is a member of the faculty of the Computer Science Department at Carnegie Mellon University, and Director, Universal Library, in Carnegie Mellon's Language Technologies Institute. He is also a Partner in the law firm of Webb Ziesenheim Bruening Logsdon Orkin & Hansen, specializing in intellectual property law. He received his BS (physics) from Princeton University, MA (Vassar College, Physics), and PhD (computer science) from Yale University and in law (J.D. cum laude from Duquesne University). Prior to becoming Director of CMU's Universal Library, Dr. Shamos held a number of teaching and research positions at CMU; he has practiced law, both privately and with several firms; and he has been involved in the software industry, as President of Lexeme Corporation (automated computer language translation) and as President of Unus, Inc. (document composition systems).

He is author (with F.P. Preparata) of the book *Computational Geometry: An Introduction.* Springer Verlag (1985, rev. ed., 1988, Russian edition, 1989, Japanese edition, 1992) and numerous papers in computational geometry, analysis of algorithms and computerized voting systems.

APPENDIX B. PROFESSIONAL EXPERIENCE OF OTHER TEAM MEMBERS

Name: **Lawrence S. Goldberg**

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Dr. Goldberg received his BS degree in engineering physics from Washington University (1961); his PhD, in solid state physics, is from Cornell University (1966). In 1966-67, he spent a postdoctoral year as research assistant at the Physikalisches Institut at the Universität Frankfurt in Germany; from 1967-1985, he was with the Naval Research Laboratory as research physicist in the Optical Sciences Division. During 1976-1977, he was on sabbatical leave at Imperial College, London, England.

His research interests have been in lasers, nonlinear optics, optical parametric devices, ultrashort pulse lasers and spectroscopy, liquid crystals, and radiation defect centers in solids. He came to the National Science Foundation in 1985 as Program Director for the Quantum Electronics, Waves, and Beams Program, in the Division of Electrical and Communications Systems, Directorate for Engineering. In the summer of 1989, he served as Acting Head of the NSF Office in Tokyo, Japan. His program responsibilities at NSF covered research areas of quantum electronics, optics, plasmas, and electromagnetics. He served also as Senior Staff Advisor and as Acting Division Director. In October 1994, he was appointed Director of the Division of Electrical and Communications Systems and served until January 1998.

Dr. Goldberg now holds the position of Senior Engineering Advisor. Dr. Goldberg serves on the federal government's Joint Management Committee for the U.S. Japan Joint Optoelectronics Project and as government representative on the Board of Directors of the Semiconductor Research Corporation. He previously was NSF representative on the Electronics Subcommittee under the National Science and Technology Council. He has helped to develop and coordinate the recent NSF multi-disciplinary initiative in Optical Science and Engineering, the NSF/DOE Partnership in Basic Plasma Science and Engineering, and the NSF Scholar-in-Residence at NIH activity.

He is a fellow of the Institute of Electrical and Electronic Engineers, the IEEE Lasers and Electro Optics Society, and the Optical Society of America.

Name: **Ronald L. Larsen**

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As the Assistant Director of the Information Technology Office (ITO) at the Defense Advanced Research Projects Agency (DARPA), Dr. Larsen manages the Intelligent Software and Systems Division. The division is responsible for research in human-computer interaction, human language systems, distributed collaboration, visualization, software engineering, information survivability, and high confidence networking and a national research program in information management, including DARPA's research in digital libraries. He is on leave from the University of Maryland, where he is the associate director of the university libraries and is an affiliate associate professor of computer science. Prior to coming to the University of Maryland, he worked for NASA for 17 years. He spent five years at NASA Headquarters in Washington, DC, where he managed the agency's research in automation and computer science. Before coming to NASA Headquarters, he worked at Goddard Space Flight Center, where he programmed real-time mission support systems and conducted research in computer networking.

He holds a BS from Purdue University (electrical engineering), an MS from Catholic University (applied physics), and a PhD from the University of Maryland (computer science). His primary research interests currently focus on digital library technology.

Name: **Hiroshi Morishita**

Address: HMI Corporation
Matsudo Paresu 1002, 35-2 Koyama
Matsudo 271-0093, Japan.

Mr. Morishita, President, HMI Corporation, specializes in ultra-micro manipulation technology for MEMS (MicroElectroMechanical Systems). He founded HMI Corporation in 1991 to commercialize his ultra-micro manipulator system. He extended his interest and business to the field of archaeological excavating machines and to a new robot manipulator system to help bed-ridden persons. In 1994, he became a consultant to WTEC concerning WTEC study tours in Japan. He graduated from the University of Tokyo (BA, MA, mechanical engineering), and is in the final stage of preparing his doctoral thesis. He was a visiting researcher in the Mechanical Engineering Department in 1992 and 1993, and at RCAST (Research Center for Advanced Science and Technology) of the University of Tokyo in 1994 and 1995.

Name: **Robert Duane Shelton**

Address: Professor of Computer Science and Engineering
Loyola College
4501 N. Charles St
Baltimore, MD 21210-2699

Robert Duane Shelton has led international technology assessments since 1984, as science policy analyst at NSF, and now as ITRI Director. His degrees are in electrical engineering from Texas Tech (MCL), MIT (as NSF Fellow), and the University of Houston. Dr. Shelton worked at Texas Instruments, Inc. on electronics R&D, and at NASA in performance analysis of the Apollo space communications system and of TDRSS—the system currently used for Space Shuttle communications. He was a professor at the University of Houston, University of Louisville, Texas Tech University and now Loyola College. During this time, he has served as principal investigator on 35 grants, has written 58 technical papers and one book, and has chaired 60 MS and 3 PhD thesis committees. He has chaired academic departments of applied mathematics, computer science, engineering science and electrical engineering. During 1995, he was an IEEE Congressional Fellow, serving as legislative assistant on science issues for Rep. Lloyd Doggett. His current research interest is science policy analysis: international technology assessment, high-technology trade problems with Japan and national strategies for engineering education.

APPENDIX C. SITE REPORTS

Site: **Advanced Telecommunications Research Institute International (ATR)**
2-2 Hikaridai Seika-Cho Soraku-Iun
Kyoto 619-02, Japan

Date Visited: 27 March 1998

WTEC Attendees: R. Chellappa (report author), B. Brown-Davis, R. Larsen, J. Mendel, H. Morishita, R. Reddy

Hosts: Dr. Shigeru Akamatsu, Head, Department 2, ATR Human Information Processing Research Laboratories
Dr. Michael Lyons, Invited Researcher, Department 2, ATR Human Information Processing Research Laboratories
Dr. Kenji Mase, Head, Department 2, ATR Media Integration and Communications Research Laboratories

BACKGROUND

ATR, a private company, was established in 1986 with support from industry, academia and government under the Japan Key Technologies Center (KTC) initiative with a mandate to serve as a major center of basic telecommunications R&D. ATR also fosters national and international research collaborations through an invited researcher program, workshops and seminars. The research activities of ATR are carried out in four research laboratories:

1. Media Integration & Communications
2. Interpreting Telecommunications
3. Human Information Processing Research
4. Adaptive Communications Research

Transitioning of research into products is done under the auspices of one or more of the following laboratories:

- Communications Research
- Interpreting Telephone Research
- Auditory and Visual Perception Research
- Optical and Radio

Communications Research

Findings are widely disseminated through domestic and international conferences and journals. ATR International's capital is ¥22.03 billion, as a result of investments from 140 companies. The total annual research budget is about ¥8 billion, divided among the basic research laboratories. 70% of the research budget is from the government, the rest being from private companies.

Staff

The total number of employees is 295, of whom 235 are involved in research. The 235 researchers are composed of 53 invited international researchers, 38 invited domestic researchers, and 118 researchers transferred from other companies, the remaining 26 being staff (in-house) researchers. The distribution of researchers among the four basic research laboratories and the headquarters is as follows:

- Headquarters 24
- Media Integration & Communications Research 50
- Interpreting Telecommunications Research 51
- Human Information Processing Research 69
- Adaptive Communications Research 41

RESEARCH ACTIVITIES

The hosts were from the Media Integration and Communications, Interpreting Telecommunications, and Human Information Processing Research Laboratories. The site report discusses research projects that were selected from ongoing research efforts.

Human Information Processing Laboratory

The activities of the Human Information Processing Lab were presented by Dr. Shigeru Akamatsu. The focus is on multi-modal interactions between perception and production through *kansei*. *Kansei* is defined as computing that relates to, arises from, or is influenced by human characteristics such as sensibility, perception, affection or subjectivity. A national research project sponsored by the Ministry of Education during 1992-1995 gave impetus to giving computers human-like responsiveness.

One of the media of *kansei* information is the face, as it is able to express subtle emotions. There are two aspects to what is perceptible from a facial expression. One deals with image engineering issues of accurate, robust face recognition and expression algorithms. The other deals with human-science aspects of mimicking human information processing. For example, to respond to queries such as who looks similar here? or who is the most senior? one should incorporate ideas from human information processing. The emphasis of this group is on combining psychophysics and image engineering. Annual symposia emphasizing this for face processing are being held. These symposia have invited lectures from domestic and international researchers. Dr. Michael Lyons demonstrated a gender/expression recognition system using the Gabor wavelet-based group matching technique developed by Dr. C.v.d. Malsburg and associates. Dr. Lyons is investigating the possibility of using discriminant analysis for this problem.

Interpreting Telecommunications Research Laboratory (ITL)

The research activities in ITL, supported by Japan Key Technology Center and other major Japanese companies, started in March 1993. The main focus is on basic research efforts on multilingual speech translation technologies. As part of this seven-year effort, researchers in ITL plan to develop key component technologies such as speech recognition, language translation and speech synthesis. ITL is a core member of the international Consortium for Speech Translation Advanced Research (C-STAR). As part of this involvement, researchers are involved in a joint experiment in multilingual speech translation technologies. Languages under consideration are Japanese, Korean, English and German. The WTEC team saw a demonstration of multilingual chat translation in the domain of travel-related conversations. The prototypical system demonstrated uses a combination of examples and rules in a unified framework and handles two-way translation between Japanese and English, Korean or German and outputs synthesized speech in these languages. The example-based approach is trained using a large number of spoken expressions, while the rule-based approach makes full use of linguistic rules. Multilingual translation is accomplished in an incremental fashion. Example-based translation is done using a semantic similarity measure between words. Rule-based translation relies on manipulation of syntactic rules, lexicons and dependency structure rules.

Natural-sounding speech synthesis using a concatenation based scheme was demonstrated. More details on multilingual translation algorithms developed at ATR may be found in the following references: Sumita and Iida 1992, Furuse and Iida 1996, Wakita et al. 1997, Mima et al. 1997. Related work on parallel implementations using a massively parallel associative processor and a CM-2 connection machine is described in Sumita et al. 1993 and in Sumita et al. 1994. A comparison of implementations of example-based retrieval schemes using serial, MIMD and SIMD architectures is in Sumita et al. 1994. Using the relationship between architectures and response times, an appropriate architecture may be designed

depending on the response time constraint. Related work using associative parallel processors may also be found in Sumita et al. 1995.

Media Integration and Communication Research Laboratory

An agent interface that serves as a tour guide was demonstrated. This generic approach will be useful for exploring cyberspace. Other ongoing research efforts in this laboratory are communication by mental images including *kansei* processing, virtual reality, art and technology, including interactive environments, understanding of emotions from music and people's voices and human communications science. Due to time constraints, the site visit team could not see demonstrations of these projects. See the WTEC Panel Report on Human-Computer Interaction (http://itri.loyola.edu/hci/) for more details concerning ATR's HCI research. The forthcoming WTEC report on the Japanese Key Technologies Center program will also include further information on ATR (see http://itri.loyola.edu).

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Wakita, Y., J. Kawai, and H. Iida. 1997. Correct parts extraction from speech recognition results using semantic distance calculation, and its application to speech translation. In *Proc. Spoken Language Translation*. Madrid, Spain. July.

Site: **Fujitsu Laboratories, Ltd.**
Multimedia Systems Laboratories (MSL)
4-1-1 Kamikodanaka
Nakahara-ku
Kawasaki 211-88, Japan
http://www.fujitsu.co.jp/hypertext/flab/index-e.html

Date Visited: 23 March 1998

WTEC Attendees: M. Shamos (report author), T. Ager, L. Goldberg, R.D. Shelton

Hosts: Jun-ichi Tanahashi, Senior Vice President and General Manager, Personal Systems Laboratories
Hiroshi Muramatsu, Deputy General Manager, MSL
Haruo Akimoto, Director, Media Integration Laboratory, MSL
Mitsuhiko Horii, Multimedia System Promotion Section, Digital Library Project Dept.
Kunio Matsui, Senior Researcher, Media Integration Laboratory
Dr. Satoshi Naoi, Senior Researcher, Media Integration Laboratory
Akira Ushioda, Senior Researcher, Media Integration Laboratory

BACKGROUND

Fujitsu Limited is a $36 billion diversified company focused on personal computers, server systems, network computing and electronic devices, including mainframes and disk drives. Fujitsu Laboratories, Ltd. was formed in 1968 as a wholly owned subsidiary of Fujitsu. It has 1,500 employees and seven laboratory divisions. The panel visited the Multimedia Systems Laboratories, which develops high-speed, large capacity multimedia processing and infrastructure technology. Development of networked multimedia information service products takes place at the Personal Systems Laboratories in Akashi and Fukuoka. This laboratory was represented by Mr. Tanahashi.

Mr. Akimoto gave an introduction to Fujitsu's Media Integration Laboratory. Fujitsu management's view of a digital library goes beyond the academic setting to encompass corporate information management. Digital library development takes place within Fujitsu, not Fujitsu Laboratories.

DIGITIZING CORPORATE INFORMATION

Dr. Naoi presented the research being performed in the Media Integration Laboratory. Fujitsu is working on corporate information management, part of which involves digitizing archival paper records. It is not sufficient to perform OCR on such materials because they must also be indexed. Fujitsu has developed a system for identifying document titles from font, location size and separation data. It requires about one second per page on a 166 MHz Pentium and identifies the title correctly more than 90% of the time. The correct title is among the first three candidates 97% of the time.

If the documents are in tabular, rather than free structure, such as business forms with known or learnable field locations, the system is able to achieve nearly 100% recognition from type in 1.5 seconds at any resolution of 200 dpi or greater, even in the presence of noise or incomplete input. It operates by building a forms dictionary, recognizing pairs of parallel lines and extracting keywords that identify fields. It then matches lines and scanned keywords from the input document to isolate the form type.

SECURE ARCHIVER

Mr. Muramatsu explained Fujitsu's digital security technology, which relates to four areas:

- *Digital Signatures*. Methods of assuring genuineness of digital (not handwritten) signatures and preventing alteration.
- *Copy Protection.* Methods for preventing unauthorized copying and accounting for authorized copying of digital materials.
- *Digital Watermarking*. Methods for detecting works based on copying or altering digital materials.
- *Secure Archiver.* A technology for obtaining provably authentic and time-stamped versions of documents. Electronic documents, even ones with digital signatures, can be copied. Furthermore, legitimate multiple copies of documents, such as contracts, are often required. It is essential to be able to differentiate between authorized legitimate copies and forged or altered ones. The Fujitsu Secure Archiver contains a dedicated LSI board for detecting data alteration combined with a magneto-optical disk separate from the computer's regular hard disk. When a document is created, it is time-stamped from an unalterable secure clock, and a serial number is assigned based partially on the location in which the document resides and a media serial number. If the document is copied, the information in the copy will be inconsistent and the copy easily detected.

Transmission of reliable documents is performed by secure archivers at the transmitting and receiving ends. The devices code and confirm transmission. If necessary, the recipient's copy can now be encoded as an "original" while the sender's version becomes a copy. Through internal clock records, the original of any document can be tracked, and a list of recipients and retransmitters generated. Revisions can be controlled and portions modified after initial creation can be identified.

The secure archiver is the first commercial technology of its kind. Such technology is critical for digital libraries because of the need to detect impostor documents and those that have been altered without the consent of the original author.

Japan is considering establishment of an electronic notarization office, primarily for dating and archiving contractual agreements between corporations. While it will be inexpensive to have documents electronically notarized, the office is not intended for routine commercial transactions, such as credit card purchases, whose volume would be overwhelming.

DIGITAL LIBRARY PRODUCTS

Mr. Horii explained Fujitsu's digital library program, which consists of government projects, joint research with universities and product development. The Electronic Library Research Group, chaired by Prof. Nagao (now President of Kyoto University) was formed in 1990 to study the functions and problems of digital libraries. Fujitsu joined in 1992 and developed Ariadne, a prototype digital library search and retrieval system, in 1994. The remainder of the group includes 3-4 universities (including the University of Library Information Science) and about nine companies.

Fujitsu's digital library product is called iLis and incorporates concepts from Prof. Nagao's Ariadne system. An iLis search was demonstrated in a test database of several thousand documents. The system searches bibliographic data, tables of contents and body text. It has the capability of searching for synonyms, translated words and inflected forms. The user's personal search history is maintained. Search results can be viewed via a page-turning system and can be read horizontally or vertically, the latter being more convenient for Japanese. Output can be read aloud by the computer, although the voice is typically mechanical. iLis provides a mechanism for users to communicate with librarians so they can be assisted in search functions. This is referred to as a "question-and-answer" system, although the answering is performed by humans, not software.

A MITI-funded next-generation digital library project at Fujitsu employs about 20-30 people. The project is scheduled to last until 1999. Fujitsu's role is to develop retrieval technologies and integrate them into a new prototype system.

Mr. Matsui presented Fujitsu's Terass (Terabyte Search Server) product, which is able with inverted indexing to search a gigabyte file in about 1/20 second. Japanese full-text search is complicated by the fact that the

language does not use word separators. Terass can search for any string, regardless of whether it consists of complete words. Part of the Terass technology is its index structure algorithms, which store the pointer of index, which includes the low frequency of occurrence of Japanese character strings. This method would not work on English words. Japanese kanji characters do not repeat nearly as often, so storing gaps is efficient. On a Japanese-language patent database of size 1.6 GB, Terass was able to create an index in 4.3 hours that allowed searching in .23 seconds for OR queries. For the previous system, an index was created in 22.3 hours in which searching took 19.2 seconds for OR queries.

Mr. Ushioda explained cross-lingual information retrieval. The problem being worked on is to retrieve English documents related to a given Japanese document. The terms appearing in the source document are ordered by frequency of appearance. Each term is then mapped to a corresponding English term (translation). The set of terms in the source document can be regarded as a vector in a vector space of the corresponding English terms. The magnitude of each coordinate of the vector is related to the frequency of occurrence. Each English document in the collection to be searched can also be viewed as a vector in the same coordinate system. The inner product of the source vector with each vector of the target population is calculated and the resulting hits ordered by decreasing magnitude. This method succeeds in retrieving highly relevant material.

Site: **Hitachi, Ltd.**
Central Research Laboratory (CRL)
1-280 Higashi-koigakubo, Kokubunji-shi,
Tokyo, 185-8601, Japan
http://koigakubo.hitachi.co.jp
maeza@crl.hitachi.co.jp

Date Visited: 25 March 1998

WTEC Attendees: R.D. Shelton (report author), T. Ager, B. Croft, L. Goldberg, M. Shamos

Hosts: Shinichi Fukushima, Chief Manager, National Project Promotion, ISG
Akio Azuma, Engineer, Information Systems Department, ISG
Junji Nakata, Researcher, Systems Development Lab
Hiroyuki Maezawa, Department Manager, MSR Department
Hiromichi Fujisawa, Chief Researcher, MSR
Yoshie Ohno, Sr. Researcher, MSR
Yasushi Kanada, Sr. Researcher, MSR
Minoru Ashizawa, Sr. Researcher, MSR
Junichi Matsuda, Sr. Researcher, MSR
Toshiko Aizono, Researcher, MSR
Yuko Nakamura, Research Cooperation Center, CRL

BACKGROUND

Hitachi is a $68 billion (net sales) company with 330,000 employees that invested over $4.07 billion (6% of sales) in electrical and electronics R&D in FY 1996 (Hitachi 1997a).

- The Central Research Lab, one of Hitachi's seven corporate laboratories, provides the Hitachi Group (Hitachi Ltd. and affiliated companies) with R&D in information and media, electronic devices, and medical electronics with 820 technical personnel on its lovely 50-acre campus in western Tokyo, in the city of Kokubunji (Hitachi 1997b).
- The WTEC team visited the Multimedia Systems Research (MSR) Department, one of 11 research departments at CRL. The company also brought in researchers doing related work from other units in the Tokyo area: a business group, the Information Systems Group (ISG) and the Systems Development Lab., which is another corporate laboratory of Hitachi, Ltd.

MITI DL PROJECT

Mr. Fukushima provided a briefing on the Next-Generation Digital Library System Research and Development Project (NGDL), funded and initiated by the Ministry of International Trade and Industry (MITI). Hitachi has contributed to the design of the architecture for the system, as well as provided some of the background research. Five Hitachi units are participating in the project. Fujitsu will integrate the prototype system of the project. Seven other companies are involved. The background research and design was completed during FY 1996-97 and development and testing will be conducted during FY 1998-99.

The overall architecture selected contains three layers: Presentation, Function, and Data based on a distributed object-oriented model. The messaging architecture features synchronous and asynchronous communication and a WWW-CORBA connection protocol. The basic agent architecture is based on FIPA agent management, agent communications via FIPA and KQML, and migration via OMG. The multimedia database architecture is based on SQL3, SQL/MM, and OODB with SMGL document management. The mobile agent architecture is based on CORBA, OMG/MAF and the Java programming language, and is being developed by Nihon Unisys. The intelligent information retrieval agent, which can search a variety of databases on the Internet, is mainly being developed by NEC.

The Japanese Information Processing Development Center (JIPDEC) has a set of slides on this project at http://www.jipdec.or.jp. This site contains a list of several other enabling technology development efforts now underway.

Hitachi developed the predecessor PILOT digital library system now in operation at the Center for Information Infrastructure (CII) in Fujisawa City (http://www/cii.ipa.jp/el/index_c.html).

DEMONSTRATIONS

Concept-Based Text Retrieval (T. Aizono)

This was the one NGDL-funded project shown; the others were apparently internally funded. This Japanese-language system is intended to assist the user retrieve text information via a thesaurus and document clustering. The thesaurus is automatically extracted from the database by term extraction and compound term analysis leading to co-occurrence data acquisition: syntactic co-occurrence, co-occurrence in the same window, and co-occurrence in the same sentence. The first and second order correlations are determined and stored for browsing. Document clustering is based on clustering query-related terms, which are used to assign documents to clusters via the group average method. Performance data included 86% precision of the compound term for the thesaurus, and real time clustering of 2,500 documents in 15 seconds.

Multilingual Translation System (J. Matsuda)

Hitachi has a mature commercial English/Japanese machine translation (MT) product being sold as an application program for some ¥9,800 in the Akihabara electronics shopping area of Tokyo. This demonstration showed some improvements of this product for English language Web page browsing by Japanese speakers plus some of Hitachi's new interests (also seen at several other sites) in Japanese/Chinese and Japanese/Korean MT systems. It was difficult for the panel to evaluate the accuracy of the translations without an interpreter, but the user interface was clearly well done.

Encyclopedia Retrieval System (Y. Kanada)

This is a text retrieval system based on combining a keyword search with a second one such as some unit of measurement mentioned in the records. Mr. Kanada demonstrated several searches, including one that combined the Japanese word for “riot,” or civil disturbance, with the date of occurrence in the encyclopedia. A second search combined the names of rivers with the area of their watershed.

Webshelf—Virtual Personal Library (M. Ashizawa)

At the IBM Tokyo Research Lab, the WTEC panel saw a demo of Global Digital Museum, which allowed the user to assemble a personal collection of museum-quality artifacts, at least virtually. A sudden desire to be able to assemble a personal library of rare books was satisfied the next day at Hitachi Central Research Laboratory by Webshelf, an attractive human-network interaction (HNI) system, which allows users to personalize information on the Web. The display showed an image of a conventional bookshelf containing books, the title on each spine being linked to a URL. Two types of bookshelves exist: a communal bookshelf located on the server allowing for “books” (URLs) to be shared, and a private bookshelf located on the client. By clicking the spine of a book, the document is recalled from the Web in the page-style of a physical book and is read by turning the pages using page-turning graphics. Electronic marginalia could be appended. Webarchive, a hypermedia archive proxy server, stores all versions of data and links browsed by the user separately, allowing the user to browse past versions of Web pages, as well as saving the version as a particular edition of a book.

CONCLUSIONS

A half-day's visit to a company the size of Hitachi can only sample the relevant R&D projects. For information on some other projects, a copy of Hitachi Technology 97 (Hitachi 1997c) was provided. A reprint (Kamiuchi et al. 1997) described the digital image system (DIS), which is the basis of Hitachi's respected virtual museum “Viewseum” hosted at http://www.viewseum.com.

Also, the company's homepage at http://www.hitachi.co.jp links to sites of the Hitachi’s other corporate labs, which contain short summaries of many interesting projects. A recently announced prototype system at CRL was a display system for the visually impaired of *Windows*® 95 screens using a 3D acoustic field. A part of this work was performed as part of the National Research & Development Programs for Medical and Welfare Apparatus under entrustment by the New Energy and Industrial Technology Development Organization (NEDO).

The Hitachi Systems Development Lab (SDL) Web site lists an impressive digital information access program including, for example, a video-based virtual reality system, data mining for digital libraries, and at least five projects on network security.

The breadth of all these efforts is impressive, and those demonstrated in detail show great promise as building blocks for large information delivery systems such as digital libraries.

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Kamiuchi, T., N. Hamada, and N. Ikeshoji. 1997. Digital image system and its applications. *Hitachi Review*. Vol. 46. No. 5.

Site: **IBM**
Tokyo Research Laboratory (TRL)
1623-14 Shimotsuruma
Yamato, Kanagawa, 242-8502 Japan
http://www.trl.ibm.co.jp

Date Visited: 24 March 1998

WTEC Attendees: T. Ager (report author), B. Croft, L. Goldberg, R.D. Shelton

Hosts: Dr. Hong Jung-Kook, Manager, Solution Research Center, TRL
Dr. Kazuo Iwano, Director, IBM Research, TRL
Dr. Hiroshi Maruyama, Manager, Network Applications, TRL
Mr. Masayuki Morohashi, Associate Consultant Researcher, TRL
Mr. Kunihiko Tejima, Program Manager, Asia Pacific Solution Development IBM Japan Ltd.

BACKGROUND

Tokyo Research Laboratory is one of eight IBM research labs (New York, California, Texas, Japan, China, India, Israel, and Switzerland). It was established in 1982, and currently has 165 employees. The lab's focus includes mobile computing, graphics, object-oriented technologies, user interface, computer science theory, compilers, storage, and LCDs. The lab also does research on digital libraries, collaborative computing, and electronic commerce.

The lab collaborates closely in these areas with IBM Laboratories in the other sites, product development, manufacturing and marketing groups, and its work has resulted in the adoption of many TRL ideas and technologies in IBM products and customer solutions. TRL also conducts joint work with universities, other research institutes, and customers through joint studies, workshops and visiting scientist programs. Lab research activities are made public through presentations to academic societies and publications in technical journals.

PRESENTATIONS AND DEMONSTRATIONS

Dr. Hong Jung-Kook gave an overview of the lab's mission and functions in IBM's worldwide research division. He described the following TRL technologies that are closely related to organizing and managing digital information. Where further information is available from the TRL Web site, URLs have been provided. A high performance "just in time" Java compiler gives 1.3-25 times increase in speed over interpreted Java, and for some programs up to a 50x increase in execution speed.

A System for Creating Mobile Java Agents Called "Aglets"

An aglet is a Java object that can move from one host on the Internet to another. That is, an aglet that executes on one host can suddenly halt execution, dispatch to a remote host, and resume execution there. When the aglet moves, it takes along its program code as well as its state (data). A built-in security mechanism makes it safe for a computer to host untrusted aglets.

A Speaking Web Page

A speaking Web page, designed to support Internet access for the blind, uses text to voice and voice synthesis technologies.

A Personal Translator

The Japanese translation capabilities of Web homepages are achieved as top-level technology in the Japanese marketplace. IBM has capability of Web homepage translation in the different language pairs, such as G-J, G-K, G-C, E-F, E-S.

Video Mosaics

Video mosaics (creating a panoramic view from individual video frames based on object segmentation) and video indexing were shown.

TECHNOLOGIES PRESENTED IN GREATER DETAIL BY TRL PROJECT LEADERS

Information Outlining

Mr. Masayuki Morohashi presented "information outlining." This is an information retrieval technique that combines metadata extractors with visualization tools. For a corpus, classifying functions extract values for predefined categories such as dates, city names, personal names, brand names, countries, etc. Viewers are developed that can map attributes, distributions and frequencies to visualizations such as maps (for city or country names), time lines (for dates), and business charts for distributions. Because content is both keyword-indexed and classified, a keyword search result can be organized in several complementary visualizable modes, and these modes can interactively manipulated. Time lines can be compressed or expanded, for example, having the effect of refining a search with respect to date of publication or dates mentioned in the articles. Or, it is possible to represent the times and/or places associated with the mention of a public figure, such as President Clinton. The technology has been demonstrated, and has been incorporated in an IR system IBM is delivering to a major newspaper in Japan. Further information about information outlining is on the Web. The technique is discussed in several papers (Morohashi and Takeda 1997, Morohashi and Uramota 1996, Morohashi et al. 1995).

Reliable Multicast Transport Protocol (RMTP)

Mr. Kunihiko Tejima discussed and demonstrated RMTP. RMTP enables content providers to reliably deliver content to 5 to 10 thousand recipients at once. It requires RMTP software on client (recipient) systems. The RMTP protocol runs on existing Internet enabled for multicast. RMTP clients track packet arrival, and after the original dispatch is completed, contact the server to request missing packets. In this way, multicast is made more reliable, so that RMTP-based multicast can achieve assured synchronization of data, scheduled delivery of information, while also saving server and network costs. From the server standpoint, a 2 MB payload can be delivered to 5,000 clients in three minutes. Using consecutive FTP would take 3 hours. Conventional IP multicast does not provide the client-side capabilities of RMTP, which add the assured delivery characteristics.

RMTP is being proposed as an Internet standard by the TRL.

Security and Electronic Commerce

Dr. Hiroshi Maruyama explained the many projects at TRL relating to the protection of information in digital library and electronic commerce applications. Security technologies exist at all levels of modern layered systems, from chip-level encryption, storage device protection, through middleware security methods such as secure servers, firewalls, key management, and secure desktop applications or clients. TRL is actively involved with technologies at all levels including the following:

- *Key Delivery Protocol.* In multiparty encrypted sessions, such as secure collaborative work, the overhead of redistributing keys when a party leaves the session is reduced if the keys are distributed along paths described by a binary tree instead of each party receiving a key directly from the sender. In the binary tree distribution technique, key updates need only occur along the chain leading to a party that leaves the session.

- *Security Hardware.* TRL has developed a hardware RSA decoder that can be embedded in devices such as a personal digital assistant or smart card. It can decode a 1K key in 27 ms (63 ms in PDA when embedded). Software decoding on a current palm pilot takes 4 minutes.

- *Key Management Framework.* Using a protocol called Time Release Key, information is encrypted in such a way that it is only releasable at a predetermined time. This can be used for electronic delivery of sealed bids, thus protecting the bid amount until the announced opening time.

- *Code Security.* Issues in the security of network distributed code were discussed. Examples of insecure Java applets and Active X controls were presented. These examples illustrated weaknesses in the current practice of co-designing, where developers attest to the safety of their applet or control.

GLOBAL DIGITAL MUSEUM

In addition to the specific technologies for organizing and managing digital information, TRL has been working with Japan's National Museum of Ethnology since 1986 on a digital museum project. Currently the project includes additional collaboration with the British Museum and Cornell University. The project focus is online, interactive material development for museum education at the K-12 level. It includes capabilities for search, navigation, browsing and annotation and personal exhibit construction. The participating museums provide curatorial, collections, and cataloging expertise. Cornell adds evaluation and curriculum development skills, and TRL provides technologies for the project. In its overall structure, the project is very much like many computer-based education projects in the United States. Funding is mainly derived from IBM. Architecture and implementation of the Global Digital Museum are discussed in greater detail in Chapter 4. A current report on the Global Digital Museum appeared in June 1998 (Takahashi et al. 1998).

CONCLUSIONS

The team was impressed by the breadth and depth of research being done at TRL. The IBM Tokyo Laboratory is both a solution provider and a creator of new technologies. It works directly with customers, and its contributions to IBM are complemented by other research laboratories and product development labs worldwide. Thus only a partial picture of IBM's total approach to digital libraries was represented in the TRL visit. Nevertheless, it was apparent that there are many unresolved issues of policy, standards, and accepted practices, and that the TRL is investigating many different approaches to information organization and content management.

The Global Digital Museum addresses architecture and systems for a solution to worldwide access to museum information for K-12 instructional purposes. In other areas affecting digital libraries, particularly protocols and security, the TRL has an international focus.

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Date Visited: 25 March 1998

WTEC Attendees: J. M. Mendel (report author), R. Chellappa, B. Davis-Brown, L. Goldberg, R. Larsen, R. Reddy

Hosts: Toshiyuki Takamiya, Prof. of English, (leader/sr. spokesperson of the Keio delegation)
Shigeaki Iwai, Lecturer of English
Takami Matsuda, Assoc. Prof. of English
Tomoko Ushiyama, graduate student

HUMI PROJECT

Background

This section was extracted from the typewritten remarks of Professor Takamiya and Mr. Iwai, who generously provided them to the panel at our request.

The Humanities Media Interface Project (HUMI) was launched at Keio University in Spring 1996, with the aim, among others, of digitizing major rare books and manuscripts—Western, Japanese and Chinese—in the Keio collection, including the Keio Gutenberg Bible. (Obtaining the Gutenberg Bible was remotely connected with Keio University's founding president Yukichi Fukuzawa, who saw the Gutenberg Bible on his visit to St. Petersburg as early as 1862.) The HUMI Project has been supported by the Education Ministry, the Information-Technology Promotion Agency (IPA), which is attached to the Ministry of International Trade and Industry, and Keio University.

The Keio University Library has a very large collection of rare books, including 8,000 Western rare books. Project participants seem to have a very progressive view of digitization of books, namely that, once digitized, the book can be reassembled any way a person wants. The Keio Gutenberg Bible has played a very important role in the HUMI Project. It was acquired not just for possession of an important article of Western cultural heritage, but because Keio University believes that modern research libraries should possess works significant enough to be digitized for the benefit of today's scholars and for the greater goal of preserving these treasures for posterity without further decay.

Prof. Takamiya summarized the reason for the HUMI Project. He pointed out that, "Digitization means more than just creating a passable facsimile on a computer screen. It is an opportunity for transcending the confines of the traditional format, with its bound pages. Once digitized, every component can be unbound and rebound in an infinite number of ways. The book becomes a new entity in 'cyberspace'—perhaps more vivid than ever possible in the real world, where rare books are often inaccessible. In the worlds of virtual reality we can re-experience it in a personal way. This means that digitized rare books, including the Gutenberg Bible, will never become forgotten relics of past wisdom. They will come alive every time someone has access to them. This, then, is the raison-d'etre of the HUMI Project."

According to Prof. Takamiya, "The HUMI Project aims to digitize manuscripts and rare books, process them, research them, and provide online access to multimedia representations. Data and results will be transmitted via high-speed networks and the Internet. The global academic community will thus be able to use this material for education and research. In terms of digitization, there are two roles for the HUMI Project: (a) to establish the foundation of digital technicalities from a viewpoint of research in humanities, and (b) to explore the possibility of producing what should be called digital bibliology by applying digital imaging techniques to history of the book, information management, and pedagogical presentation."

As an inter-faculty initiative organized by Keio University, the HUMI Project is envisioned as a first step in the establishment of a digital research library based on the rare book collection at Keio. Bibliographical analysis of the rare books and manuscripts has been conducted by members of the English Department, led by Prof. Takamiya; non-destructive testing has been performed at two research laboratories in the Faculty of Physics and Technology under the supervision of Profs. Ozawa and Inoue, respectively; and virtual reality applications have been developed under the guidance of Prof. Okude of the Faculty of Environmental Information. Technical aspects of the HUMI project have also been supported by various firms forming a consortium.

The HUMI Project began its activities by taking advantage of the Japanese government's request for participation in the electronic library pilot project. This governmental project has its origin in the fact that Japan was nominated as one of the main promoters of a global electronic library at an international summit conference. In 1995, the government established the Center for Information Infrastructure (CII) at Keio University's Shonan-Fujisawa Campus as a part of the activities conducted by the Ministry of International Trade and Industry's Information Technology Promotion Agency (IPA). The Electronic Library Pilot Project began by digesting the resources of the National Diet Library, including 10 million pages from Japanese rare books and other materials. Many of these digital resources have already been opened up to the public through the Internet.

The Keio University HUMI Project began its partnership with CII in 1997, and provided digital images of the Keio University collection, which included both oriental and Western rare books.

In March 1997 project members successfully digitized a complete set of images of the Keio Gutenberg Bible (about 650 images). The group used a digital camera jointly developed by NTT (Nippon Telegraph & Telephone) and Olympus Optical Company. Since this camera is an experimental one-shot 3-CMD model, it took only a few seconds to acquire a full color high-resolution image (2,048 x 2,048 pixels). With this camera and a special book cradle developed by the HUMI Project, the team also successfully digitized the Cambridge University Library copy of the Gutenberg Bible (2 volumes, about 1,300 images) within four days in November 1998.

Online Catalog

Prof. Matsuda described the online catalog (OLC) of Western manuscripts and rare books in the Keio University Library. He emphasized non-traditional access points (in addition to author, etc. information) and that the catalog is non-static and can constantly change. Different experts can add to the index, based on their interpretation of an item, and the index is easily updateable. There are no current plans for collaboration within Japan on the OLC and digitization, in the area of rare books and manuscripts. To-date the project has digitized 5,000 pages in about two years. High quality and resolution are emphasized. The project managers are considering re-digitization again and again as higher-quality digitization equipment becomes available.

Photo Labs

The WTEC team members then toured three photo labs in the old library, in which project staff members are experimenting with different camera techniques ranging from high speed digital cameras to slower, but higher-resolution line scanning cameras. One laboratory contained a very high-speed digital camera, an NTT-Olympus prototype that takes 5 sec/page to get a large image onto a display. Curvature of the page is a problem. Bleed-through from the back of a page (which is actually present because the rare manuscript was originally written and illustrated on both sides) needs to be removed digitally, if the viewer so desires. This camera is used to copy an entire book very quickly. In a second laboratory, a Dicomed digital camera back with a Mamiya RZ67 camera is used to digitize Western illustrated books. The camera has a viewfinder and takes about 2 minutes per page. In the third laboratory there is a Kodak Professional PCD Scanner 4045 which is being used to scan 4 x 5 and 6 x 7 films.

VIRTUAL REALITY LABORATORY

Virtual Tour of Monastery of San de Marco

The team members then went to the new library where they were given a demonstration of a virtual tour of the monastery of San de Marco in Florence, Italy. This is in Prof. Okude's laboratory. Unfortunately, he was traveling; however, his student, Ms. Tomoko Ushiyama, gave the team a wonderful presentation. The tour was displayed on three flat screens using back projection; each screen has its own projector. No glasses were required. One thousand photographs were taken at the monastery. These were then used with a 3D modeling package to create the tour. Buildings and surroundings were all synthesized, whereas the artwork was all photographed. This required 200 MB of storage. On the virtual tour it is possible to zoom in on the many works of art. The tour is controlled using a joystick. This is a wonderful example of how digital information can be used for education and learning about artwork at a location that most people will not have the opportunity to visit.

Digital Gutenberg Bible

A digital Gutenberg Bible was demonstrated. It was pointed out that today almost no one can read or touch this kind of rare book; but, in the virtual reality environment, researchers, even young students, can access the Bible directly. The human interface of turning the pages, makes researchers learn intuitively. One can see the Bible as close up as possible, and pages can actually be turned. The Bible can be opened and closed, and we can look at its cover. Signatures of its past owners can be found, so we can get to know who kept this Bible in the past. It's possible to tear a page and see several pages at one time.

Technology Agenda

WTEC's hosts then described two technical problems for their project:

1. *Interface*. The three main characteristics of the virtual reality technology are immersion, interactivity and information intensity. The project staff members would like to use three big flat screens as an immersive experience without using a joystick, gloves, head-mounted display, or glasses. Researchers believe that researchers or scholars want to have a more natural interface to communicate with computers to have the real experience. They, therefore, want the future interface to be more intelligent and responsive to researchers' wants and needs.
2. *Object Oriented Database*. Digital libraries will become distributed information managers of the links to other digital libraries. Researchers want not only to get the information, but also to create new ideas and knowledge and to have their own collections, and communicate with other researchers. The project staff members believe that an object-oriented database is necessary to use multimedia data and to communicate with each other in a distributed networked environment.

Collaborations

Finally, the WTEC team had a short question and answer period with the Keio University hosts. On the question of university/industry collaborations, they invited computer companies to join in a consortium, and 20-25 joined. Hitachi has been very helpful; NTT provided the digital camera (they want to be able to share the results of the HUMI research just for publicity purposes); and, Hitachi provided digital imaging systems for removing stains and processing of very high-resolution images. Keio University has excellent connections with companies; their graduates now occupy very high management positions in the 20-25 companies and are very supportive of their work.

Accessibility

On the question of making the virtual reality space available to others, it was stated that the space will be made available to researchers, and it is not going to be used just for demonstrations.

Lessons Learned

On the question of what lessons were learned and can be shared from their experiences, project team members stated that international collaboration would be very useful on such a project. In addition, the two weeks it took to scan the 600 pages of the Gutenberg Bible scales up, so that their experience in doing this can be used to help estimate costs of other projects.

ANSWERS TO "ISSUES FOR DISCUSSION WITH HOSTS"

Answers to a large collection of questions that were sent ahead of the panel's visit are provided below. The questions were circulated among members of the HUMI Project and were then compiled and transmitted by Kenji Umeto, Secretary, HUMI Project, Keio University (uk@tempus.keio.ac.jp).

[Okude] = Naohito Okude, Professor, Faculty of Environmental Information, Keio University

[Hosono] = Kimio Hosono, Professor, School of Library Science, Keio University

[Shibukawa] = Masatoshi Shibukawa, Professor, Faculty of Environmental Information, Keio University

[Armour] = Andrew Armour, Associate Professor, Faculty of Letters, Keio University

[Iwai] = Shigeaki Iwai, Lecturer, Faculty of Letters, Keio University

A. GENERAL

1. Please describe your long term vision or scenario for:

a. digital information generally

[Okude]

Digital information technology offers the most extraordinary opportunities to teach and study the liberal arts in new ways. Digitization of the liberal arts drastically democratizes them. The people who developed computer literacy perceived it as a device of democratization from its inception. This democratization is the most powerful influence of digital technology on modern thinking.

[Hosono]

In the academic environment digitized and printed information should co-exist together. Roles that printed information like academic journals have played can not be completely replaced by digitized versions in the near future. Digital information is not necessarily reliable in terms of its quality, stableness and durability.

[Shibukawa]

The supposed digital library could be considered as logistics of supplying any necessary information to common people, which would thoroughly differ from what we call 'library' now.

The current library, though useful, is not able to provide all the information concerning people's everyday life (personal, domestic, professional, or social). This, however, is the goal of the digital library: it must enable people to "live" using the digital network, in which all the digitized, organized, and united information can be retrieved. It is not predictable when and how such a system will be realized; its dynamics would be a harbinger of a social change. The "library" has progressed for 5,000 years, and the realization of the digital one will still need some other years though it will come true before the quincentenary of the Gutenberg revolution. This view is based on the statements of Fukuzawa Yukichi ("Knowledge develops courage," 1879), P. Butler ("Books are one social mechanism for preserving the racial memory and the library one

social apparatus for transferring this to the consciousness of living individual," 1933), and P. Barker (his scenario from "Polymedia libraries" through "Electronic libraries" to "Digital libraries," 1996).

b. digital libraries specifically

[Okude]

The role of the nineteenth century library as the custodian of physical printed materials will remain, but the digital libraries will become distributed information managers of the links to other digital libraries. A grand distributed global digital library is the dream and the final goal of the digital libraries' endeavor.

[Hosono]

Digital libraries could be defined in several ways, such as networked information resources, digitization of traditional libraries (i.e., integration of digital collection and the systems for utilizing it), computer systems emulating fundamental library functions, etc. If they are recognized as digitization of traditional ones, they may not become popular in the near future because of copyright issues, difficulty to establish inter-organizational management policies, unstableness of methods and technologies to capture and represent digital contents, etc.

In addition to frequently discussed copyright issues, we will have to face several kinds of managerial ones. The example is the decisions related to what materials in the collection of a library should be digitized (i.e., priority issues). As far as we limit the objectives or aims of digitization to the research by the use of, or feasibility studies of a particular IT, issues may not be so tough. If we seek, however, digitization of works in an operational base, the situation will change drastically. In this case, the following must be defined adequately and this is not easy to do at all. Issues include the following: (1) Who is responsible for making decisions in terms of selection, processing, maintenance and management of materials that are to be digitized? (2) How can we carry out cooperative digitization activities with other institutions in order to avoid duplication and establish a network to share the products among them? (3) Where should a digital collection be preserved and archived as the last resort for academic research and studies?

In addition, a lot of issues are left unsolved in terms of managing digital information provided by publishers such as electronic journals. Above (3) is also applicable here.

2. How do national and international intellectual property laws and commercial regulations or practices affect development, deployment, and utilization of digital information?

a. What technologies for the protection of intellectual property are emerging in Japan?

b. Which technologies are emerging for management and protection of intellectual property?

[Shibukawa]

Technologies including code and electronic watermark might be effective against the illegal use of intellectual property to a certain degree. We, however, are pessimistic over the development of technologies that can exterminate illegal use, especially when considering the social opinion that knowledge and information are common property of mankind on the one hand, and the existence of a genuine interest in deciphering itself on the other-hand. We, for the present, endeavor to establish a proper standard of the license contract with social consent and a system to watch the obedience of the contract with technological assistance.

It is problematic (both to social/cultural development and that of business) to insist on ownership of the creativity, regarding it as property, to be concerned only about its illegal use, and to seek the way to solve the problem only through technologies. It is far more important to ferment a common opinion that a proper royalty ought to be paid for a valuable information whether it is a property or not.

3. Please explain how your organization sees the relationship between digital library and electronic commerce.

a. What are the economic or business models that apply to digital library in Japan?

[Okude]

Education and learning is a lifelong pursuit. Within a few decades, people in Japan will come to the university in broken times and take more than four years to graduate; more years to study, and more study. This fragmented and discontinuous pattern is more the exception than the norm now, but students in the future will attend in broken times often at more than one institution. People will want to study and learn more in the future. This knowledge consumer market is the digital libraries' business domain.

b. How have those models influenced the directions digital library technologies have taken and will take in the future?

[Okude]

Learning has always been a people-to-people process. The digital library technology will promote a computer-mediated people-to-people learning process. Technology will be required to expand the libraries' traditional areas, such as information retrieval and distance learning, to the new frontier of information work application to assist the distributed constructionism learning process, using the network system.

[Shibukawa]

Keio University, as an academic institute, has no need to relate the digital library to electronic commerce. Yet present higher education, a public enterprise though it is, could vie with broadcasting and newspapers in their fields, if it will be able to provide lifelong education.

In this sense, education in universities ought to take the economic and marketing model of the mass media as an example. Since the electronic trade which deals in intellectual property will more and more become dominant in such enterprises, the digital library, which is to support the future digital university, will probably provide the information service on the basis of the electronic trade itself.

4. Which sectors of the information technology economy (consumer goods, information services, hardware, business computing, educational technology, etc.) will be the main beneficiaries of future Japanese digital library technologies?

[Shibukawa]

When the digital library realizes the prospects offered in the answer to item A.1, it will produce far-reaching benefits to every concerned area. As a university, however, we hope that the digital library will grow beneficial to academic research and education.

[Okude]

Educational and "research" technology.

5. How do you see internetworking, the convergence of communication and computation, and new distribution technologies for digital data as changing the nature of digital libraries?

[Shibukawa]

If the prospects offered in the answer to item A.1 prove to be right, the development of digital information technology as well as the creation of information contents determines the function and structure of the digital library. But we should note that the rate of the development of internetworking, the convergence of

communication and computation, and new distribution technologies for digital data are closely connected with the demand of society and people for them.

[Okude]

When people and organizations all have computers and all these computers are interconnected, they will buy, sell and freely exchange information and information services. The digital libraries will become distributed information managers of the links to other digital libraries.

6. What are the main trends in content creation technologies?

a. How would you characterize the various market segments for content creation technologies (publishing, entertainment, consumer electronics, education, business, government)?

[Okude]

The real market for digital technology is not the “information market” but the “information work” market. The technologies for information work let a person or a computer program take in information, transform it, and send it out. Today's content creation technologies do not fulfill these conditions.

b. Do you see the need for specialized content creation and management technologies for the separate sectors?

[Okude]

No. What we need are interactive technologies for information work in general.

c. Which sectors do you think will drive the industry in 5 years? 10 years?

[Okude]

Education and learning will be the huge market when the distributed digital libraries and the information work technologies are available to the content creators.

[Shibukawa]

Here we cannot enumerate all of the segments because of limited space, but it can be said that in Japan digital contents have recently been created in various fields including news, library, museum, and the medical industry. The Database Register (the Ministry of International Trade and Industry, annual) reports the details.

I myself strongly feel it necessary to construct the image information database as an enterprise of a public sector; for we now reach the point where we should reconsider the information of the past with the assistance of graphic images, and there must be a great amount of such graphic images. Nonetheless, graphic images, which have not been regarded as an information medium, are neither collected nor organized, and are therefore unavailable. Books indeed pass on to the next generation some of the past information, but not all. As texts with graphic images could probably convey information in full, preservation of the graphic images of the past would provide a new perspective for the present and the future.

In the future, the public and business sectors will cooperate in, or compete for, content creation, and so will industries and companies within the business sectors; but, it is the marketability, that is, people's needs, that will determine the direction.

B. GOVERNMENT AND POLICY

1. What are the public policy drivers of digital library in Japan?

a. How are ministries and agencies tasked and funded to implement these policies?

[Hosono]

National Center for Science Information System (NACSIS), Information Technology Promotion Agency (IPA), and National Diet Library (NDL) are taking initiatives to promote digital libraries.

NACSIS is distributing electronic journal articles directly to scholars and researchers, not via university libraries. These journals are limited to the ones published from learned societies. NACSIS's main aim is to provide academic information to end-users as effectively and efficiently as possible via the network.

IPA, which is an extra-governmental body of the Ministry of International Trade and Industry, has focused its emphasis on the technological aspect of digitization and has financially supported R&D projects carried out by computer/network companies.

NDL has tried to digitize its unique collection to make clear problems such as copyright, user-interface, efficiency of operation, etc. The project has been directed at operational systems.

b. How does the government stimulate or partner with industry in the definition, standardization or commercialization of new DL technologies?

[Hosono]

IPA has a strong direct partnership with industry and tries to support technological development related to digital libraries since such technologies have wider influences on other fields. On the other hand, the role of the Ministry of Education is indirect regarding technologies, since it financially supports university libraries as a whole when they intend to construct digital libraries. So far, at least three national university libraries have embarked on digitization projects.

2. What are the current public sector priorities and programs (education, health, social services, the arts and culture, etc.) for digital libraries?

a. What are the expected outcomes of such programs?

b. What would you identity as the main governmental activities or programs to further digital library technology in the next decade?

[Hosono]

Since the core of digital libraries is the "contents" themselves that are to be digitized and/or utilized, the main governmental activities or programs should be to create and foster a good environment where large volumes of digital information can be easily created and disseminated. Thus it is vital to establish new copyright laws or revise existing ones and strengthen network infrastructure. Introducing new concepts, atmosphere, customs and institutions to encourage digitization activities is also required.

[Shibukawa] (Answer to B.1 & B.2)

The national policy of Japan for founding the digital library is complicated under the conflicting jurisdictions of the Ministry of International Trade and Industry, the Ministry of Education, Science and Culture (MESC), and the Ministry of Posts and Telecommunications. Only MITI has secured the source of revenue and carried out a plan for promoting the digital library.

Although it is the MESC that controls academic research and education in universities, it only directs universities to develop the "electronic library" function as an improvement of the university library services. It has, however, supported model digital libraries in a few national universities (e.g., Nara Institute of Science and Technology).

As a private university, Keio University participates in the Demonstrative Experiment in the Pilot Electronic Library, which the Association for Promoting the Information Enterprise (a division of the MITI) runs in partnership with the National Diet Library and commercial publishers. Financially supported by MITI, it aims at becoming an incubator of digital information technologies, library technologies in particular; but, its technological level, based on the graphic image database, is no higher than that of the digital library of Nara Institute of Science and Technology (though the system was to be improved in 1998). In any case, the Japanese government has no clear policy on the digital library.

3. What is the expected role of digital library technology for public, school, research, technical libraries and museums in Japan?

[Hosono]

The expected roles are many. Following are examples: (1) saving spaces, that printed collections have occupied; (2) strengthening a library collection that is short in volume and variety; (3) expanding the service areas that are physically limited to the inside of a library and to the registered users of the library (this implies that not only will the service be provided to remote users, but also to new customers that formerly were not allowed to receive it); (4) increasing the variety of information that can be searched; and, (5) increasing the service menu (e.g., electronic reference service and online full-text document delivery).

[Shibukawa]

According to Barker's scenario (see the answer to A.1), it is the "traditional" library that will develop from the "book library" through the present "polymedia library" to the "electronic library," and this will also be the case with the museum. University libraries and national museums will play the role of leaders. The digital information and database produced by each library or museum will be rapidly organized.

Such digital information, however, is not composed of new intellectual content, but a legacy of the past, so to speak. New contents have been provided by publishers, newspaper publishing companies, and broadcasting stations. "Electronic publishing" will therefore take the leadership in the development from the "electronic library" to the "digital library" and the "digital museum". In addition, educational and academic research institutes, especially universities that are proposing the "digital university" projects, will play an important role in creative activities.

4. In what ways do you see the traditional skills of librarians, archivists, curators, and information specialists as being utilized or changed by the presence of increasing amounts of digital information?

[Hosono]

These skills are utilized fully for the cataloging, indexing and searching of digital information. Since digital information appears in different representation forms, easy and adequate identification of each item is crucial. Discussions about metadata imply the importance of know-how in traditional cataloging practice. Indexing and searching techniques, having been developed in the library and information science field, are also fundamental for managing digital information.

[Shibukawa]

Following Butler's opinion on the raison d'etre of the library (see the answer to A.1), it can be said that the library, as a device to convey information, must change in accordance with the change of the form of information from "book" to "digital material." Librarians, archivists, curators, and information specialists must also adapt themselves to the change. They ought to develop and acquire the professional skills to provide people with necessary information about books (museum pieces or art objects), digital contents, and

computers at their command. Of course, this does not negate the present skills, with which librarians have long administered intellectual contents, since the age of the Alexandrian library or earlier.

Hereafter, however, professional education needs a new curriculum that goes beyond the traditional framework of "book and book library." It is most important to acquire the skills to produce digital information and databases and to manage the "cyber collections" which will come to existence on the cyber network. Such skills are also necessary for the librarians in active service.

C. OPERATIONS OF DIGITAL LIBRARIES

1. Please discuss your approach to digital collection development end-to-end including:

a. Capture

[Iwai]

We have been trying the following methods for capturing digital images of rare books: (1) Kodak PhotoCD Imaging Workstation and analogue films (4 x 5, 6 x 7, 35 mm); (2) crossfield drum scanner and analog film (4 x 5); (3) scanning camera (Dicomed Field Pro with Sinar 4 x 5 & Mamiya 6 x 7 on WindowsNT); (4) one shot one CCD digital camera (Kodak DCS460); (5) three shots one CCD digital camera (Leaf/Scitex with Mamiya 6 x 7); and, (6) one shot three CCD digital camera (NTT/Olympus SHD View-2 beta version).

In making a comparatively low resolution (approx. 2,048 x 2,048 pixels) but high-quality "digital facsimile" of rare books, we use "(6) one shot three CCD camera," whose advantage is a good balance between capturing speed and quality. At present, the master copy should be produced from big size analog film.

b. Catalog

[Hosono]

Descriptive cataloging practice for printed books can be applied widely but should be expanded to include such information about technologies and/or methods used for capturing and representing digital information. Discussions about metadata are indispensable.

c. Index

[Hosono]

Indexing of digital information is extremely difficult if we expect high retrieval performance, since targets to be indexed are too dispersed to specify and standardize. In particular, index terms that enable us to get access to digital information from its subjects or contents are difficult to determine. A possible way, although its performance is limited, may be to compile a special thesaurus consisting of controlled index terms and to use it as a guide.

d. Representation

[Okude]

I use virtual reality (VR) technology for representation. Bit-mapped, graphics-based supercomputers can run high-speed graphics that track human movement. Immersion, interactivity and information intensity are the three main characteristics of this technology. In the next 10 years, we can expect a widespread and growing experience of virtual reality in a variety of everyday educational and learning environments.

While much of the humanities research community still has ears only for information engineering professionals who speak of being digital, a growing number of humanities scholars are beginning to look at the complex tradeoffs and theoretical shortcomings of the vision of computer professionals. Some scholars are starting to fight digital technology with a Luddite passion.

My approach makes a premise of balance. Virtual reality representation of human artifacts meditates the merger of virtual reality with humanities scholarship. A holographic and multidisciplinary reality will be possible using three-dimensional imaging.

e. Search

[Okude]

Being digital in a research library requires designing a post-Gutenbergian research model of humanities. Contrary to a general assumption that a hypermedia obliterates the past, digital technology is radically reconfiguring our understanding of history. Digital technology forces the recognition that texts are not higher than images. Computers rid us of the assumption that sensory messages are incompatible with reflection. Once digitized, fleeting images become available to anyone who "reads" them on a graphic computer. Imaging becomes a rich and fascinating mode for communicating ideas. Diverse phenomenological performances, whether drawings, gestures, sounds, or scents, will be rescued from the past by scripturalist professions.

To make an image search for humanities professionally, a serious training in visual proficiency is needed. Image search is an activity of focusing on transdisciplinary problems across multiple and linear disciplines in arts, graphics, film, video, or media production as well as their different histories.

[Hosono]

Searching Japanese texts does not have severe physical problems. Since there are, however, several ways to divide Japanese texts (sentences) into words, there are lots of alternatives for search terms. This means exact match methods are not so functional. Sophisticated fuzzy or approximate matching mechanisms for Japanese texts should be developed.

There are "keywords" or "shapes" as access keys for image retrieval. In terms of keywords it is helpful to develop a list of keywords that not only describe objects, phenomena or events but also represent human feeling such as "passion," "peace," "violence," etc. On the other hand, searching by shapes needs pattern matching mechanisms that still have a way to go in their development.

f. Other technologies that are necessary for managing digital collections:

[Hosono]

Technologies are needed that convert a particular digital collection into another irrespective of the lapse of time. Since technologies will change drastically as time goes by, digital information produced in past years must be easily converted to the newest version or accessed by the newest system.

[Okude]

Technologies for distributed libraries are desperately needed. Each library offers its collections in electronic form. To users, the collection of worldwide distributed libraries must look like one uniform library.

2. What are your current technologies and methodologies for preservation and archiving of digital information?

[Okude]

Texture mapping and 3D real-time computer graphics.

[Iwai]

For high-resolution rare book images, we use disk array, DAT tape, CD-R, magneto-optical disk, and DVD-RAM.

3. How do you deal with the many and frequently changing representation formats for digital data? What formats do you currently use?

[Armour]

As regards formats, the problems we face are fundamentally no different to those faced by any enterprise today. We thus tend to choose the most commonly accepted formats for binary data—Microsoft Word, RTF, TIFF, JPEG, etc. It could be argued that, in fact, there are fewer problems faced today by "many and frequently changing representation formats" than 10 years ago; there is, for example, less interest in format-conversion utilities than there used to be. Our concerns are perhaps more about the preservation of information, whether it be accented European characters (not available in Shift-JIS) or fine image detail (JPEG lossy compression is only used for Web delivery). Provided that this information is stored in one of today's common formats, we assume that it will still be accessible after, say, 10 years, when conversion to a new format may be called for.

4. How can technical materials be made useful to both experts and to the average citizen?

a. What do we need to do to make digital information useful for other communities ?

b. How can collections of historical records or of scientific images be arranged in order to promote use by scholars and school children ?

[Armour]

An answer to these questions would perhaps require clear definitions of the terms "technical materials" and "made useful." However, the average citizen might be assumed to have an interest, say, in local history and be prepared to sit in front of a computer monitor for, say, 20 minutes in order to satisfy his/her curiosity. The interface should obviously be as intuitive and thus as invisible as possible. Fortunately, the growth of the Internet is rapidly leading to a familiarity with (if not a consensus on) such interfaces. The qualities one would look for in the presentation of such information are clarity, simplicity, visual appeal, etc., and therefore "technical materials" would be kept at a different level, which the user would be free to access by, say, clicking on a button labeled "Tell me more" (a common technique). There could be several layers, into which the user could "drill down." Of course, the scholar would require some kind of shortcut to jump to these more detailed layers.

Alternatively, the user could initially identify him/herself by logging on as "Student" or "Expert." Fortunately, these problems are also faced by businesses (not everyone in an enterprise is equally well informed about all topics), and we can reasonably hope for the appearance of new tools and approaches from both academic and commercial communities. Of especial interest to us is the rapid evolution of the computer-based encyclopedias (such as the Encyclopedia Britannica, with its natural language search facility), some of which must similarly cater to different levels of expertise.

5. Are you doing retrospective digital collections of historical material or are you focusing primarily on creation of new materials? Are you converting bibliographic data as it relates to historical digital materials?

[No Answer Provided.]

D. ENABLING TECHNOLOGIES AND FUTURE OPERATIONS

1. What are the expected breakthrough technologies in the areas of automated cataloging, indexing, search, and analysis of digital multimedia content?

[Armour]

As regards textual materials, we can perhaps say that future progress in the area of automatic indexing will be incremental, as there are already many powerful tools available, with the ability to conduct "fuzzy" searches, proximity searches, etc. The search tools available on the Internet are continually being refined and made available for use locally or over intranets. What still leaves room for improvement is OCR, especially for difficult fonts or, eventually, hand-written materials such as collections of letters; a breakthrough technology in this area is sorely needed. A compromise for the interim is some form of pattern-matching, though here too the tools are as yet somewhat rudimentary.

Far into the future, we might hope for pattern-matching software of such sophistication (and involving considerable "expert knowledge") that it could be used for indexing and accessing image collections.

[Okude]

Enhancement of capabilities of networking, VR interface design, object oriented database[s].

2. What are the emerging technologies for creating, administering, searching and providing access to virtual or federated collections?

[Armour]

For centuries, the world's libraries have used virtually the same technology for acquiring, storing, and organizing their collections. In contrast, the Web—surely key to any "virtual or federated collection"—is evolving so fast that it is not uncommon for a technology to be superceded before it has had time to be adopted. While the new opportunities presented by such developments as Java, Dynamic HTML, FlashPix and Digimarc are widely welcomed, there is no denying the danger of investing significant time and resources in something that may be superseded in a few years or even sooner.

Internet technologies come and go, but among them Java—championed by Sun Microsystems—looks set to play a key role in defining the future of the Internet, even though its viability has come into question.

Clearer perhaps is the future of HTML, the lingua franca of the Web. This has long been recognized as being incapable of furnishing a foundation for the future development of the Web. At the same time, SGML has proved too difficult for most people to implement, leading to a compromise solution known as XML, or Extensible Markup Language. But this is not a compromise in the sense of "falling between two stools." XML has many advantages: it is based on existing international standards; is fully extensible and does not suffer from tag limitations; is internationalized (based on Unicode); offers simpler system administration of Web sites, and so on. These advantages, combined with the possibility that XML services may soon be made available at the operating-system level, make this a very attractive course for future development of any digital library/museum projects.

The Internet itself is suffering growing pains, which may be partially alleviated by the Active Node Transport System (ANTS) currently under development. This is an active network architecture that in effect will perform like a meta-protocol allowing for spontaneously generated protocols and will make the network as flexible as XML.

[Okude]

Java and Corba. Object oriented database[s].

3. **What new technologies are being developed especially for the preservation and archiving of multimedia digital information? Is there movement toward common preservation technologies and methodologies that serve business, academia, government and consumer oriented instances of digital library?**

[Armour]

Once information is digital, questions of whether or not it is "multimedia" or business/ academia/government-oriented are irrelevant from the point of view of conservation. The only real issues are (1) is the physical medium sufficiently stable (cf. acid paper and early film stock), and (2) will it be possible to access ("read") the information in the future? Librarians are constantly aware of the problems posed by a particular medium (such as the 5.25" floppy disk) falling into disuse, so they take steps to transfer digital data to new media (such as DVD). This process is never-ending, as we will never find the perfect storage medium; there will always be room for improvement. The format of the data is less of a problem; in theory, any format can be converted at any time in the future, though there may be some cost involved. Format conversion can be put off (till funds are available, for instance); media conversion cannot be delayed.

Rather than preservation, we have to find technologies that will serve our needs as regards security (including intellectual property rights), distribution, and image scalability.

[Okude]

Preserving technology is now reaching its maturity. What we have to care about is a distribution technology and image scalability technology.

4. What emerging technologies and data formats are most likely to enhance interoperability of digital data at all levels:

- **compressed and uncompressed data formats**
- **natural languages**
- **page description formats**
- **printer control languages**
- **database schemata**
- **document formats**

[Armour]

Database schemata are the most important. We have to incorporate distributed object-oriented technology into global digital library projects. The next most important topic is language: Unicode has yet to be widely accepted, and already its shortcomings are being criticized. We can, however, hope for some "Super Unicode" to emerge at some time in the not too distant future. Printer control languages, compression algorithms, document and page description formats are all ephemeral and of little consequence when looking at the larger picture. They can and must be left to commercial interests and the competition of the open market.

[Okude]

Database schema are the most important. We have to incorporate distributed object oriented technology into the global digital library project.

5. What is the expected volume of data in digital libraries in the next 2, 5 and ten-year timeframes?

[Okude]

Each library's data volume should remain as small as possible.

a. What technologies are you developing or depending on to manage such volumes of multimedia data?

[Okude]

Object oriented database technology is needed.

b. How critical is the need for such technologies?

[Okude]

Without this distributed object-oriented technology, there is no future of the digital library for the scholars and the people who use the libraries for their creative activities.

6. What relationships do you see between information appliances and digital library?

[Okude]

The digital library's data structure should be isolated from any specific hardware and device. Under this condition, information appliances are very useful; however, if these appliances require us accepting a specific data format, they should not be used for a research environment.

7. Do the requirements for digital libraries imply any specific requirements as to capacity, coverage, quality of service, or standardization of national and international communications infrastructure?

[Okude]

They imply an open architecture and deployment of distributed object oriented technology. Every library around the world should communicate with each other and contribute a consolidation of diverse human knowledge and experience.

8. What are the key technologies regarding multi-lingual representation, search, and cataloging of digital data?

[Okude]

Keep ISO10646-1 UCS. Make clear the distinction between the code for (1) everyday communication and (2) that for a special purpose. Use the distributed network system to provide the group code (2). So, whenever the people have to or want to use a special character set, they can obtain the code from the net and see the representation on the screen. Instead of creating the huge standard character library and carrying it within the computer, distribute the code and create the code when it is needed, and use it when needed. This approach is the same as that of distributed digital libraries. Letters as well as knowledge belong to infinite databases, so it is impossible to create a single universal repository.

[Hosono]

Machine translation systems and multi-lingual thesauri will be promising ones.

9. What innovative, multi-modal interfaces seem most appropriate for digital libraries?

[Okude]

Computer-human interface should be a central research agenda for digital libraries. Besides keyboards and mice, trackballs and joysticks move an object on a computer screen; and there are many other interface devices developed, e.g., gloves, helmets, glasses, bodysuit, and so on. These multi-modal interfaces, however, are not only immature but also are not intelligent. Future interfaces will be intelligent and will mediate communication between man and distributed computer networks, and will be more responsive to researchers' wants and needs. Lowering the threshold for researchers to engage the data in the digital

libraries, new multi-modal intelligent interfaces can span the continuum from passive reception of research data to active creation of research results.

10. Please share with us your views on the role of standards in the evolution of digital library capabilities. How, specifically, is your organization involved in utilizing or defining standards that specifically affect digital libraries?

[Armour]

The digital library should conform to various types of standards: some academic (continuing established practices), some administrative (defining good management), and some technical (ensuring that data can be exchanged and shared). Academic standards can and are being applied successfully in the Information Age, although problems remain, particularly as a result of the transient nature of digital information. Administrative standards can be similarly based on accepted principles, with necessary adjustment. In this area, lessons can be learned from the world of commerce. It has been pointed out that in an information-based economy, selling a "product" (data)—often with minimal distribution costs—actually results in the seller gaining more data (information regarding the buyer). The same applies to a digital library and its resources.

Technical standards are perhaps the most difficult to cope with: they are always changing and their adoption usually involves considerable cost. While some academic institutions, such as Keio University, are trying to contribute toward future standards, it is more realistic to think in terms of selecting, testing and perhaps finding new applications for standards that will be set by large corporate interests.

[Hosono]

Standards should be considered from the technological and bibliographical points of view. In terms of the former, because of rapid advancement and resulting obsolescence of information technologies, it is doubtful how long a particular standard can continue to function. Thus, it seems better to develop very powerful and efficient conversion software or techniques in order to transfer digital information among different systems. At any rate, the life expectancy of technical standards seems to be shorter than the bibliographical ones.

Bibliographical standards, in which Dublin Core could be included, should be definitely established to assure easy and effective retrieval and use of particular digital information. They may include information about technologies used for digitization as well as description about contents.

[Shibukawa] (Answers to D.1-10)

As Keio University has not decided yet on an electronic or a digital library, we cannot answer questions practically. Under the present situation, however, we have two problems in digitizing Japanese rare books, one of which lies in translation. While it is desirable to translate all lines in Japanese works into English, we have only bilingual bibliographical and explanatory notes. We need more translators and enough finance to get bilingual full texts. Automatic translation systems, which are not available yet, will be of great use to us. The other problem concerns a difficulty of making reference to Japanese works. It is hard to articulate and classify parts of speech automatically in Japanese texts. Therefore, it demands a lot of work to compile an index for reference.

E. EDUCATION AND DIGITAL LIBRARIES

1. In what ways will digital libraries fundamentally change the ways in which children (K-12, college) are educated? What are the major obstacles to making this happen?

2. Will digital libraries increase the costs of education (K-12, college)? If so, who will pay for this?

[Shibukawa] (Answers to E.1-2)

Any systematization of intellectual information based on digitization will change the way to utilize such information at any level of education. Even if the cost is covered by tax or commercial profits, everyone has to bear it. Therefore, the cost should be shared only by users under mutual agreement. Moreover, it is important to infer how the market for digitized information will grow.

Site: **Kyoto University**
Yoshida-Honbacki, Sakyo-ku
Kyoto, 606-8501 Japan

Date Visited: 27 March 1998

WTEC Attendees: R.D. Shelton (report author), T. Ager, R. Chellappa, B. Croft, B. Davis-Brown, L. Goldberg, R. Larsen, J. Mendel, H. Morishita, R. Reddy, M. Shamos

Hosts: Dr. Makoto Nagao, President

BACKGROUND

Professor Nagao has personally conducted and coordinated some of the most important digital information organization research in Japan. Prof. Nagao also helped organize the itinerary for this study by identifying the key sites to visit as he did in 1991 for the WTEC machine translation study tour.

ARIADNE

Prof. Nagao reviewed his design during 1991-1994 of the Ariadne digital library in operation at the Kyoto University Library (Nagao n.d. (b)). Some of the goals for this system were use of the table of contents of journals or books as a search unit, use of a hypertext structure linking documents, convenient browsing functions, and design for networks of digital libraries. Fujitsu implemented this design, which is an example of university-industry cooperation. The demonstration of this system to the WTEC team on March 26 is described in a separate site report.

COPYRIGHT

Prof. Nagao argues that the concept of copyright needs to change in the age of digital libraries. He proposes that everyone should have the right to use, make copies, or to incorporate the work into his by paying a set fee to the author or publisher. While such compulsory licenses are found in other fields, Prof. Nagao would allow the author to set the scale of charges; if there is little demand, the scale would be reduced. Prof. Kitagawa at Kyoto has a grant from the Japan Society for Promotion of Science (JSPS) to implement this concept in a "Copymart."

THE ELECTRONIC BOOK

Prof. Nagao believes that the potential for digital books and libraries will be only realized when a "portable reading device" is developed that has the physical appearance of a conventional publication. He expects that such devices will be on the market in two or three years. The first application might be newspapers whose content is delivered by wireless. The success of digital libraries depends on a reader that looks like a book; a client PC is not a sufficiently attractive interface.

EFFECT ON PUBLISHERS

Prof. Nagao believes that scientific publishing in the future will largely be done by the authors freely posting their papers on the Web for the benefit of colleagues and students. Many authors will bypass publishers entirely unless they offer superior packaging, advertising, and marketing generally. The portable reading device could make it possible for publishers to compete by offering attractive packaging—it would look like a book, but be all electronic.

MACHINE TRANSLATION

Prof. Nagao believes that in 20 years students will be able to hear their lectures from all over the world via networks. Some 20 leading languages will have good machine translation (MT) systems; Japanese-English systems will be especially well developed.

EDUCATION

The National Diet Library (NDL) has some educational features. There is a library at Ueno in Tokyo that is dedicated to children's books; the NDL is converting it to a digital library over the next two years. Kyoto University is using distance learning to bring lectures to the main campus from separate institutes.

OTHER POINTS

The infrastructure for such information systems is in good shape; the difficulty is how to accumulate contents. The Japanese government is not much engaged in coordination in the digital libraries field, except for Ministry of Education (Monbusho) support of several digital libraries, the MITI project, and the National Diet Library. Prof. Nagao believes that the field is at too early a stage for much standardization. He plans to encourage the creation of a second National Diet Library in the Kansai area in 2002 as a vehicle for national and international coordination and standardization. Kyoto University is creating a new school of informatics with 120 professors to house a wide variety of information systems research and development.

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Site: **Kyoto University Library**
Yoshida Honmachi
Sakyo-ku, Kyoto, 606-01 Japan
http://www.kulib.kyoto-u.ac.jp/

Date Visited: 26 March 1998

WTEC Attendees: B. Davis-Brown (report author), T. Ager, R. Chellappa, B. Croft, L. Goldberg, R Larsen, J. Mendel, H. Morishita, R. Reddy, M. Shamos, R.D. Shelton

Hosts: Dr. Sc. Michiko Mannami, Director, Kyoto University Library
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BACKGROUND

Kyoto University Library was established in 1889, two years after the founding of Kyoto University, and now consists of a Central Library as well as over 60 branch libraries. The total holdings comprise approximately 5,500,000 volumes, and about 66,600 periodicals. Service at the Central Library is geared primarily to undergraduate students while the branches serve the staff and graduate students of the faculties and research institutes. The Central Library collection is arranged by the University Library Classification Table (pre-1982) and the National Diet Library Classification Table (post-1983). The branch library collections are organized according to a variety of classification schemes. The Online Public Access Catalog (OPAC) is available via the Internet at http://www.kulib.kyoto-u.ac.jp/. Presently, approximately 700,000 items are represented in the OPAC. Plans include having bibliographic data available for 1,000,000 items by the year 2000 as well as tables of contents of books available for searching.

The mission of the digital library at Kyoto is similar to the one expressed at Tsukuba University Library. Indeed, both projects are supported by a grant from the Ministry of Education. The digital library project at Kyoto University is currently called a "vacant bookshelf" as no data are available, but two projects are currently planned. The "Encyclopedia of Kyoto University" is conceived as a body of digital material, which will answer any questions about Kyoto University and its activities. It will cover the historical materials held by the University as well as reports of research activities carried out at Kyoto University. The second facet of the system is the digital publishing support system, which will set up a procedure for producing such reports online.

The library has digitized several historical materials over the years and plans to digitize 170 volumes of important cultural properties as well as treasure books, pictures and maps. The research reports will come from the dissertation abstracts of Kyoto University, which number some 800 titles annually. The digitized materials, the OPAC, the circulation system, and retrieval management functions are all run under KUINS—the Kyoto University Integrated Information Network System.

Under the earlier guidance of Prof. Makoto Nagao, a prototype digital library system called Ariadne investigated advanced aspects of support for electronic reading and information retrieval. One of the promising areas was a study of conducting retrieval based on table of contents information. "Fact retrieval function" utilizing natural language processing techniques has been explored, as has the topic of user friendly interfaces to large bodies of digitized text.

Government funding for the library is similar to that of Tsukuba University Library. For the FY 1998 funding was about ¥40 million for database creation and ¥70 million for the rental fee of the digital library system and the computer.

ISSUES

Japanese materials produced more than 50 years ago are in a script that most people no longer read. Thus, conversion of large numbers of these materials is difficult, and it is not known what utility there is to making them available. In terms of digitizing the important cultural properties 500 years of age and older, it is very difficult to read the text from the image, if it can be read at all.

According to the WTEC panel's hosts, original images are taken in 2,048 x 3,072 pixels (Kodak Pro-Photo CD, 16BASE), but with the limitations of the network speed and the resolution of the CRT display, they are currently distributing the reduced images (1,024 x 1,536 with JPG compression). However, with the progress of the technology, they plan to distribute more precise images with closer resolution to the original images.

There is some feeling that the job of a university library is to collect data, not to be charged with producing it. The library administrators acknowledged that there is tension between balancing traditional library acquisitions and producing digital collections, especially in light of a 15 percent budget cut planned for the next few years.

Science and engineering students and faculty have different needs for digital information than do those in fields such as history and literature. Current technical information is required from all over the world, and this is an area in particular where the university personnel feel they should collect digital materials via online journals and database services.

The administrators also acknowledged that there is no national coordination between projects financed by the Ministry of Education and those supported by MITI and the IPA. For example, the idea of the National Diet Library (funded by MITI and IPA) sharing information about its effort to scan 10 million pages of documents with the universities at Tsukuba or Kyoto is not seen as a topic of mutual interest. Rather, the Japanese government gives similar or identical themes to different ministries (and agencies) and lets them compete. In this way, it is felt that the best output quality of a new technology will result.

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Site: **Matsushita Electric Industrial Co., Ltd.**
Multimedia System Research Laboratory
Shinagawa-Ku Tokyo
Japan

Date Visited: 24 March 1998

WTEC Attendees: L. Goldberg (report author), T. Ager, B. Croft, M. Shamos, R.D. Shelton

Hosts: Hideki Yasukawa, Manager, Multimedia Systems Development Group
Hiroshi Nishikawa, Manager, Planning Group
Tomoki Tsumura, Executive Engineer, Multimedia Center
Osamu Katayama, Multimedia Systems Development Group
Hitoshi Kato, Multimedia Systems Development Group
Masaki Kiyono, Manager, Multimedia Systems Development Group
Sachiko Motoike, Multimedia Systems Development Group
Takamasa Oyama, Multimedia Systems Development Group

BACKGROUND

Matsushita Electric is a conglomerate company in the consumer electric and electronics field representing some 281 individual companies, including major names, such as National, Panasonic, Technics, and Quasar. The company employs 270,000 workers and had net sales of $62 billion in 1997. This visit was conducted at the Multimedia Systems Research Laboratory, one of 13 specialized company laboratories that includes a Central Research Laboratory in Osaka. The company has increased efforts in areas of telecommunications, home equipment, and industrial equipment, while seeing a decrease in the area of traditional consumer video equipment.

The Multimedia Systems Research Laboratory undertakes projects with a time horizon of five years, in comparison to 10 years at the Central Research Laboratory. The mission of the laboratory is the development of networking-based systems and the support of business creation. Three key elements to achieving this are differentiating technology development, fundamental systems development, and creation of new business. The laboratory sits in an exceptionally modernistic building which houses business units, system integration units and an extensive display and demonstration area. The concept of the whole building is to become the systems business front end of Matsushita, with a view to developing new applications and responding quickly to needs of customers.

LAB DEMONSTRATIONS

Full-Text Search

Mr. Oyama previewed a project to develop an English language search engine software based on the company's prior work on Japanese language search engines. Researchers have developed a method of maximal word indexing that is considered well suited for indexing of Japanese text and affords improved accuracy in retrieval. The method utilized character-based indexing, and the size of the index is about 2 times as big as the original text. The demonstration was the full-text search of the U.S. patent literature. The search speed was said to be the fastest in the industry, at an average of 700 million words/sec index search for up to 1 million documents on the server. Compiling the index of the document set required approximately 1-1/2 hours for 1 GB of data. Similar efforts are under way employing their unique methods for the Chinese and Korean languages (4 billion characters/sec in Chinese and 2.4 billion characters/sec in Korean), as well as for other European languages.

Mr. Yasukawa then described another text retrieval project, involving 100,000 documents, that is intended as an intelligent search finder on the World Wide Web. The functions include document ranking, by a similarity measure; automatic summary generation, with quoting of relevant parts of a retrieved document;

and extracting related keywords, by selecting a set of keywords relevant for a query from the retrieved documents. The method uses special indexing techniques to compensate for finding words, as in Japanese, which have no spacing as word endings.

Digital Video Disk-Internet Linkage System

Mr. Kiyono described creation of a new business model for providing high-quality video digital information services over the Internet based upon the use of Digital Video Disk (DVD) technology. The DVD ROM, residing with the end user, is encoded with disc identifiers, which when transmitted to the Web server, enables automatic access to a specific Web server. The Web server in turn sends an HTML file to the user to generate up-to-date Web page information and simultaneously provides MPEG-2 playout of the desired video data from the DVD. This service is in preparation, under the growing popularity of DVD with 600 titles recorded. Panasonic has been playing an important role in DVD forum. Some 10-11 companies are involved in this area, and they do not see a problem in setting common formats for this technology. The range of applications envisioned for these services is electronic publishing, electronic commerce, information service, and remote education.

Video Archive and Browse System

Mr. Kato described development work on a visual system of retrieval for large video tape archives, such as those held by TV broadcast stations or even in home video libraries. The video medium is registered and encoded by keywords for subsequent search. Currently, 63 (9 x 7) video clips within the medium are digitized and displayed in a single composite screen in MPEG format.

OPEN DISCUSSION

Following the demonstrations, an extensive discussion period took place dealing with questions raised by the visiting WTEC group. The text following each question below is paraphrasing the hosts' replies.

What are the Activities in Cross-Lingual Retrieval?

[Mr. Yasukawa] The company is just starting such a project and has 6 or 7 researchers in the natural language area. As to speech recognition, it is working in Japanese, English and Chinese. It is planning cooperation with other companies and Japanese universities in this area.

Is Digital Libraries an Application Area?

[Mr. Nishikawa] Matsushita is interested, but since it is a business company, it is hard for it to invest in such a large project. Matsushita is interested in personal home video and document access.

Are There Test Beds for Video Retrieval?

Only for text search but none for visual data.

Is There Interest in Music Downloading?

This lab doesn't deal with music, but it will be a very interesting area.

Where Does Multimedia Fit in?, And How Will it be Supported?

The government supports promotion of multimedia in municipal systems, but customers aren't ready. This laboratory has little government support at this time, but the government has asked for proposals to be submitted. There are a lot of such opportunities.

Is Virtual Reality Being Supported By the Company?

We don't have any projects here, but other Matsushita labs are working with broadcast studios.

Is There Any Focus on the Human Interface?

This is very important for our consumer activities. Only commercial divisions are pursuing it from the practical approach, e.g., designing control buttons on remote controls. Our laboratory focuses on the needs of consumers—hence it is more short term. For example, the National Museum of Ethnology's need for MPEG images drives that work.

[The following two questions elicited a thoughtful response by the senior engineer, Mr. Tsumura, who had the longest experience in the company.]

Does Matsushita Have A Theme?

The company is strong in the consumer electric field. It has been strong in that field and we would like to remain a leader. The future is for a home information infrastructure—with small personal computers in the home. We'd like to build this up.

Is Information a Commodity to be Sold by Matsushita?

There will be a variety of types of information from the society to the home. We need to have something for the homes; neither PCs nor TVs as currently used will be sufficient. We have been a company that provides hardware, but in the future, we need content, technology to manage content, and hardware to play it. We are not so capable in the first two areas of content or management of content.

Where Has the Growth Been in Telecommunications?

[Mr. Nishikawa] In wireless phones, where the number of subscribers reached 20 millions in only five years in Japan. Matsushita is looking at the wireless infrastructure and working on access systems in the home. The company is working jointly with NTT.

Where Do Your Ideas Come From?

The definition of basic research is becoming ambiguous. Multimedia is an applied science that is important. Some work done at the Central Research Laboratory in speech recognition has been going on for the past 20 years.

[An issue of common interest was the level of cooperation between universities and industry in each country. This led to the following question:]

At What Level Are Your Staff Educated, and How Much By the Company?

[Mr. Nishikawa] Employees are educated at the Bachelor's and Master's level, and then trained by the company. Some companies said that they did not always hire professional people. They don't want workers trained in any way, because the companies want to go in a certain direction. They wanted collectivism, not individualism. In this point, general education is more welcome. But things are changing. To create new technology, we need specialists. So the role of universities becomes critical. Generally speaking, their projects have been small, but some universities collaborate and form large projects. This trend helps to accelerate new technology development.

[The young people sitting at the table were asked what their experience level was before joining the company. Most were at the Master's level in computer science related fields, and some had had subsequent experience in basic research, such as at the Electrotechnical Laboratory in Tsukuba.]

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Video archive & browse system. Briefing material.

Site: **Nara Institute of Science and Technology (NAIST)**
Ikoma, Nara
Japan
http://nara.aist-nara.ac.jp/

Date Visited: 26 March 1998

WTEC Attendees: L. Goldberg (report author), T. Ager, M. Shamos, R.D. Shelton

Hosts: Kaoru Tsuda, Deputy Head of Cooperative Research Division
Hikaru Tsuji, Cooperative Research Division
Muneo Matsumura, Deputy Head of Information and Digital Library Services Division
Shunsuke Uemura, Professor, Graduate School of Information Science
Kosuke Sato, Associate Professor, Graduate School of Information Science
Masatoshi Yoshikawa, Associate Professor, Graduate School of Information Science
Shinji Kimura, Associate Professor, Graduate School of Information Science

BACKGROUND

The Nara Institute of Science and Technology (NAIST) was established in 1991 as one of two national universities in Japan devoted exclusively to research and graduate education. The uniqueness of these institutes, in addition to their exclusive focus on graduate education, lies in at least two areas. First, their policies and broad research directions are overseen by external boards of distinguished scientists from academe and industry. Thus, while their faculty enjoys somewhat less autonomy in selecting and pursuing their research topics, they are subject to fewer of the regulations imposed on other national universities by the Ministry of Education, Science, Sports, and Culture. A second distinction lies in the limited number of disciplines encompassed. NAIST currently has only three faculties: the Graduate School of Information Science (established in 1991), the Graduate School of Biological Sciences (1992), and the Graduate School of Materials Sciences (1996). A fourth faculty under discussion is the Graduate School for Library Science. If realized, this will be one of the first faculties to educate students as digital librarians.

The NAIST library opened two years ago as a true digital library intended for educational and research usage, the first such national library in Japan. The library provides five services:

1. real-time service for users, in which its main goal is to digitize all newly received materials within three days
2. network access from a university room or anywhere
3. media center, including CD-ROM, video, etc.
4. full text retrieval, using OCR on documents—270,000 pages at the time of this visit
5. alert function, in which users can register key words for alerts on new document arrivals

The Web homepage is provided in both Japanese and English. Statistics on document retrieval show about 3,800 pages accessed per day. Copyright licenses have been negotiated at reduced subscription costs with the publisher, Elsevier, so that all students, staff and faculty are covered, although this is not a significant issue given the university's small size of only 1,000 students. Video search is provided for approximately 800 titles, running about 100 hours of content in MPEG2 (180 GB). The entire digital library content requires approximately 6 TB storage, on magnetic tape and magneto-optic disk media. The library does not plan any new cataloging approaches different from MARC format for its digital content. The WTEC panel was shown NAIST's extensive library technical facility where new journals were photocopied, scanned and converted by OCR.

LAB DEMONSTRATIONS

Speech Processing Technology—Speech and Acoustics Laboratory

The major research projects in speech processing include speech recognition synthesis, enhancement, coding, and multi-modal dialog interface. NAIST researchers are conducting interesting new work on synthesizing lip movement based on mapping from input speech using the method of the Hidden Markov Model (HMM). In the acoustic signal processing they are working on active noise control and sound field reproduction. They demonstrated experiments on three-dimensional sound generation and additive cancellation from secondary sources measured by two microphones. The experimental facility includes a sound proof chamber with an array of 112 microphones independently input into a multichannel analyzer.

Electronic Design Automation

This well-equipped laboratory is used for LSI layout and related research and education projects. It includes equipment for printed circuit board design and production, although chip fabrication is conducted at a commercial foundry. One of the projects discussed was a method of binary digital diagrams (BDD), which provides a concise expression of logic functions for small layout areas, while requiring storage of only 2n entries for n variables on many practically used logic functions.

ParaDocs Project—A Database System for Documents with Object Links

The goal of this effort is the design and implementation of a database system, which can manage structured SGML documents and other data in an integrated manner. The approach involves the application of database facilities in document processing and the management of document components using database types. The parallel text model, or ParaText, has an appearance layer (= character string) and a reference layer (= database objects or values represented by substrings in the appearance layer). The retrieved information can be linked to external databases.

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Yamamoto, E., S. Nakamura, and K. Shikano. 1997. Speech to lip movement synthesis by HMM. In *Proc. AVSP'97 Workshop.* Rhodes, Greece.

Site:	**National Center for Science Information Systems (NACSIS)** **3-29-1 Otsuka,** **Bunkyo-ku** **Tokyo 112, Japan** **+81-3-3942-2351 (Exchange)**
Date Visited:	24 March 1998
WTEC Attendees:	R. Reddy (report author), R. Chellappa, B. Davis-Brown, R. Larsen, J. Mendel
Hosts:	Professor Hiroshi Inose, Director General, NACSIS Professor Jun Adachi Dr. Shin-ichi Sato Several members of the research staff

BACKGROUND

The National Center for Science Information Systems (NACSIS) is the principal center within Japan for promoting comprehensive digital library information systems in service for all the universities in Japan. The center tries to achieve fundamental functions common to the universities across the nation, such as supplying science information and performing research and development related to distribution of science information. In particular, the nationwide SINET, which is the principal Internet backbone network within Japan connecting universities, is under the control of NACSIS. SINET is analogous to the NSFnet in the United States. NACSIS also is responsible for Japan's library digitization efforts in science information. The electronic library service (NACSIS-ELS) was started in 1997.

During the WTEC panel's visit to NACSIS, there was a broad discussion of the conceptual issues associated with digital libraries, as well as presentations on a number of ongoing research projects. A brief description of these is provided here.

PROJECTS

NACSIS has several major projects that it is responsible for in support of the university activities in Japan. These projects are described here.

Catalog Information Service

The Catalog Information Service is a union of catalog databases covering the whole country with an online network. This database includes monographs and serials. To prevent duplicate catalog work in libraries and save labor and processing time, NACSIS-CAT refers to standard bibliographic databases such as JAPAN MARC and U.S. MARC.

Libraries can utilize data extracted from the catalog information services databases for general users and build their own library systems. At present, over 500 participating libraries in Japan use this service, including national universities, municipal universities, private universities, research institutes, junior colleges, and colleges of technology. A book and a CD-ROM version of the Union Catalog of Serials have been published by NACSIS. The book is in eight volumes and consists of 7,500 printed pages.

NACSIS also provides support for interlibrary loan services among the libraries by using the Union Catalog Database. Libraries can select and order destinations by reference to the latest information in the Catalog Information Services Databases resulting in labor saving and quicker document delivery. Requests may also be redirected to the National Diet Library and the British Library Document Supply Center. All of this can be done by the researchers without having to make a trip to the library.

Information Retrieval Service

NACSIS provides a national information retrieval service. There are 59 different databases covered through this service, containing 71 million records of information in fields of humanities, social sciences and natural science for online retrieval. The services are offered for scientific research in general and for library reference work to academic staff, library personnel, and graduate students. There is a nominal charge of ¥50 per minute connection fee, ¥13 per case retrieved, and ¥22 for a sheet faxed.

Electronic Library Service

The NACSIS-ELS is an information service that enables users to retrieve a page image from a database containing academic journals and magazines, along with bibliographic information, via the Internet. Researchers can search journal articles by title, author names, or keywords from their workstations as well as obtain necessary articles after reviewing the table of contents. High quality printout of pages can be immediately permitted at the local printer.

Permission to use journal data for experimental purposes was granted from academic societies in 1993. This was converted to regular service in 1997. Currently the database includes most of the academic journals published by Japanese academic societies. At present, the use of this service is limited to faculty members, graduate students and members of academic societies participating in the NACSIS-ELS. At present the service is provided free of charge. It was anticipated that there would be a nominal fee beginning in April 1998.

Electronic Mail and Bulletin Board Services

NACSIS provides and operates the inter-university electronic mail network, SIMAIL. This service is offered via the SINET, the Japanese equivalent of NSFnet. It also acts as a gateway to the Internet for mail forwarding and delivery leading to worldwide exchange of research information. The bulletin board service, NACSIS-BBS, offers a service for distributing messages to many unspecified users. This permits users dedicated to a specified topic to set up a separate bulletin board for exchange of ideas and opinions. Electronic mail service is free of charge when used domestically, while a fee of ¥20 per kilobyte is charged for international electronic mail service.

DEMONSTRATIONS

A number of research systems under development in support of NACSIS activities were demonstrated. These included access to full text content of scientific journal papers, retrieval of images based on face similarity matching, and a visual query generator for retrieval and discovery of image based information.

CONCLUSIONS

NACSIS is one of the major centers for digital library based activities within Japan. At present, the center outsources much of the scanning of the content. It was estimated that it spent ¥70 million on this in 1997. It costs approximately ¥1,200 to scan a paper of 8 pages, roughly a dollar a page.

The white paper on the national activity on the promotion of an advanced information and telecommunication society (AITS) in Japan produced in February 1995 provides a blueprint of NACSIS's plans in this area. The key action items for the realization of AITS include a society in which everyone can benefit from advances in information and telecommunications, with a special emphasis on the "have nots," contributing to regional vitality, leading to free distribution and access to information, and enabled by the comprehensive development of information and telecommunications infrastructure.

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Sugimoto, Masanori, Norio Katayama and Atsuhiro Takasu. 1997. COSPEX: A system for constructing private digital libraries. In *IJCAI-97*: 738-744.

Site: **National Diet Library**
1-10-1, Nagata-cho
Chiyoda-ku, Tokyo 100-8294 Japan
Tel: 03-3581-2331
http://www.ndl.go.jp

Date Visited: 24 March 1998

WTEC Attendees: B. Davis-Brown (report author), R. Chellappa, R. Larsen, J. Mendel, H. Morishita, R. Reddy

Hosts: Hiroyuki Taya. Administration Department
Email: taya@ndl.go.jp
Kenji Uetsuki, Assistant Chief, Planning Division, Administrative Department
Tel: 03-3506-3311, Fax: 03-3597-5617
Email: uetsuki@ndl.go.jp

BACKGROUND

The National Diet Library (NDL) serves the information needs of the National Diet and is a repository for all materials published in Japan. The NDL is looking forward to the construction of a new building in the Kansai Culture and Science City, which aims to be a "future-oriented library, which will include new library services using advanced information technology" (Taya).

The National Diet Library has undertaken two pilot electronic library projects. The National Union Catalog Network Project assists 43 public libraries throughout Japan in sharing cataloging information. The project claims to automate the addition and comparison of bibliographic records and holdings information without the amount of human intervention needed in systems such as OCLC or RLIN. While the National Union Catalog Network Project is an enhancement of traditional library practices, the Electronic Library demonstration experiment project prototypes the NINVEH system in terms of the digital library of the future. Sponsored by the Ministry of International Trade and Industry (MITI), in cooperation with the Information-technology Promotion Agency (IPA), the project thus far has been to scan the equivalent of over 10 million pages of paper. The scanned collections include rare books from the Meiji Era, rare books of the NDL, World War II era books on economics, journals published in Japan, issue briefs for members of the Diet, modern Japanese political history documents, and materials provided by publishers. Many of these materials were scanned from microfilm, and project literature states that the content is primarily for experimental use. It also appears that many of the materials have not been cleared for distribution due to copyright restrictions. In terms of organizing and retrieving this large amount of digitized material, the NDL WWW site states that another purpose of the experiment is to research "high-level information retrieval techniques and other database managing technologies." The WWW site goes on to state that "it cannot be denied that the system is not satisfactory at present in some aspects."

The format of the actual digital content varies. The issue briefs, for example, are marked up in a "simple" version of Standard Generalized Markup Language (SGML), and page images from each report are available. Three types of searches are available in the system. A bibliographic record search is available with Boolean search operators, and a choice of Chinese characters or phonetic characters to search on appear in a drop-down box. A menu search is offered by categories such as titles of journals. The third type of search is a full-text search based on the titles from cataloging records. It was unclear whether full-text searching of the OCR'd materials was available in this option. Currently, 100 users are testing the system, but it is not open to the public.

The scanning work is done by private companies, which are coordinated by the IPA and the NDL. Although the purpose of this content is to provide the base for the new library at Kansai, the Ministry of Finance has not yet approved the budget for the creation of the "electronic library." Funding for the building itself has been approved.

A separate electronic library for children is being planned for the year 2000. So far, 8,000 of the 130,000 children's books at the NDL have been imaged. They were by and large published before 1950 and appear not to have copyright issues. These books are retrieved via information in the bibliographic records. In a project NDL has undertaken with 13 publishers, children are guided to 300 different new books. Users see an online summary of the book but are not shown the full text.

ISSUES

There are three ways envisioned in which the NDL will create digital content: conversion of page images from older materials, receiving text from publishers, and placing electronic publications on file servers. Delicate relationships with publishers impact these choices, and Mr. Naya acknowledged that not all services will be free of charge. He also stated that he felt that the intellectual property issues and not the technical issues were what largely stood in the way of their digital library project at this time. "The technology has gone beyond what the legal climate can accept."

It is assumed that in the 21st century most information will be originally generated in digital format. Reduced storage costs mean that multimedia materials will be a larger percentage of digital content than they are now. The challenge is how to position digital museums and digital libraries and to put digital content into the system.

Global issues for digital libraries imply that standardization of character codes is necessary and that personal computers must be able to display codes from all Asian countries. Software development for automatic translation is making progress in Japan, but whether viable translation software will be available soon is hard to say. UNICODE is not popular in Japan because it cannot distinguish accurately between Chinese, Japanese, and Korean characters in context.

The three largest barriers to realizing the NDL's vision are the following:

1. For materials without copyright problems, the vision of the NDL can be achieved. But those materials are only a small portion of what NDL management hopes to accomplish as a full-scale electronic library.
2. Electronic libraries must be attractive enough to the public to justify the budget allocations that are necessary.
3. Internal management and organization issues exist in the NDL concerning conflict between the library's traditional orientation and the new challenge to provide electronic library materials and services.

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Site: **National Museum of Ethnology**
10-1 Sentri Expo Park
Suita, Osaka 565, Japan
http://www.minpaku.ac.jp/eng/index.htm

Date Visited: 27 March 1998

WTEC Attendees: T. Ager (report author), B. Croft, L. Goldberg, M. Shamos, R.D. Shelton

Host: Prof. Sugita Shigeharu, Deputy Director-General of the Museum

BACKGROUND

The National Museum of Ethnology was established in 1974 as an inter-university research institute under the Ministry of Education, Science, Sports, and Culture (Monbusho). It has been designated as a center of excellence in the field of ethnological studies. Its mission is

- ethnological and anthropological research
- collection and conservation of ethnographic materials
- public exhibition

The museum staff includes 75 professors, 21 staff members in the information and documentation center and 34 members in the administration department.

ACTIVITIES

Research Institute

In addition to research by resident scholars, the museum conducts symposia and joint projects, hosts visiting scholars, publishes four periodicals and three series of occasional papers or reports.

Graduate University

Japan's Graduate University for Advanced Studies, School of Cultural Studies, has its Regional Studies and Comparative Studies departments located at the museum. About 18 PhDs have been graduated since this function began in 1989.

Information Center

The museum maintains a library of about 460,000 volumes, 13,000 bound volumes of periodicals, 62,000 audio-visual or multimedia items, and 216,000 artifacts. Virtually all the books, reports, periodicals, and artifacts are cataloged online. About 60% of the artifacts have been imaged, and this image data is included in the online asset management system. Currently all new artifact accessions are imaged as part of the acquisition and cataloging process.

Exhibition

The permanent exhibition of 11,000 items is about 4% of the artifact collection, and is open to the public six days a week. A Special Exhibition Hall is used for temporary exhibitions, often including rare materials loaned from other museums. The exhibition halls have many multimedia and computer-based kiosks. Especially interesting is the Videoteque, a 45-seat video-on-demand system, currently supported by a robotic laser-disk library containing about 1,600 disks.

Further information about the museum's programs, operations, and exhibitions can be found on the Web site listed above.

PRESENTATIONS AND DEMONSTRATIONS

Prof. Sugita hosted the group and gave an overview of the museum functions and operations, as summarized above. The annual budget of the museum is ¥4.774 billion (1997) of which ¥550 million is for computer functions; procurement (¥399 million) and computer leases (¥150 million). The 1998 Japanese government funding for the digital-museum project consisted of ¥450 million (which included money for special hardware (¥200 million) and contents (¥100 million) and computer leases (¥150 million)).

The museum makes extensive use of technology including the online catalog and asset management system for artifacts, books, periodicals, and special collections such as the Human Relations Area Files (about 863,000 test pages). Virtually 100% of the museum's holdings are cataloged online. But the most interesting aspect is that for the artifact collection, a program of using 3D scanning, imaging, and measurement is applied to every new artifact (subject to scanning size limitations) that is acquired.

Three 3D scanning devices are in operation. The smallest is used for objects in which the largest dimension is less than 40 cm. The largest can handle objects of maximum dimension 1 meter. This large device can also image the object from all directions in ½ degree increments, providing more than ample data for various VR and 3D representation techniques. Typically, however, an object is imaged from front, back, left, right, and top. Such scanning generates about 12 megabytes of image data per artifact. The image devices are also capable of measuring the object's overall height, width, depth, and can map its contours as well. About 100 objects per day can be cataloged by the three imaging systems. One operator for all three is sufficient. The museum does joint research on 3D imaging with NAIST.

The museum's online catalog allows search by subject term (the objects are cataloged using a controlled vocabulary). Query by image content is not supported in the artifact catalog. The catalog and other museum databases are shared among some other research institutes and universities, but are not available to the general public over the Internet. Prof. Sugita expressed the desire to extend more of the museum's online resource to the public, including some online exhibition capability. The museum is working with IBM Japan, the British Museum, and Cornell University on a Global Digital Museum Project (see IBM Tokyo Research Laboratory site visit report).

The museum's video collection is almost 20 years old. It began with cassette tapes, and was converted to laser disk. Another conversion to DVD during the next 2-3 years is being planned. The first conversion from cassettes to laser disk cost ¥600 million. The conversion to DVD is estimated to be about half that. These format conversions and digital material refresh costs are a concern for all institutions that undertake digitization. Although the actual copying from one format to another is routine, one can expect that the transition from an analog format such as laser disk brings requirements for new distribution technologies, and affords new opportunities for cataloging, indexing, search, and cross-linking with other digital materials.

The museum is participating in an IBM customer or user-group initiative called the IBM Asia-Pacific Digital Library Consortium. The WTEC team was invited to a luncheon with the IBM consortium while both were at the museum. In addition to the National Museum of Ethnology, libraries or museums from Taiwan, Korea, China, and Hong Kong, are participating in the IBM consortium. Although the consortium consists of IBM digital library and content management customers, its focus is on larger shared problems, including especially the development of standards and accepted practices for interoperability of digital collections.

CONCLUSIONS

The WTEC team that visited the National Museum of Ethnology was impressed by the scope of the digitization process for museum artifacts. The team members also felt that the utilization of multimedia resources in the exhibition areas of the museum was advanced and very comprehensive. Utilization of the museum's digital assets on the Internet is not as far along, but the museum indicated that greater use of Internet is under discussion.

The museum's twenty-year history of utilizing advanced computer technology for museum operations, internal research programs, and public exhibitions has clearly been instrumental in achieving its current

advanced utilization of technologies for managing digital information. The team agreed that the National Museum of Ethnology was an excellent example of an advanced, technologically sophisticated museum.

Site: **Nihon Keizai Shimbun, Inc. (Nikkei)**
Electronic Media Bureau (EMB)
1-9-5 Otemachi
Chiyoda-ku, Tokyo 100-66, Japan
http://www.nikkei.co.jp/enews

Date Visited: 23 March 1998

WTEC Attendees: M. Shamos (report author), T. Ager, L. Goldberg

Hosts: Koji Hayashi, General Manager, Electronic Media Bureau
Shunsuke Nittsu, Deputy General Manager, Electronic Media Bureau
Tomomi Tsubota, Manager, News Bureau Development
Takashi Habara, Deputy Manager, Multimedia Editing Department
Shigenori Eto, Multimedia Editing Department
Michitaka Sekine, Multimedia Editing Department

BACKGROUND

Nikkei has been a financial newspaper company for 122 years. It is famous around the world for the Nikkei Average of leading Japanese stocks and is roughly comparable to Reuters or Dow-Jones. Its daily newspaper, Nihon Keizai Shimbun, is the world's largest financial daily, with a circulation of three million. It publishes four other newspapers, owns Nikkei Satellite News TV Tokyo and five other television companies, produces books and magazines, and sponsors large-scale cultural events.

The company views itself as a reporting conglomerate with 1,400 reporters generating economic, business and financial stories that are stored and then disseminated through both print and electronic media. Having the first computerized daily newspaper in Japan, Nikkei owns the largest and oldest full-text database of Japanese news stories, complete since 1985 with some dating back to 1975. It has set a goal of increasing its profit from electronic sources to 20% within the next several years. Company managers believe that with low-cost dissemination methods such as the Internet, profit rather than revenue is the appropriate measure of success.

Nikkei employs 13 people directly involved in research and development in information systems and retrieval. Thirty more are employed in affiliated companies.

ELECTRONIC INFORMATION

Mr. Habara explained that Nikkei has the largest electronic information sales of any Japanese company by virtue of its huge historical database comprising over 1.3 million stories. Its in-house ANNECS composing system was inaugurated in 1972 and forms the basis for capturing its stories in electronic form. It is used in various stages of production and manages the 14 different editions of the paper that are produced daily. Reporters transmit their stories directly into PLES, a paperless editing system, by modem over telephone lines, if necessary, or through the Internet. The system produces voice output for proofreading, allowing verification of articles at high speed. The voice component was provided by NTT. The company is noted for the speed with which news stories that may possibly affect market prices can be transmitted to its customers, in some cases within a few minutes.

English materials are handled by NETS, a proprietary system for receiving and disbursing material in the Roman alphabet. Nikkei's software systems are specified by Nikkei but built by outside contractors, including IBM.

ONLINE SERVICES

Mr. Eto gave an overview of the company's electronic businesses. In addition to text databases, Nikkei has maintained a numerical database business for almost 30 years, selling corporate financial and stock price information through a service known as NEEDS. QUICK-IS provides data for analysis in personal computer environments. The services Nikkei Telecom 21, Nikkei Telecom, Nikkei Net and Nikkei Online offer news stories and summaries electronically in English and Japanese.

Telecom 21 provides full-text search in Japanese and English. Its fees are designed to promote large-scale usage. The basic subscription rate is ¥8,000 per month for a single user ($60 per month as of March 31, 1998). This goes down to ¥500 per month for each user ID over one hundred. With the basic subscription, headline reading is free, stories can be retrieved for ¥20 each ($0.16). A search hit on a headline costs ¥5 ($0.04). A variety of other usage plans are offered. Nikkei's Web site experiences ten million hits per day, three million accesses and over a hundred thousand billable transactions, making it the second most active Internet site in Japan. Chinese language capability has been considered but is not presently regarded as a profitable business opportunity.

Approximately 1,000 stories per day are added to the database by Nikkei reporters. At 2:00 a.m., the stories in the 14th and last edition of the newspaper (by now corrected, if necessary) are sent to the archive, which is stored on an IBM 3090 mainframe computer. No summarization or abstracting is performed. Nikkei points out that these operations are unnecessary because the stories are usually short and their editorial style is such that the lead sentence serves as an abstract. Dow Jones supplies 1,500 stories per day to Nikkei under a cooperative arrangement by which about 10% of the items are translated into Japanese, published by Nikkei and added to the electronic database. Numerous articles from other Asian newspapers such as the Straits Times (Singapore) and the Bangkok Post, as well as different Japanese newspapers, are added to the database every week.

Nikkei's corporate database includes information on over 200,000 Japanese corporations and over 18,000 other Asian companies.

In 1997, Nikkei, Mitsui and America Online (AOL) began a joint venture under which Nikkei became the largest supplier of information to AOL in Japan. Nikkei offers its services in tiered levels designed to fit the budgets of its customers. At the bottom level, AOL subscribers can expect to pay ¥3000-5000 per month. The next higher level is Telecom, and the highest level of numerical data is QUICK, which is now saturated.

The WTEC group was given a tour of Nikkei's demonstration facility, where we were shown full-text retrieval via AOL. (Full text is available, but only for selected stories.) Telecom 21 offers retrieval of text with motion pictures and sound in English and Japanese. Nikkei also make available other text databases under license from outside publishers. Collective search is possible. Stories of interest to a particular customer are downloaded to his PC each week so that local searching can be performed to reduce the load on the mainframes supporting the online service.

Nikkei's view of its databases is entirely proprietary. They are a revenue-producing asset of the company and are made available to others only for a fee through Nikkei services and interface software.

Site: **Nippon Telegraph and Telephone (NTT) Corporation**
Yokosuka R&D Center
Hikarinooka, Yokosuka-Shi
Kanagawa, 239 Japan
http://www.ntt.co.jp

Date Visited: 25 March 1998

WTEC Attendees: R. Chellappa (report author), B. Davis-Brown, R. Larsen, J. Mendel, H. Morishita, R. Reddy

Hosts: Shinichiro Yoshida, Associate Vice President, Executive Manager, NTT Multimedia Network Laboratories
Dr. Minoru Ohyama, Director, Global R&D Strategic Planning and Promotions Office, NTT R&D Headquarters
Kazuhiko Kushima, Senior Research Engineer, NTT Information and Communications Systems Laboratories
Yoshinobu Tonomura, Sr. Research Engineer, NTT Human Interface Laboratories
Shoji Kurakake, Sr. Research Eng., NTT Human Interface Laboratories
Tadashi Kayano, Sr. Research Eng., NTT Multimedia Networks Labs.
Kayatake Vehira, Senior Research Engineer, NTT Integrated Information and Energy Systems Laboratories

BACKGROUND

NTT, celebrating its 50th anniversary, is undergoing a transformation from a telecommunications company to an information communications business, and eventually to an information distribution business. Three major thrusts pursued to realize this transformation are “Electrum Cyber Society (ECS)” “Megamedia” and “Next Generation Infrastructure.”

As all the hosts and research demonstrations were drawn from the ECS thrust area, this report addresses this area only. NTT's vision of ECS, eloquently expressed by Mr. Toshiharu Aoki, Senior Executive Vice President and Senior Executive Manager of R&D Headquarters (NTT n.d.(a)), is electronic exchange of information products and money through secure networks. NTT's activities are focused on becoming a center of excellence in multimedia research through R&D and active participation in several national and international collaborative consortia and standardization efforts. Some of the notable activities include involvement in the Asian multimedia forum Photonic Network Forum, creation of ECS test-beds, cyber-society open experiments, “An Open Lab,” and contributions to national social projects, such as the medical information network.

Budget

The budget of the research and development headquarters is approximately 5% of net sales. Over the last seven years, R&D expenditures have been around ¥3 billion. Roughly half of R&D expenditures are allotted to research laboratories.

Organization and Staffing

NTT R&D Headquarters is divided into three Laboratory Groups (NTT n.d.(b)):

- Telecommunication Network
- Multimedia Systems
- Science and Core Technology

The hosts, led by Mr. Shinichiro Yoshida, represent the Multimedia Systems Laboratory Group. This group is divided into seven laboratories:

1. multimedia systems development
2. multimedia networks
3. information and communication systems
4. human interface
5. software
6. wireless systems
7. integrated information and energy systems

The laboratories are split across different R&D centers. Researchers and engineers use video conferencing facilities to keep abreast of related activities. The total size of the workforce has been steady at 8,500 over the last seven years. Of these approximately 3,000 are engaged in research, the rest being in development. Approximately 150 new hires are made every year, replacing those that are lost to academia, other subsidiaries, and retirement.

RESEARCH ACTIVITIES

The site visit team was shown several demonstrations representing ongoing work in some of the laboratories in the Multimedia Systems Laboratory Group. These are as follows:

- network library systems
- electronic commerce
- content-based image retrieval
- cyberbook
- high-presence video teleconference system

The network library system provides multimedia services based on a broadband ATM network. The network is served by Hi-Fi music, MPEG-1, MPEG-2 and digital library servers. Processing engines for voice recognition, search, Japanese/English translation and text-to-speech are provided. A key component in this network is a super-high definition display, at a resolution of 2,048 x 2,048 pixels, 24 bits/pixel operating at 60 frames/sec for video. The network library is being used for doctors' viewing of medical images, sight-seeing tours, teleconferences and on-the-fly machine translation between Japanese and English.

Text and content-based retrieval of video is a critical component of a digital library for automatic indexing and retrieval. Two demonstrations in this area were shown. One involves reading the Japanese captions from TV broadcasts so that topic- or concept-based video retrieval can be accomplished. This work is expected to be commercially available by the end of 1998. Key algorithmic steps involved are detection of frames that contain text, extraction of text region, character segmentation and recognition. Details of these steps may be found in Kurakake et al. (1997). The other demonstration was on ExSight, a multimedia retrieval system (Yamamuro et al. 1998; Kon'ya and Kushima 1998) using object-based image matching and keyword-based retrieval. Unlike pixel- or impression-based approaches, object-based approaches, such as ExSight, search over a large data-base using content. The steps involved include automatic object extraction, feature extraction (color, shape, etc.) and high-speed similarity matching. Query fusion (as a union of image objects) and high-speed browsing are provided as Java applets. Potential commercialization applications are in electronic commerce, digital museums (show all the pictures of a boy with a dog), and digital photo albums. Although primarily image-content driven, the system can accommodate keyword-based retrieval.

Electronic commerce is viewed as being one of the promising opportunities in the ECS thrust area. Major concerns in making this feasible are guaranteeing security, copyrights and maintaining the timeline of transactions. Two demonstrations illustrating how electronic money can be securely moved around between

interested parties and how copyrights can be protected in the sale and distribution of digital objects were the highlights of electronic commerce activities over the network. In the demonstration of moving electronic money around, a smart card is used for making purchases from anywhere as long as one is connected to the network. This demonstration illustrated how secure transactions can be achieved.

When digital objects are marketed over the network, the sellers need to ensure that their copyrights are protected. The project InfoProtect demonstrates the secure distribution of images. The owner of the digital content first creates a partial image (semi-disclosed) and its descrambling key. The descrambling key is registered with the system center and the partial image is transmitted to the potential buyer. The buyer decides to purchase by inspecting the scrambled image and buys the descrambling key via a secure key transmission protocol known as InfoKey developed at NTT. The key is used to descramble the image. The buyer ID is embedded using digital watermarking, providing protection against copyright violation.

The high presence video teleconference system is centered around two large projection displays (each 110 inches long along the diagonal). The resolution is four times that of high-definition TV and enables interaction with real-life sized humans. The quality of display performance was demonstrated using 2-D monocular and stereo still images. The monocular images were viewed at a resolution of 6 million pixels/frame and the stereo pairs each had about 3 million pixels/image, giving excellent quality to the stereo images. Although this system as a whole is expensive, key components of the display technology have been commercialized. Using sound localization, an enhanced multimedia presentation is possible with applications to remote museums and education.

When audio books and video are collected and bound as digital objects, it is critical to provide user-friendly interfaces to access them. In the CyberShelf project, books created from HTML documents are accessible using a book metaphor description language.

Another interesting demonstration was an image mosaicking system that produces a panoramic view from a sequence of translating images. User-friendly interfaces to the mosaicking algorithms have been provided. Details of the mosaicking algorithms are in Akutsu et al. (1995) and Taniguchi et al. (1997).

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Site: **Omron**
Information Technology Research Center
Shimokaiinji, Nagaokakyo-City
Kyoto, 617, Japan
http://www.wg.omron.co.jp/index.html

Date Visited: 26 March 1998

WTEC Attendees: B. Croft (report author), R. Reddy, B. Davis-Brown, G. Mendel, R. Chellappa, R. Larsen

Hosts: Hiroshi Nagaoka, Project Leader, Multi Media Group
Shunji Ota, Project Leader, Multi Media Group
Ryuji Yamasaki, Project Leader, Multi Media Group
Toshihiro Fujinami, Engineer, Multi Media Group
Seiji Kuwari, Engineer, Multi Media Group
Shinichi Mukaigawa, Engineer, Multi Media Group

BACKGROUND

Omron is an international, diverse company with about $6 billion in annual sales and more than 22,000 employees. The main products are in the areas of control components and systems (more than 50% of sales), electronic fund transfer systems, public information and traffic systems, medical and healthcare equipment, and open systems. Products related to digital information organization technology would come under the last category. The four core technologies originally identified by the company are fuzzy technology, sensing technology, computers, communication and control technology, and life science technology.

Recently, "humanmedia" or "flexible intelligence" technology to support "human-oriented computing" has been identified as a new direction. This technology is being developed both to support other Omron products, such as ticket sales machines, and as stand-alone software products. The goal of Omron's humanmedia technology is to create "human-oriented equipment" to achieve the "Optimization Society," where people can enjoy work and private lives suited to their individual needs. Although digital libraries are of potential interest to the Multi Media Group within the information technology research center, Omron currently has no products in that area or plans to develop such products. Some Omron software products, however, are important components of current commercial retrieval systems in the Asian markets.

In terms of government funding, Omron receives funding from NEDO, which provided ¥22 million for the FY 1998 and was expected to provide ¥24 million during FY 1999.

RESEARCH TOPICS AND PRODUCTS

Omron's "humanmedia" technology is a combination of language processing technology, speech recognition technology, image processing technology, and "*kansei* processing technology." *Kansei* is a term that the WTEC team encountered frequently during this visit and is related to the development of intuitive interfaces and to the concept of affective computing proposed by the MIT Media Laboratory. Each of these technologies is summarized in the following sections.

Language Processing Technology

The topics that were discussed here include morphological analysis, multilingual input and language recognition. SuperMorpho-J is a Japanese morphological analysis system that is used for word segmentation and part-of-speech tagging. The system has high segmentation accuracy (about 98%) and can process more than 1 GB of text per hour. The system can also deal with some issues specific to Japanese such as word variants and word breaks at the end of the line. Versions of this system have been developed for Korean and Chinese. Supermorpho-J is being used in the Japanese versions of Infoseek and Verity's search engine.

Although segmentation and different character encodings are often described as significant problems for Asian languages, it was clear from this discussion that these issues have been largely dealt with and are not an obstacle to multilingual retrieval systems.

Wnn is a well-known input system for Japanese and Chinese that was originally developed in the UNIX environment. This system has been steadily developed as a product and ported to Windows and Java. The system now also supports multiple languages in one document and many encodings, including Unicode. Once again, from the point of view of multilingual digital library systems, it is clear that input will not be a major issue.

Speech Recognition

A speech recognition project based on word spotting was described. Word spotting was preferred to large vocabulary language model approaches due to the potential for better robustness in noisy environments, such as information kiosks or ticket machines. Omron is now focusing its technology on Japanese language, and a detailed explanation was not provided.

Image Processing

An image retrieval project was described as Omron's part of a national project supported by NEDO. More than 13 companies, laboratories, and universities are involved in 3 working groups. The group that Omron was involved in is "*kansei* agent and human media database." The image retrieval project is viewed as a means of developing a better understanding of *kansei* rather than being leading edge research in image processing. The definition of *kansei* used by this group is "subjective criterion in human information selecting." Images from a database of postage stamps are indexed using four types of composition templates: horizontal, vertical, circle, and radiation. Combinations of these templates are being used for retrieval experiments, and excellent results have been obtained for the domain (postage stamps).

Site: **Toppan Printing Co., Ltd.**
Electronic Media Bureau (EMB)
1, Kanda Izumi-Cho
Chiyoda-ku, Tokyo 101-0024, Japan
http://cpj.topica.ne.jp/toppan/index2.html

Date Visited: 25 March 1998

WTEC Attendees: M. Shamos (report author), T. Ager, B. Croft

Hosts: Dr. Hiroshi Kukimoto, Director, Multimedia Division
Katsumasa Sakai, Deputy General Manager, Information Technology Laboratory
Teiichi Nishioka, Chief Manager, Multimedia Division
Hisashi Oguro, Manager, Multimedia Division
Hiroshi Tarumi, Manager, Multimedia Division, Virtual Reality Lab
Jun Furuta, Deputy Manager, Public Relations Department
Toshio Takeda, Software Engineer, Cybermap Department

BACKGROUND

Toppan is one of the largest printing companies in the world with 1997 revenue exceeding $10 billion. Founded in 1900, it regards the year 2000 as one of rebirth as the company shifts its emphasis from traditional paper printing to digitized multimedia. The Toppan philosophy is that it is not in the business of creating printed matter but of disseminating information through all available technologies, including print and image manipulation. Toppan plans for 20% of its revenue to be derived from multimedia by the year 2000, as opposed to 7% in 1998.

Toppan has a long history in digitized typesetting, including integration of text, graphics and photographs in an in-house prepress system developed over many years. To this technology it has added database, search and retrieval, data conversion and communications capability permitting it to add sound, animation and map data on demand. It sees its new markets as the Internet, database systems, systems integration, mediamixing and broadcasting. Toppan takes an expansive and advanced view of electronic publishing, the object of which, it believes, is not to make books digital but to do what books cannot, that is, create an immersive visual experience.

MULTIMEDIA DIVISION

Dr. Kukimoto presented an overview of Toppan's Multimedia Division. Because of the Japanese writing system, printing and graphic arts in Japan present important cultural issues not found in Western publications. The appearance of a document or Web page is imbued with culture, customs and history conveyed through the arrangement of text and the appearance of written characters. Graphical expression must exhibit *kansei*, a largely untranslatable Japanese concept of "look and feel" combined with sense awareness. Toppan is extremely sensitive to *kansei* in its development efforts. Another important product design theme at Toppan is that the user must be able to control the medium with his own hands to give a sense of involvement and empowerment.

Toppan produces a full spectrum of digital products, including CD-ROM, CD-I, HDTV and DVD. It also produces television programs and maintains a complete digital editing studio.

Mr. Sakai explained Toppan's move from traditional printing to multimedia. Because of its expertise in high-quality print technology, including desktop publishing on 2,000 dpi monitors and design and advanced color management software, the company is well-poised to make the transition. Approximately 99% of Toppan's business is in Japanese and English, so the company is not exploring technology for other languages. Toppan believes that SGML will not become popular in Japan because of its complexity, but that XML may become a standard.

INTERNET SERVICES

Mr. Oguro explained Toppan's entry into Internet services. As a graphic design and printing company, creation of customized Web pages is a natural extension of Toppan's business. Toppan entered the Internet domain by providing online service during the 1994 World Cup in Los Angeles. It then opened the first Internet shopping mall in Japan, which has 70 virtual stores and receives 100,000 visitors per day. Through its subsidiary, Cyber Publishing Japan, Toppan's goal in this arena is to create new media to bring its customers' messages to the public. It provides 3D chat rooms in which conversants are represented by avatars that move about in a virtual world. Of the 300-400 people in Toppan's Multimedia Division, about 10% are devoted to the Internet.

DIGITAL MAPPING

Mr. Takeda demonstrated Toppan's MAPION digital map service, a joint development with NTT and the largest Internet map service in Japan, with over 200,000 visitors per day. Almost half the residential territory of Japan is available through the system. Customers can advertise by having their logos appear on the maps in the appropriate location. For example, a bank might have its logo appear at each branch location. Maps with resolution down to 1 pixel per meter are provided. The Toppan map database can be used to produce paper maps or digital maps available through a variety of delivery services, all of which can be customized to individual needs.

A related offering is PHS, a personal positional location service. Through the use of low-power cell phones, the location of a particular telephone can be fixed to within approximately one block. A child can be provided with a functioning telephone that looks like a toy. If a parent wants to find the child's location, he can call the child and see where the child is on a map on the parent's home computer. Toppan's future plans include adding vertical, underground and multistory building data to the database.

PACKAGED MULTIMEDIA

Mr. Tarumi discussed Toppan's entry into packaged multimedia, including CD-ROM and DVD products. In an area replete with technical standards that must be followed, Toppan's advantage comes from improving product quality within the confines of the standards. For example, a troubling aspect of MPEG encoding is that viewed motion pictures suffer from "jitter," in which the image jumps in position slightly from frame to frame. Toppan demonstrated a system to remove jitter from MPEG-encoded video. It also has techniques for improving the shading and tone of JPEG images to make them more realistic.

VIRTUAL REALITY GALLERY, DIGITAL MUSEUM

Mr. Nishioka presented Toppan's Virtual Reality Gallery, which consists of a portion of a spherical screen in an auditorium giving a visual range side-to-side of 150 degrees, so the viewer is enveloped by the image being displayed by a digital projection system of resolution 3,500 x 1,000 lines. Toppan demonstrated a virtual reality tour through the Sistine Chapel that was created by taking still photographs from 50 different vantage points throughout the Chapel, digitizing them and using them to create a three-dimensional digital model. The viewer is able to move around within the Chapel by means of a hand-held game controller. It is possible to move in any direction and look at any angle, zooming in on any object in the room, including such ordinary items as the inside of a door jamb. The effect is electrifying—every member of the WTEC group was stunned by the demonstration. Each of the panel members who had visited the real Sistine Chapel found the Toppan Gallery visit to be more rewarding. It is possible to zoom up to the ceiling and lie on one's back, looking upward at God and Adam as Michelangelo did while he was painting. The striking commercial and educational opportunities presented by this technology were immediately apparent. Toppan estimates that it costs approximately $500,000 to create a virtual reality (VR) model of the scope of the Sistine Chapel and plans to do one each year for the foreseeable future. It is difficult to overstate how impressed the panel was with Toppan's virtual reality gallery. Its effect on the viewer is immediate and profound.

The VR gallery is Toppan's entry into digital museums. It is working on VR authoring tools and has plans for installations in more than 150 museums. Toppan managers believe that 3D VR will be the interface of choice for cyberspace.

Unlike many other companies visited on this trip, Toppan maintains close ties with universities, including Keio, Tokyo, Yamagato, the MIT Media Lab and Oxford University.

Site: **University of Library and Information Science (ULIS)**
1-2 Kasuga, Tsukuba
Ibaraki 305, Japan
http://www-nowaki.ulis.ac.jp/

Date Visited: 23 March 1998

WTEC Attendees: R. Larsen (report author), R. Chellappa, B. Davis-Brown, J. Mendel, H. Morishita

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INTRODUCTION AND BACKGROUND

The point of contact at ULIS was Prof. Takeo Yamamoto, Vice President of ULIS. Prof. Yamamoto was an early pioneer in the development of information retrieval systems for chemical publications in Japan; his work ultimately led to the development of the current system in place at NACSIS. Prof. Yamamoto introduced the team to Dr. Masayuki Yoshida, the President of ULIS, and to Yukio Fujino, the Vice President and Library Director of ULIS.

ULIS was created in 1979 and admitted its first students in 1980; its predecessor was in Tokyo and was responsible for library training. ULIS currently has approximately 700 students. Its 70-member faculty includes computer scientists (20), information professionals (30 “conventional” library science faculty), and scientific/technical experts (20) in the informatics of application areas, or the study of content-oriented systems. ULIS was presented as having a strong tradition of conventional library science in the faculty.

Approximately 160 new freshman, 30 additional undergraduate transfer students, and 16 new masters students are admitted to ULIS each year. ULIS is trying to develop a doctorate-level program. Other Japanese universities working in this area include Keio and Aichi Shukotoken, which offer doctorate programs in Library Information Science (LIS), but these programs are offered out of humanities and literature departments. Tokyo University has only one professor in this area, and Kyoto University only has one associate professor working in LIS. Japan currently has no “genuine” doctorate LIS program.

ULIS has greater focus on LIS specifically and the largest organized faculty/student body in this area. The one-year program focuses on core culture coursework. Then the program bifurcates into information processing (systems-oriented) or information management (conventional library science).

ULIS has 6 formal research groups composed of 10 faculty each, plus 3 centers (P.E./Health Care; Foreign Language, Information Processing). Prof. Tabata is the director of the Information Processing Center. This is reportedly the only national university that has only one department. Actual research teams are put together as crosscuts on the 6 research groups.

Profs. Tabata, Sugimoto, Sakaguchi were present to describe their digital library work.

Prof. Tabata received his education at Kyoto University with Takeo Kanade of CMU; he developed an early multimedia network in 1973, while a graduate student. The network operated at 1 Mb/s and was used to link PCs together over a network. Prof. Tabata has also done work in voice recognition. He came to ULIS in 1982, working on concurrent LISP and, later, digital libraries. He is currently widely engaged in digital library developments throughout Asia.

Prof. Masunaga conducts research on object-oriented database systems.

Prof. Ishizuka was in attendance from the National Institute for Japanese Literature, representing ULIS research on information retrieval. He has done work on SGML with Japanese chemistry publishers and was subsequently involved with XML.

ULIS students started a student Web site in the fall of 1993. They taught themselves, and then reportedly went on to teach the faculty. ULIS has reportedly always been heavily involved in networking.

Profs. Ishikawa and Harada are involved with the Ariadne project (Prof. Nagao's digital library project) at Kyoto University.

Other faculty are involved in the sociological aspects of digital libraries: Prof. Sekiguchi (education), Prof. Matsumura (policy), and Prof. Matsui (history).

CURRENT EFFORTS

ULIS faculty members reported that their current research involves small amounts of data, perhaps appropriate for a testbed, but not representative of a library. Their objective is less that of creating the data than of providing services around the data, to get it into the hands of people. They view digital libraries as the back-end function to more user-oriented front-ends.

Critical issues cited include contracting, funding, charging (e.g., pay-per-view, microcharges), privacy, and security. WTEC's hosts noted that conventional libraries routinely deal with these issues for physical media for local users (those physically in the library). Digital library services, however, are not limited to local users. In fact, digital libraries turn the traditional views of libraries inside out. Whereas a traditional library brings the world of information to local users, digital libraries bring local (e.g., university) information to a global constituency.

Challenges noted included charging for service and output quality (resolution, dealing effectively with a large number of open documents, physical size and scope of display).

Why Digital Libraries? Prof. Ishikawa stated that he was particularly interested in building a desktop library (with all the incumbent issues of network speed, size of displays, multiple windowing, convenience of operation, navigation, and the need for digital reference librarians).

Prof. Yamanoto expressed the opinion that the economic success of digital libraries will depend on appropriate involvement of and engagement with the entertainment industry.

Prof. Tabata is working on multilingual HTML (MHTML) for multilingual display of correct fonts without the user needing to explicitly load foreign language fonts. The approach is currently user driven, in terms of identifying the language to be displayed. Prof. Tabata's group also has interest in multilingual information retrieval and is beginning some work in this area.

Prof. Ishizuka is heavily involved in SGML developments in Japan, particularly in working with Japanese scholarly publishers on the electronic delivery of SGML publications to digital libraries. This work appears to parallel work in the United States at UIUC, but Prof. Ishizuka noted that a significant difference was that Japanese publishers were behind their U.S. counterparts in the deployment of SGML, making it potentially easier to work with them towards a common interpretation.

DEMONSTRATIONS

Four demonstration systems were shown to the WTEC team:

1. Iconic query formulation for search of children's literature in the National Diet Library. The demonstration system currently supports about 100 terms through iconic representations (people, places and things) and enables a child user to construct a multi-term query into the collection. The demonstration system included bibliographic citations for approximately 300 books. At least some of the books were recorded. Selecting their bibliographic record brought up a playback control window of a reading of the book. Multiple language support was also present.
2. The Java-based MHTML browser for font mapping.
3. A prototype multilingual retrieval system using the Open Text search engine for constructing foreign language queries.
4. Concurrent display of full translations (manually generated) of children's stories in multiple languages (selected from French, Japanese, English, and Spanish) as a language training aid for children.

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Tabata, Koichi, et al. 1998. Social activities and research activities on digital libraries. March 23.

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Yamanoto, Takeo. 1998. Introducing ULIS faculty to ITRI/WTEC mission. March 23.

Site: **University of Tsukuba Library**
1-1 Tennodai 1 chome, Tsukuba-shi
Ibaraki-ken 305-8577, Japan
Tel: 0298-53-2347
Fax: 0298-53-6052
http://www.tulips.tsukuba.ac.jp/

Date Visited: 23 March 1998

WTEC Attendees: B. Davis-Brown (report author), R. Chellappa, R. Larsen, J. Mendel, H. Morishita, R. Reddy

Hosts: Dr. Reona (Leo) Esaki, President, University of Tsukuba
Tel: 0298-53-2000, Fax: 0298-53-6314
Dr. Akira Ukawa, Chair, Special Committee for Digital Library, University of Tsukuba
Dr. Seiichi Nishihara, Special Committee for Digital Library, University of Tsukuba
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Email: naito@tulips.tsukuba.ac.jp
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BACKGROUND

Ms. Akane Mori gave the WTEC panel a tour of the University of Tsukuba Library on March 23, 1998. She was accompanied by Dr. Ukawa and Mr. Naito. A highlight of the visit was enjoying lunch with Leo Esaki, President of the University and a Nobel Prize winner.

The University of Tsukuba was founded in 1973. Its predecessor educational institutions began in 1872 with the Normal School, and its name before 1973 was the Tokyo University of Education. The library holdings include 1.9 million total volumes and over 17,000 serial titles. The centralized library system includes three branches in addition to the Central Library: The Art and Physical Education Library, the Medical Library, and the Otsuka campus library in Tokyo. Automation of library cataloging and holdings began 20 years ago as did the university. Currently, 60% of the 1.9 million volumes are cataloged online.

The library utilizes two computing systems. One system uses what are called "Educational Computer terminals." These are networked to the Information Processing Center of the University, which students can use for math and computer science problems. Each floor has these as well as the OPAC (Online Public Access Catalog) system terminals for Tsukuba University Library digitized Information Public Service (TULIPS). The library classifies materials using the Nippon Decimal Classification (NDC) scheme. It is a revised version of the dewey decimal classification scheme, and the panel was told it is the standard Japanese cataloging classification system. Universities under the Ministry of Education get their cataloging data from NACSIS, which seems to provide cooperative bibliographic data to participants much as OCLC does in the United States. (See related NACSIS site report.) Books are arranged on shelves multi-lingually by subject. Commencement was being held on the day of our visit, but the library generally averages 2,000 users per day.

TULIPS is the library's interface for its online offerings. In the Public Access Computing System (PACS) Corner, 10 Fujitsu terminals on each floor of the library make available Web access, the library catalog, online journals, and 20 CD-ROM titles. Ms. Mori is also providing special terminals for handicapped and blind library users. While the CD-ROM and online journal titles are not available off-site, the rest of TULIPS is open to the world. The system uses Limedio software, which was created for Tsukuba in collaboration with Ricoh Corporation.

The nature of collaboration between the university and Ricoh is that "Ricoh supplies an already established technique for a system that works." Ricoh had created Tsukuba's cataloging system before the digital library system. Ricoh was selected by bid for a one-year contract having already held a three-year contract with the university. Ricoh also worked with NAIST for three years, and there developed the full-text digital library system. Ricoh has experience with large amounts of full text. At Tsukuba, Ricoh has integrated digital texts with the OPAC and developed its own search engine.

A prototype video-on-demand system is on the hard drive of a single computer in the library. There is only one video available, which is a film of a student robotics contest at the university. The next challenge is to put this video-on-demand function online. The MPEG2 format is used for the video file, and cataloging data are added to a file header. Metadata are generated manually at the title level.

For digital conversion of rare materials, the librarians have worked on some 100 year old textbooks, which are duplicates of wood block prints on Japanese paper. The engineering and physics titles that we saw featured an old style of Japanese lettering that librarians must translate for users. We saw a number of rare materials in an area that is a new cedar-lined vault that still awaits "curing" so that materials published or printed before 1600 can be stored there. A four-volume set of a first edition of *Emile* by Rousseau is the most valuable treasure. Many of the library's rare books have been preserved via microfiche, and the oldest scroll is dated AD 734.

The Minolta PS 3000 scanner is used in-house to scan bound volumes at 400 dpi grayscale. The library house staff creates the TIFF image, and it then automatically creates a corresponding GIF image. At the time of scanning, some cataloging and necessary metadata are input for each image.

PRESENTATION AND DISCUSSION

Ms. Mori prefaced by saying that some options are not yet available in the digital library as it had just "opened" the previous week. Seven years have been spent preparing data. Ms. Mori spoke of the center of the system as the university's LAN. The OPAC is the most important point of the library. Full text search in and of itself is not enough information, because the user cannot know where the material is located. The idea of the OPAC with the digital library must be transformed. Before, there was just a cataloging database. All catalogs were put into an OPAC. Users can find only through the OPAC where the books are located (through holdings information).

OPAC does full text or index search. For seven years, the librarians have been putting data from indexes and abstracts into the OPAC. They can do full-text search of materials produced in the University of Tsukuba. They hope to digitize materials they have collected that are rare and unique. As they prepare more content for the digital library, they plan to scan microfilm to capture images of rare materials.

Faculty members are able to submit reports to be published digitally via a form in the copyright report that we were given in English translation. They are also able to clear issues for copyright through this form. Professors bring their books or reports to the library and decide how much of the documents they wish to make available online. Recently, a faculty member submitted text already in HTML format. The library is considering the adoption of Standard Generalized Markup Language (SGML) but has not yet. Soon, the university will ask for every thesis in the library to be submitted in digital format, and if a project is supported by the university, the project will be required to be made available electronically. Also, many students from other parts of Asia come to the university, and apparently they are supposed to pay for copies of their dissertations. If they are able to submit these publications electronically, they will no longer have to pay for the cost of printing and binding which is an economic hardship for some of them.

Eight hundred titles have been scanned from the rare books collection. These are available as CD-ROM products. In terms of staffing, no new dedicated staff has been added to the digital library project at Tsukuba. The library has changed portions of its production system and added some part-time help. Librarians have been doing HTML markup for four years.

The library management's vision for the project five years from now is that of the role of digital library providing information generated at Tsukuba University. Other digital libraries are not transmitting original data but are making collections. At Tsukuba, librarians feel strongly that they want to contribute original data. They feel that what they are trying to do at Tsukuba is for people all over the world. They want to provide good quality data, and the type of digital content made available in the next five years will set an important tone for digital libraries for years to come.

The librarians cited issues of assuring data redundancy, data storage, and data preservation as concerns. The Ministry of Education supports their work and one third of money received is for content creation. They have not studied their costs in detail at this point, although someone had calculated a cost of ¥150 per page image, including overhead costs. They stated that for a page image only the cost is ¥40.

In response to a question concerning the use of tools and techniques and research on how digital libraries will be used, Ms. Mori reiterated that the goal at Tsukuba was to provide outgoing information from rare books and results of faculty and student work at Tsukuba. In response to the idea that selection of content is important and that the definition of a digital library implies remote access, Ms. Mori said that currently there was no such research on content selection.

NACSIS, Kyoto University, NAIST and Tsukuba University are members of a joint committee as they are all funded by the Ministry of Education. The Tokyo Institute of Technology will join them next year to discuss these issues as well. In terms of funding, it is estimated that there will be government funding of approximately ¥104 million (which includes rental fees for computers of approximately ¥69 million).

QUESTIONS ASKED OF THE WTEC TEAM

What Are the Major Issues That Came Out of the Digital Libraries Initiative?

Raj Reddy detailed other digital library issues under consideration, such as how to pay for content; scanning from microfilm; intellectual property issues; and electronic reprints for out of print articles.

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The University of Tsukuba Library System. (Brochure.)

APPENDIX D. GLOSSARY

ACA	Agency of Cultural Affairs (Japan)
Acquisition	means by which visual and 3D information present in the world surrounding us is acquired (e.g., by libraries)
AFOSR	Air Force Office of Scientific Research (United States)
Aglet	Java object that can move from one host on the Internet to another
ANNECS	computer-based publishing system (Nikkei)
ANTS	active node transport system
ARO	Army Research Office (United States)
ATIP	Asian Technology Information Program
ATR	Advanced Telecommunications Research Institute International (Japan)
CD-I	compact disk interactive
CD-ROM	compact disk read only format
CORBA	Common Object Request Broker Architecture (object management software for digital libraries)
DARPA	Defense Advanced Research Projects Agency (United States)
Databases	systematic organization of information that is readable by computer
Digital information organization	methods of rendering information into digital form so it can be stored, retrieved and manipulated by computer
Digital library	an integrated set of services for capturing, cataloging, storing, searching, protecting, and retrieving information
Digital library architecture	emphasizes organization, acquisition, preservation, and utilization of information
Digital library services	brings order where data floods and information mismanagement have caused much critical information to be incoherent, unavailable, or lost
Digital library systems	realizations of an architecture in a specific hardware, networking, and software situation
Digital signatures	methods of assuring genuineness of digital (not handwritten) signatures, and preventing alteration
Digital watermarking	methods for detecting works based on copying or altering digital materials
DIVL	digital image and video library
DLI	Digital Library Initiative. Project sponsored by NSF, DARPA, and NASA to advance the collection, storage and organization of digital

	information, and to make such information more easily available through communication networks
DVD	digital video disk
E-books	electronic books
Electronic library service	an information service that enables users to retrieve a page image from a database containing academic journals and magazines, along with bibliographic information via the Internet
GB	gigabyte (10^9 bytes)
Granularity	the level at which an item is described
HCI	human-computer interface
HDTV	high definition television
Indexing	description of intellectual content of the specific holdings in a library's collection
Intellectual metadata	information that provides access to the subject or content of a digital object
Intellectual property	legal and/or economic rights of an author for his works, ideas
IPA	Information Technology Promotion Agency (Japan)
IR	information retrieval—an area of both computer and information science that studies retrieval processes
IRAL	Information Retrieval with Asian Languages (annual workshop)
J-CIS	Japan Copyright Information Service
JIPDEC	Japan Information Processing Development Center
JPEG	Joint Photographic Experts Group (graphics file compression standard)
JPG	short for JPEG
Kansei	Japanese term for computing that relates to, arises from, or is influenced by human characteristics such as sensibility, perception, affection or subjectivity
KUINS	Kyoto University Integrated Information Network System
LSI	large scale integrated [circuits]
MB	megabyte (million bytes)
Mb/s	million bits per second
Metadata	information about an item, rather than the information in the item itself
MHTML	multilingual HTML
MITI	Ministry of International Trade and Industry (Japan)

Monbusho	(Japanese government) Ministry of Education, Science, Sports, and Culture—alternatively referred to in this report as "Ministry of Education" and "MESC"
Morphological analysis	identification and normalization of inflected word forms
MPEG	Moving Picture Experts Group (defines compression standards)
MT	machine translation
NACSIS	National Center for Science Information Systems (Japan)
NAIST	Nara Institute of Science and Technology
NARA	National Archives and Records Administration (United States)
NASA	National Aeronautics and Space Administration (United States)
Navigation	moving about in a digital collection
NDL	National Diet Library (Japan)
NEEDS	a database service and text search and retrieval system (Nikkei)
NETS	a system to convert information originally in Japanese into English for resale or inclusion in Nikkei English-language products
NEWS	a distribution system (Nikkei Economic Data Wire Service) that feeds broadcast and online services
NGO	non-governmental organization
NIKKEI NET	an Internet, Web-based news service that charges users
Nikkei Telecom	an Internet service that features a hyper-linked online newspaper format that offers search and retrieval for specialized business information such as corporate strategies and management news items
NLP	natural language processing
Non-text materials	information such as mathematical equations, tables and drawings music and visual materials other than text
NSF	National Science Foundation (United States)
NSN	an all-business television channel that is broadcast using digital satellite technologies (Nikkei)
OCR	optical character recognition
ONR	Office of Naval Research (United States)
OPACS	online public access catalogs
Operational architecture	an information management system represented in terms of the business processes it supports, and how information related to conduct of the business processes passes through the system's components

Physical/structural metadata	information about the digital object and its relationship to other digital objects in a repository
PLES	"PaperLess Editing System" that prepares material for publication (Nikkei)
QUICK	customizable, personalizable online product that delivers high-end business information to select customers
Search	locating items in libraries
Secure archiver	technology for obtaining authentic and time-stamped versions of documents
Systems architecture	shows the technology enablers and their inter-relationships
TB	terabyte (10^{12} bytes)
Technical architecture	breaks down operational (business) processes into functional components and capabilities
TIPSTER	was a DARPA-led effort to advance text processing technologies
TREC	Text Retrieval Conference: annual NIST-sponsored conference with the purpose of encouraging research in information retrieval from large text collections
VR	virtual reality
WWW	World Wide Web