The Digital Library Toolkit

Second Edition

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Contents

Preface

This Digital Library Tool Kit was sponsored by Sun Microsystems, Inc. to address some of the leading questions that academic institutions, public libraries, government agencies, and museums face in trying to develop, manage, and distribute digital content. The evolution of Java programming, digital object standards, Internet access, electronic commerce, and digital media management models is causing educators, CIOs, and librarians to rethink many of their traditional goals and modes of operation. New audiences, continuous access to collections, and enhanced services to user communities are enabled. As one of the leading technology providers to education and library communities, Sun is pleased to present this comprehensive introduction to digital libraries.

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Purpose and Scope

This second edition is an update and expansion of the original April 1998 edition. It contains more of everything. In particular, the resources section has been expanded and updated.

This document is designed to help those who are contemplating setting up a digital library. Whether this is a first time computerization effort or an extension of an existing library's services, there are questions to be answered, decisions to be made, and work to be done. This document covers all those stages and more.

The first section (Chapter 1) is a series of questions to ask yourself and your organization. The questions are designed generally to raise issues rather than to provide definitive answers.

The second section (Chapters 2-5) discusses the planning and implementation of a digital library. It raises some issues which are specific, and contains information to help answer the specifics and a host of other aspects of a digital library project.

The third section (Chapters 6 -7) includes resources and a look at current research, existing digital library systems, and the future. These chapters enable you to find additional resources and help, as well as show you where to look for interesting examples of the current state of the art.

This document was produced on commission to Sun Microsystems, Incorporated. It is available as an Adobe PDF document on the Sun web site at *http://www.sun.com/edu*, or on the EduLib web site at the location below.

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Part 1

Questions to ask before creating a Digital Library

This section raises questions and discusses the issues raised to provide an insight into the full ramifications of the project you are about to undertake.

For most of the questions there are no correct answers. The intention is to enable you to consider a wide enough range of potential options and to think seriously about whether the obvious answers are the right answers.

It is also important to consider how the topics will affect, and be affected by, your specific and its wider context. Doing this topic by topic will focus your attention and eventually give rise to a picture of the whole of the project and its interaction with the current and future library world.

The Questions 1

The questions are divided into broad areas. Each question has a brief discussion of its topic and/or a number of subsidiary questions. This is intended to raise issues that may have been overlooked, and to give the reader a reason to pause and consider what he/she is contemplating doing.

The discussions center on practical issues and considerations rather than theoretical ones. There is no intent that this document should be used as a defining thesis. It is intended as the first stage of a `how to' guide.

Definitions

What is a Digital Library?

Conventionally there are two possibilities:

- library that contains material in digitized form;
- library that contains digital material.

The difference is sometimes very subtle and is discussed below.

The important point is that a digital library has material stored in a computer system in a form that allows it to be manipulated (for instance, for improved retrieval) and delivered (for instance, as a sound file for playing on a computer) in ways that the conventional version of the material cannot be.

An automated library is not necessarily a digital library, since a library consisting entirely of conventional physical material (such as only printed books) may be very highly automated. This automation does not make it `digital' in the sense we are considering here. However, it is true that a digital library must be automated in some of its essential functions.

Because the material is in digital (or computer readable) form, some new possibilities are opened to the digital library which are not there for a conventional library, even one with the same material.

As an example: the material delivery process can be very different from the removing a book from a shelf and checking it out. Because the book in digitized form can be copied to a user's computer for reading, but still remain in the computer stacks, it can be loaned immediately to another user. This implies that holds (reservations) could become a thing of the past for a fully digital library, at the expense of a very much more complex usage tracking system.

This example has added complexity when the digital full text may be stored as a repository outside the library, or even the library's specific. The material may be downloaded to a portable reading device (an e-book) or it may be sent to the reader's private permanent store (a personal digital library). Ownership, rights management, and commercial considerations become much more complex in this environment.

What is Digital Material?

In this computerized age, information and the medium on which it is recorded can be considered as either digitized or not. There are many other ways of categorizing the material, but computer readability is the important criterion here.

`Digital' can be taken as a synonym for `computer readable'. This is a serious generality, but it is this aspect of information which is most relevant to a digital library. The creation of digital information from conventional is generally a two stage process.

The first stage is digitization. This is essentially the conversion of the physical medium into a digital representation of that physical medium. It takes no account of any information content of the original material.

Consider the process of scanning a piece of paper. This produces a computer readable (digitized) image of the paper within the computer. It is stored as a computer file which can be manipulated as any other file (i.e., it can be sent from computer to computer, or be copied or deleted). The original paper could be a page of text or a picture or even blank. We would recognize different information content in each of these cases. The computer only recognizes a digital `picture' of them.

The second stage of the computerization process is to have the computer extract information from the digitized image. For text, this is done by Optical Character Recognition (OCR) software which recognizes the shapes of the letters of the alphabet and produces a file exactly the same as one produced by a word processor used to type in the same text. Feature recognition software can perform an analogous process on a digitized image of an original picture, or on a sound file from a tape or record original. This stage allows some of the information from the original page to be made available to the computer. Thus, it is now able to index the text for retrieval and is also able to reformat the text for different forms of output (at the digitized image stage, it is only possible to perform so-called “graphical manipulation”, such as stretching, compressing, turning color to black & white, etc. on the image).

All this processing applies to material which comes originally in non-digital form. Most of the existing stock of libraries are in this form. For this material to become part of a digital library, the material must be at least digitized or, more usefully, be converted to computer-manageable form. This is the process that takes time and money.

Once this process has been completed for an original object, such as a book, the library now has three alternative representations of the same object. They each have different properties and allow for different activities.

It is important to realize both the power and dangers of this information in its different forms.

The process of digitization and conversion is not perfect. There are losses of information. However, with some intellectual input, it is possible to apply a reciprocal process to reproduce a facsimile of the original. In its simplest form, this consists of merely printing out the text file form of the original document. If enough information has been captured, then the reproduction may approach the level of a duplicate, matching size, style, and typography in the case of a printed document.

	Original	Digital Image	Digital Information
Physical Form	Physical object (book, video)	Computer file	Computer file
Format	Varied (English text, VHS)	Graphical file (.BMP,.MPG, etc.)	Structured file (.DOC,.MPG) database & index records
Readability	Human or special equipment	Computer graphics program	Computer text, video or database program
Reproduction	Physically duplicate original (photocopy duplicate)	Copy file and print any number of exact duplicates	Produce original information in different form (re-print book in large Italic type, play video with different sound track)
Manipulation	Physically modify (write in margins, cut and splice tape)	Mark electronically and manipulate graphically (add user specific notes, reduce/enlarge, re-sequence, change colors, paste alternate images)	Edit the original information, produce derivative work, copy and distribute endlessly

Today, increasing amounts of material are originally produced in digital form. In one sense, these have no physical presence other than the computer file which is their original form. Thus there are an infinite number of ways they can be realized for human consumption, all of which are valid, yet all of which vary in the sorts of detail which abound in physical objects.

As a particularly nasty example, consider a computer program. This has two very clearly distinct methods of reproduction for human consumption. One is a listing of the program commands in a programming language. The other is the program itself when it runs and interacts with the user. Which is the more 'correct' representation? And how should it (they?) be represented in the digital library?

A more common example would be the text displayed or printed from a digital book. Most people would see no problem in utilizing a copy of a textbook in Times Roman font. However rendering the text of a Medieval manuscript into the same format would be seen as a great loss because of the departure of the illuminated script and possible marginalia and so forth. However the 'plain text' version of that same manuscript is now amenable to textual analysis to help determine authorship and other interesting information which would have been impractical except as a lifetime's work.

What is the Leading Edge of Technology?

This is where many digital library projects have foundered. As an example, consider the digitization and conversion process which is at the heart of many libraries' problems.

Digitizing and converting the images to information are very difficult exercises. The computer hardware and, particularly, software which perform these functions are good and practical, but less than perfect. Many companies, including Sun, provide hardware and software that provide excellent choices for digitizing and conversion projects.

> *Optical scanners have suitably high resolution, but are mechanical devices. They break down, and they need single sheets of paper, which often means photocopying the material first. Computer disks fill up and files get lost or overwritten. Optical Character Recognition has errors which have to be manually corrected or ignored. Characters are not recognized or are incorrectly recognized. Non-Roman character sets cause havoc.*

All of this means that the process which seems so swift and painless in the salesman's hands with standard texts and simple requirements, may become a painfully expensive reality. This is particularly true if material is old, in mixed languages, faded, or just voluminous. Here, you must ask yourself the question, “Is it worth it?”

Much material will never be catalogued onto an automated library system because it is not used. Likewise, much should not be shoveled, in its entirety, into the computer as digitized images or information.

Even once digitized, the problems may not be over. Searching and finding material is often still a rather hit and miss affair for digital material. Delivery mechanisms, such as streaming the download of a video to the user’s home computer, sound fine and perform well in the laboratory. But the real life Internet gets in the way, and low bandwidth connections, clogged trunk routes, and incompatible Browsers all mean a less than happy experience for many users.

What is Automatic Indexing?

This is the extraction of the information for a bibliographic record (the metadata) directly from the original text by a computer program. It is concerned particularly with the extraction of keywords as an indication of the content of the document. Often it is called free text or full text indexing. Such schemes do differ, but an important part of their appeal is the automatic extraction of the indexes from the text.

Its advantage is that there is no human intervention. Thus it can be run continuously and cheaply. The extraction (indexing) process is the same for all documents and thus avoids the idiosyncrasies of individual cataloguers. Authority files or lists can be used extensively to further ensure consistency.

Its disadvantage is that there is no human intervention. Thus a document is characterized by the frequency of certain words and these may give a very wrong picture of the actual content. Standardized subject headings are difficult to apply as they must be matched through statistical means. Here again the chances for deviation are quite large.

However, Web searching is performed against such indexes of web sites, and is thus a common form of user interaction. Until more powerful tools come along, this may be the way users will be forced to interact with the digital library, and automatic indexing will be what is used to serve them.

Policy

Is there a need for a Digital Library?

Does the specific have a collection of purely digital material? Is it required that this material be delivered directly to users' computers? Do users need to search in non traditional ways for the material they need? Which material types in the existing library would benefit from being digitized? How? Is there a need for multiple copy distribution at the same time? Is there a need for the material to be modified and returned to the library?

Are there other sources for searching and retrieving the material that you wish to digitize? Is the material unique or confidential? Are the users geographically and temporally widespread?

Generally the more `yes' answers, the more a digital library is a sensible proposition.

Is the current library expanding?

If it is, then is the new material obtainable in digital form? Particularly if the library is essentially an organizational report repository, then material can be acquired in digital form and the costs of setting up the operation as a digital library are reduced. The same question applies to externally acquired material. If it can be acquired in digital form, or can be referenced in digital form, then the ongoing cost of the library is reduced.

If the library is static then the cost equation is different as it is the availability of the existing material in digital form that is important to costs.

Is the Library central to the specific?

Does it contain material that the workers in the specific need to access as part or all of their work? A library maintaining a report repository would be central, whereas a report archive would not be.

The question really is whether the cost of digitizing the material is justified in terms of the use that will be made of it. Will digitizing actually make the material more used? Will it make it easier (and hence quicker and cheaper) to find the material? Will the material be in a more usable form?

Here the cost/benefit matrix becomes more complex. A report holding library where the reports have to be printed in hard copy to be marked up or filled in, and then re-digitized, does not seem to have any benefit over a paper library. A library where the videos are always retrieved by producer name, and are filed that way, does not need advanced searching features.

How valuable is the Library's information?

This is a sub-question of the previous one. If the library is central, then presumably the information is important. If the library is used only occasionally but intensively, as in the reference section of a library attached to a research laboratory, then it is still valuable. The best benefit may be obtained through improved search tools for internal and external information rather than digitizing everything in sight.

If the library is used infrequently or is an archive, then the cost of digitizing may still be justified, but on different grounds.

The library may have been bypassed as an information dissemination center, and digitizing its collection(s) may be a way to re-position the library into a more central role. This may well have cost implications for the specific as a whole rather than just the library or its parent division.

Is the information changing?

If information is changing, then the ongoing costs of re-entering the information into the system will need to be considered. Also important is the policy for handling different versions of documents within the digital library.

An alternative scenario is that the focus of the library, and presumably the specific, is changing. If this is the case, then it is prudent to consider if now is the time to start a digitization program. Much of the material may be irrelevant in some months' time. However, this may be just the time to start the process as the new material can be acquired and processed directly into a digital library system. The material may be acquired in digital form or the costs may be justified by one-time processing as the new material is acquired.

Does the library or specific want an in-house Digital Library?

This is a methodology question. It may be possible to outsource all or most of the functions of a digital library. Alternatively, it may be possible to buy access to external search and delivery services which cover most of the library's requirements in the digital area.

Buying such access can save on initial digitization and on-going administration costs. Service organizations exist which will operate the whole digital library remotely in complete security and confidentially, from the initial digitization through the ongoing provision of the search and delivery services.

However, they do not in general have the subject expertise of the in-house library staff and there may still be security and service availability issues to consider. A factor which modifies this discussion is the growing prevalence of Application Service Providers (ASPs). These organizations do nothing but provide the library with access to its particular application requirements in an environment which is staffed with experts in the particular application area. Although this is not a common business model in the Library Automation area at present, it is a growing trend. This is a factor which can change many of the economic numbers if a suitable partner ASP can be found.

Should a Digital Library coexist with a conventional one?

This is really the all-or-nothing question. Is the intention to replace the existing library with an all digital material version, or is the intention to supplement what the existing library does with new services?

The question here impinges on the perceived role of the library in the organization, its efficiency, how the organization is going to handle internal and external communications in the future, and whether or not there are different functions and facilities provided by the physical library and the digital one. Bearing on this are the issues of branch or local campus libraries, specialist knowledge, specialist collections, centralization vs. decentralization, and the other spin-off functions of the library, both physical and digital. Serendipity is the word here, especially in the supply of tangential material, the answering of strange questions, the place to work quietly, the superior analysis tools available on-line, and the benefit to the organization of informal communications.

Is the object to run a library or manage material?

Is the organization trying just to provide just facts or to provide more extensive services? Is the real purpose of the library as an archive? Is it to track the routing of reports and files? Is it to perform research and analysis services for the organization?

These sometimes hard questions need to be considered because the capabilities of a digital library are very different than those of a conventional physical one. The true function of the library in the organization should be considered thoroughly in the justification for a digital library.

Audience

Is there a demand for new services and/or material?

Is the digital library proposal coming from the library users or is it generated by the library staff or the computer (MIS) department? This is really a question addressing the issue of how the organization decides on the introduction of new services. Is it market driven or does it follow a planned introduction of services or technology?

If the digital library is being proposed by management, it is important to determine that it will prove beneficial for the organization and its potential users. If the potential user demand extends outside the organization, it becomes a marketing and a business case to determine which, if any, digital library services and information sources are justified.

Has the market been sized?

How much use will be made of the library and its services? Is the potential user population large enough to achieve the organization's goals, whether they are cost recovery, better information flow, or even corporate publicity?

There are no absolute numbers for the user population as it depends on the services, their cost, and the desired return. However, an estimate of user numbers must be made so the global benefit can be discussed.

How is it composed?

Is the user population internal or external to the organization? Do each of these groups consist of different types of users (e.g. students, research workers, teachers, etc.)? Do the different types of user want, or form a potential market for, different digital library services or information resources? Are they willing to pay different amounts for the different information? How do they use existing conventional services and how will a digital library affect this use?

How will a Digital Library be used?

Will users be offered new and different services which are not currently available? Will some of the services replace those of the conventional library? What changes in the way users work will be introduced by the advent of the digital library? What changes in the rest of the organization will be needed to accommodate the new method of operation? What will be needed to make best use of the digital library? Is there likely to be an improvement in conventional library services as a result of converting some services and information to digital format?

As an example, the delivery of material directly to the user's desktop can have a profound impact on work patterns. For a magazine publisher where the library holds the picture library, careful design and integration of the remote digital library holding the magazine's pictures means that the journalist can drop straight from *her word processor into the library search routine, find an appropriate picture, and copy it directly into the page. This may be appropriate where the journalist is also responsible for page make up. However, it may be a better use of resources if the journalist gets only a low resolution place holder picture and the high resolution image is queued at the final printing equipment for inclusion at that stage. In this example both the method of working and the nature of the information held by the digital library are candidates for modification. This generally involves an iterative process to achieve the best result.*

How will a Digital Library be accessed?

Since digital libraries are held within computers, it is important to realize the possibilities for access that are offered and that are denied. Access can be permitted from the user's desk wherever that may be. Traveling workers can be given access directly or via the Internet if desired.

If users do not all have computers then public access must be provided. Is this best done within the physical confines of the library or should/could it be distributed across different buildings? If these library access stations are used, then they will need equipment and maintenance, but will be physically close to the users. It may be a good idea to add some extra facilities to the stations (reference material, chained copy of the staff handbook, local color printer, etc.) so that they become specific work points. This leads the deployment of the digital library within the organization in a particular direction with certain benefits and costs.

Another access model is to assume all access will be from desktop computers. These do not need to be fully functional PC's. Network computers or clustered workstations, such as Sun’s SunRay enterprise appliance, can be tied to a local server and provide inexpensive access to users who do not have full PC's. This model has the advantage of cheap deployment, easy desktop access, and access to a wide variety of applications, possibly held within the digital library itself.

There are many models, even within a defined IT strategy, and the choice of one and its modification to local requirements needs as thorough a study of the users as of the library itself.

Is there competition?

If much of the library's resources comes from outside the organization, there may be alternative sources which either the library or the end users can access for those resources. This ability could enhance the library's case if it acted as the conduit for this material and added value. Or it could diminish the library's case if the material was easily and, possibly, freely available through external sources directly to the user's desk.

The advent of specialized ASPs and their services means that the information market is being served in different ways. A specialized search service which was individually subscribed to, and could deliver results on a par with those of the library, could be a very powerful competitor for the potential audience. If the library can set up a portal of its own and provide access to its own and external information sources, then it is providing a benefit which will prove competitive. The question here is how much of an adventurous step is the library willing to take?

Reasons

To expand services?

Are digital services being added to expand the repertoire of the existing library or are they seen as a replacement for existing services? Are the services and information sources being added to complement the existing ones or to break into new service territory? Are there resources to expand the services? Are the new services supposed to be self funding? If so, how is this calculated and what are the expected figures?

To make the library more central to the organization?

Is the library taking on a more central role in the organization and thus expanding its services or, are the services being added to make the library more central? Are the services and new information fundamental to the operation of the organization? Again, if the library is expanding and taking a more critical role, has it the resources and equipment to fulfill this position?

To generate income?

Is the intention to sell new digital services and/or information? If so, is it to be sold internally or externally? Is it to be sold for real money or some form of internal credit transfer? How are the prices to be set? How will the users come by the money to pay for the services? Will priced services just drive them away? How will the costs be recorded and accounted for? Bear in mind that most library software does not have the capability to charge for services on a per transaction basis. Even recording logged-on time often is not possible resulting in a very detrimental effect on user satisfaction.

If income is generated then the matter of copyright payments and even taxes becomes important, as well as a possible change of status of the library. In addition to these regulatory and legal matters, it may well be that the bookkeeping associated with charging and collecting the fees costs more than the income generated.

To promote collections?

Some libraries have unique collections and the promoting of more widespread use of them is one common aim. This is particularly true where the collection is one of rare and expensive material. Fragile material with special handling needs is another good reason to digitize the collection. In all these cases once the digitization process has been undertaken, the original material can be returned to its preservation environment. Because the digitization is done by experts, and only done once, it can be painstaking and must be mindful of the preservation and security needs of the collection. The originals will be required for study much less often because the only reason would be to study the actual construction of the objects, not the information content. Obvious examples are rare books, manuscripts, pictures, and the like.

It may be that a single collection (or exceptionally a single work such as the British Library's “Beowulf” project) warrants the expense of digitization because of its rarity, value, or utility. Since the decision may be based on publicity or public benefit grounds, the actual cost may not be important.

To raise the library's profile?

The library may feel it needs to undertake a project to raise its profile either internally within its parent organization or externally. This is a perfectly good motive, but it should be understood as the motive and not hidden.

Because of staff pressure?

Similarly to the above, it may be staff pressure which suggests the creation of digital collections or the conversion of the library to a digital format. This may stem from a desire to better serve the library users, to better exploit the collections, to experiment with new technology and techniques, to continue to be part of some external organization (such as an information sharing consortium), or to undertake interesting and challenging projects. Staff may wish to enhance their professional training and remain abreast of current technology and thinking in their field.

Alternatives

Do nothing?

Instead of creating a digital library, it may be just as effective to continue with a conventional library or to upgrade the library or information service in some other way. This may be a service consideration or it may, eventually, be a cost based one.

If the library is providing a good service and the users are well adjusted to, and happy with, what is provided, then there may be no case for digitizing even part of the collection. One of the problems here is assessing whether best use is being made of the collections and whether the users are being most effectively served. To make this assessment, it is necessary to take a larger perspective that just that of the library. Often users do not know what alternatives could be made available to them and thus they don't know what they are missing. They may be satisfied, but not realize more is possible. The same is true for library staff who may well be doing a sterling job with the resources they have, not realizing that alternatives are available.

Introducing a digital library just because it is a technology that has caught someone's eye is wrong. It is important to consider the needs of the users, the resources in the library, the requirements of the organization, and the whole spectrum of available improvements.

This document asks many of these questions without a bias towards digital libraries. It is important that there is a person on the decision making team who is able to suggest suitable alternatives.

Out-source?

Even if it is decided that a digital library is needed, it may be that the best way to achieve it and run it is to give that task to another organization.

The process of retrospectively digitizing the material from the chosen collections may be highly specialized and need expensive equipment for best results. Since this will be done once, contracting for the service may be the most cost-effective way. Even ongoing conversions may be best handled on a bureau basis. Equally, some of the conversion work may be mechanically very simple and repetitive and hence not a good use of a highly skilled librarian's time. There are companies who undertake nothing but this type of work.

Once the material has been digitized it is worth considering the costs of making it available, particularly if the service is to be provided externally and will be paid for. Availability around the clock may be required. Large computers may be needed to handle peak loads. Staff and facilities will be needed to back up and secure the data. These and other considerations may make it a sensible proposition to contract out the actual running of the service. There are all sorts of levels at which this can be done, with different degrees of security and service, and, of course, different costs.

It may be that running a service for external users through the World Wide Web is considered an option, perhaps through a commercial provider (an IPP or Internet Presence Provider), particularly in the beginning. This reduces the requirement for possibly extensive capital investment and can provide much needed expertise in areas where the librarians and the organization itself may have little or none.

The advent of the library ASP (Application Service Provider) is imminent and may provide yet another avenue for moving much of the cost or the risk into a purely financial monthly fee. The ASP has the specialist skills for migration both of the material and of any existing library processing. They have invested in all the expensive capital costs of equipment and infrastructure. The increasing use of Intranets means that such an organization may be able to service both the external world and internal users.

Provide a gateway?

If the library is considering primarily providing access to already digitized material and/or material acquired from other parties, it may be sensible to consider a gateway operation. In this, the library is running a service which is only a re-direction of the users' questions to the holders of the original digital material. The gateway may provide its own indexing and search services and it may combine original resources from a number of different providers.

The major difference between outsourcing and running a gateway is that the outsourcing is entirely of your information and is an operation being run for you by a third party. A gateway is where your operation is linking to independent third party sources.

As an example, in an outsourcing operation, the library would have to acquire copyright clearance to disseminate all the material it acquires from a third party. It would do this at the time of purchase of the material in the form of a contract that would almost certainly require the library to be responsible for counting usage and assessing and paying the fees to the owner. In the case of the gateway operation, the third party source has negotiated such a license and it merely bills the library for each access to a particular piece on information. It is the third party which is responsible and undertakes all the accounting.

Both outsourcing and a gateway service can be provided through the organization’s computer addresses and with the organization’s logo and house style for the screens. If designed properly, the eventual users would be unable to tell if the digital library were in-house, outsourced, or a gateway operation.

Costs

What are start up costs?

The variability in start up costs depend mostly on the material to be included in the digital library. Volumes are an obvious factor. The type of material, the degree of digitization, and the completeness or resolution of the digitization also affect the cost. Care and attention to fragile material adds to the cost.

All the above apply to local material to be digitized. If the material is to be acquired in digital form then it has an obvious cost.

Once the material has been digitized, it has to be loaded into a suitable library application. This will store the digital material (often in a database or in a file store), index it, and add it to the library housekeeping database. There will need to be normal library housekeeping operations such as authority file maintenance, assigning material to access classes, determining library policies, etc., just as in any library system. The library system will have to run on computers. Either a large server and workstations, a server and network computers, or a network of computers will be needed. The configuration and the need for specialized computers such as video servers must be determined in consultation with the supplier of the library system software.

Networks and network and application servers may need to be set up or upgraded. Bear in mind that digital files are generally very big, take a lot of storage space, and are slow to transfer across a network. Thus a network which is perfectly adequate for office automation may well be totally inadequate for allowing users to view videos, even one at a time.

Added to all the above capital expenses are the training costs for both library staff and end users. Disruption inside and outside the library adds a cost to the whole exercise. If the service is to be made widely available, particularly outside the organization, then it must be advertised and promoted in some way. If the service is to be made publicly available then there may well be registration and licensing costs involved as well as trademark and name protection. If some services will come from external organizations, then there is an obvious, though not necessarily easily quantified, cost attached to them.

What are ongoing costs?

Addition of new material to the library incurs the same processing or purchasing costs as when the retrospective conversion was done. If there is a regular flow of material, it will be possible to negotiate a reduced per unit rate with a conversion specialist. For externally networked service, there may be telecommunications charges, particularly if the service is transferring large amounts of data across a third party network such as the Internet or a public carrier network.

Occasionally, the physical capacity of the computers either to store material or to handle the number of users will be exceeded and the computers will need to be upgraded. The organization's IT policy and infrastructure will change and the application and data must be migrated. Regular backups of the data must be made, checked, and archived.

Staff will change and they need to be trained. Users will also need regular training.

How to reduce costs?

Determine exactly where the services have to be delivered. Accurately size the amount of material for both conversion costs and computer costs. Try to acquire gateway access to material which is not your own. Determine which are the core collections and which are most needed. If necessary, aim for an 80/20 solution by dropping services or collections which are not extensively required or are infrequently used. Consider access to other suppliers for those services on an as needed basis. Determine exactly what use will be made of the material and how it will be searched for. Do not buy a retrieval (catalog) system which charges for features that your users do not want or will not use. Be careful of this last suggestion as it could lead you into a low functionality trap. It is always better to buy the more functional system rather than to sacrifice the possible function or service. The cost savings here are not generally large in the overall scheme of things.

Income

If the library is going to attempt to at least cover costs, then all possible sources of revenue must be considered. Organizational limitations and licensing requirements may limit what can be done.

Direct payment for information is the most obvious income source. Usually this is for access to the full text document or the full video, etc. Access to index and catalogue records is not usually charged for, though this may occur in some cases. Payment may be on a pay-per-view basis, which is cheaper for the occasional user, but a serious administrative problem for the library to collect the fees. A subscription basis is better for either some counted use (number of visits, number of hours on-line, searches, texts read or printed, etc.) or for unlimited use (within certain functional areas) for a fixed period. It is quite common to allow on-screen reading as a base, with printing as an added cost.

Also a possibility is the provision of advertising to obtain revenue. This option has to be considered very carefully because inappropriate advertising (and sometimes any advertising at all) may appear to compromise the integrity of the site. Sponsorship may be more appropriate than on screen advertisements, but advertising must still be carefully considered as an option.

Hosting of collections and services for other libraries is a possibility. This requires the investment in the professional staff and equipment to make it possible.

Providing a gateway service or portal for a group of libraries may be an option. Here, the library acquires the portal services (possibly outsourced to a third party), and resells part of those services to other libraries. This is becoming a fairly common e-business model. It makes most sense when there is some commonality with the other libraries, either in material coverage or audience. Then there can be seen an obvious advantage to the libraries and the users of such an aggregation under one portal. This may be an actual service or it may be an idea initiated at some level of regional co-operation so that the library may share in the portal as a partner rather than as the principle. The organization or higher authority may not allow other than shared participation.

Sources of Material

Internal sources?

Does the organization generate the material itself? Does it generate it in the original physical form, in digital form, or both? If a digital form is not currently produced, can it easily be produced by the creator?

A typical example here would be where one of the collections is to be the full text of internal reports. If the report writers were to submit an electronic form of the report as well as the current paper copy, a lot of time and expense could be saved in creating the digital collection. It would also save the necessity of correcting the mistakes introduced by the imperfect digitization process.

Does the organization have the means already at its disposal to digitize its material? Is most of the material going to come from existing collections? What percentage of these collections is unique and will have to be converted as opposed to being purchased as pre-converted information?

Archives, etc.?

If archives are involved, the biggest question becomes, “Is it really worth it?” If the archives are rarely used, there is little reason to go to the expense of digitizing them unless the reason for their non-use is that they are inaccessible in their present form. Obviously security and collection promotion considerations can radically alter the worth of the collection in digital form.

An alternative to wholesale retrospective conversion is to create a computerized index to facilitate access and then to digitize as required by use. In this scenario it would probably be sufficient to just create images of the archive material and not try to extract the information from them (if they are text). This would offer quicker and cheaper methods and would supply the advantage of electronic delivery.

External original sources?

If the source of the material is external to the organization, it is important to ask whether a gateway operation would be more suited to what is required. The copyright and commercial issues of dealing with this material become much more complicated than for owned material.

One possible reason for locally held, externally originated, material is to enhance the value of the whole library. Here it may be desired to manipulate the contents of the material and this has to be considered very seriously before it is undertaken.

The external material may be bought outright, its use may be licensed, leased, or on a pay-per-view basis. The material may be acquired through exchange or gifts just as conventional material is. Sometimes the attractiveness of the proposed library site to external users is so great that the library may charge for external material to be made available through the library.

Delivery

Local material and delivery?

Does the original material in the library reside in a place where it will be delivered to the users? The digital component of the library may be a portion of the original material held in digital form for searching (such as full text) or for manipulation (such as a 10 second video clip to determine if the tape is the `right' one).

The general assumption about the use of a digital library is that the material will be delivered to the user at their desktop completely digitally. Thus the collections held in the digital library must be of sufficient quality for the users' needs. It goes without saying that for digital delivery, the whole of the object must be available since the librarian has no means of knowing what aspect of the object the user is interested in.

If all the material is not stored digitally then some method of delivery must be devised. The user may be required to borrow the original physical item. The item may be digitized on demand. The item may be available from a branch library or remote delivery point. Note that the digitize on demand option does not necessarily require that the whole digitization process be undertaken. Just scanning and delivering the images will probably suffice in most cases. Some system designs envision delivery by fax in an updated version of the Inter-Library Loan (ILL) process.

Proxy delivery?

If the user cannot be expected to have a suitably functional computer to receive the material or play it then an alternative is required. Most computers are perfectly capable of handling pages of documents as either text or images. But video presentations may be beyond their capabilities, necessitating the possibility of the proxy client.

The proxy client is a computer local to the user or located at some special site, such as a computer lab, that is guaranteed to be capable of handling the material. Unless special highly specified computers are supplied by the library, the machines will have to be found from those available. This means that different machines may be needed for different material types, an unsatisfactory state of affairs. It may be that the library has to either limit what it is prepared to deliver, depending on what the user can play or read, or it has to undertake the supply of the necessary computers and limit access to certain digital collections to those machines.

Another aspect of delivery is the bandwidth consumed by high resolution images or video. These may be a reason to look at a special delivery mechanism such as satellite delivery. This, again requires specialized equipment at the user end, but it may be practical with a closed, or limited, audience for whom the added cost is acceptable or can be justified.

An example of this would be in an academic institution where the library plays a part in the storage and delivery of distance education material. This often involves video, simulations, programs to be run locally, etc. Such material consumes bandwidth, but the audience is finite and fairly small. The receiving equipment could be loaned to the individual students or the schools taking part in the lessons, or the cost could be reduced by grant funding or other means.

Where is it delivered?

Is the digitized material to be delivered to the user's desktop? Is it sufficient to deliver to the user's building? Is it sufficient to deliver to the user's local library? Must the material remain in the library?

How permanent is the delivery?

Even if the material can be successfully delivered at a technical level, there is the question of ownership to consider. If a copy of the material is delivered to the user, that user effectively has as much of the material as the digital library, and could re-distribute it. This is different than the physical situation where there are only a certain number of copies and the act of copying is either physically impossible or prohibitively difficult.

One possibility is to consider delivering non-permanent material. These are files which are encoded and usually compressed and are then run through the included decompression program. After a certain time, the program refuses to run and the material cannot be used. This effectively introduces a borrowing time to the material, just as with physical material.

If the material is delivered on a physical medium (say CD-ROM) then it is necessary to ask if the CD has to be returned. If so, then the library has to run a circulation system as for physical material. The ill-fated DiVX DVD format for commercial videos attempted to address this issue by allowing ownership of the medium (the DVD disk), but requiring the user to pay for access to the information (the video) stored on it.

What capabilities are required?

Are high bandwidth communications needed to deliver the material before the user has lost interest in it? This would be the case for digitized video if it were sent over a network. A possible solution here is to use streaming technology and play the video for the user as it is transmitted. However, the user may wish to have an editable copy rather than view it. In this case, streaming will not help. It may be that hard copy delivery of a CD-ROM or DVD-ROM is the best answer even though it reverts to physical object delivery. For this, a CD or DVD writer would be needed at the library, or a stock of the CDs would have to be held as with any conventional material. This introduces the physical object handling (circulation) problems, or the decision that the material is not returned. This has both cost and copyright implications. Much software is available today over the web for free download or it is available on CD for a modest charge ($5 - $10) to cover the medium, postage, and handling.

If large files are to be delivered to the user, his computer must have the capacity to store them. In the case of a researcher, this may mean very large capacity indeed and, if the work is being done at a library carrel, the library may be involved in some of this cost. If material is to be printed, then fast capable printers are needed and the delivery system (the library, the file transfer, and the printing systems) must be capable of handling network interruption, paper jams, etc. without imposing an undue load on the rest of the operation.

Special multi-media presentations not included under the digital library's umbrella, may need sound cards, graphics accelerators/3-d graphics cards, big screen monitors, etc. on order to be played properly. These will generally not be available at the user's desktop. The solution here may be a proxy delivery (see earlier section).

Copyright/Intellectual Property Rights

Who owns the material?

The material may belong to the organization, to an affiliate or subsidiary of the organization, or to a third party. It may be in the public domain, belong to a foreign organization subject to different copyright laws, or to an individual. Of course, it may belong to a mixture of the above.

Having a copy of the material does not necessarily constitute ownership in terms of copyright laws. There is only one copyright owner even though many copies are made. This is true for computer copies, digitized or otherwise, as well as physical copies. Also be aware that the right to re-distribute material usually is not acquired when a copy of the material is bought.

Re-use and dissemination

Many countries allow for material to be copied for research purposes by individuals (“fair use”). However, making copies for re-sale or re-distribution is usually a matter for a commercial contract between the copyright owner and the organization wishing to re-distribute.

Usually, the owners will require that payment is made if all or part of the material is disseminated. It may even be that the owners require that they remain the source for the eventual distribution of the whole material object. This is the case for many publishers where they allow their journal articles to be catalogued and indexed in retrieval systems, but the delivery of the full text of an article must be done by the publisher.

Remember that the bibliographic records describing the objects in the library are themselves intellectual works and have copyrights. They belong to the person / organization creating them, so be certain of the limits on re-use if the library’s catalog records come from some form of shared cataloguing resource.

Charging?

The digital library may not wish to charge for material, but may have no choice as far as copyright fees are concerned. If these fees are payable to the copyright holder then the organization will have to pay them. It may decide to absorb these fees itself as a service to its users. This is often the case where the library is exclusively used internally to the organization.

If the library intends to charge for the information it disseminates, the terms of its license with the copyright owner may change, and the price the owner charges may be much higher than for free material.

Again, it must be pointed out that all the accounting for these costs and charges must be done for each individual transaction. Thus, it will be necessary to utilize distribution software which is capable of this level of detail.

Partial delivery?

Accounting becomes more difficult when an order cannot be completely fulfilled. Part of the material has to be charged for and other parts not. This is a problem particularly where network distribution is being used, because the delivery has to be secure from end to end across the networks, including public networks such as the Internet.

If a network problem causes a failed delivery or a corrupt file at the user end, but the sending system believes the material has been correctly sent and should be charged for, there will be a problem when the user is asked to pay for material which did not arrive. Equally if the material is sent entirely before the transaction is posted, then it may be possible for a user to break the connection and obtain the material while the sending system believes it has not been correctly received. These problems have been solved for the on-line delivery of software, but they are not simple and the complex solutions would be needed by the library.

An increasing trend in software delivery across the Internet is for the user to acquire the file and then activate it by means of a key obtained independently from the distributing organization. This method could be utilized by a library for delivery as long as an installation program was sent to the user to communicate with the library sending program. This is not a trivial exercise to set up and will certainly involve extra cost, which third party fulfillment would not.

Act as an agent?

If the library does not own all the material it wishes to offer, it may act as an agent for the eventual owner. This removes many of the problems discussed above. However, if any of the material is owned by the library's organization, it will have to address the issues.

If the library decides to distribute material it charges for, and invests in the necessary software and network safeguards, it may wish to consider making those facilities available for other libraries to use. It could thus become a “database spinner” for other libraries wishing to make digital collections available.

Fair use

The concept of fair use is recognized by many legal systems, allowing users to make a certain number of copies of copyright material for purposes of private study. This concept was instituted upon the advent of photocopiers, but has become more important with the advent of digital forms of material.

To make a photocopy, it is necessary to have a photocopier, and most individuals do not have them; certainly not of sufficient performance to contemplate copying whole books. However, every user of digitized material has the means built right into the basic equipment to copy that material. It is thus very easy for users to copy material and pass the copies on. The library may have no knowledge of this. That does not mean that they are necessarily blameless for such copying, unless they take sufficient steps to make it difficult.

Security

Just like physical material, the digital material of the library is valuable. Access to it must be guarded and its well-being must be ensured.

Security for the digitized material must be provided in the form of restricted access to the computers that hold the material. This includes both physical access and electronic access across a network. The precautions are elementary and are well known in the commercial world. However, they may be unknown to the library. Unlike the physical stock of the library, the digital stock must be copied and secured. This protects it from natural disaster, malicious damage, and software errors.

Access security must be allowed for in the digital library. The library may be freely accessible to all, but certain sections must be protected. Just as certain sections of the physical library are protected no matter how open the catalogues and stacks may be, certain areas of the digital library and certain functions must be protected. If the material is not freely available, a method of restricting access to authorized personnel with a minimum of inconvenience must be provided. If the material is to be paid for, it must be secure until the payment is arranged and then it must be correctly accounted for. The users must also be given an option to back out of any situation where they are about to commit a sum of money.

The increasing use of smart cards and the concept of user customization means that security is now both more possible and more difficult than a few years ago. Systems which allow customization do not always extend that to internal functionality. Thus it may not be possible to block the dangerous functions when required, except by the introduction of passwords for all.

There exists now specialized software (such as EduLib’s STOPit system) for use on library workstations that allows the functionality of those machines to be linked to individual users via their library card or some form of key. This solves some of the security issues and can add extra features such as gathering usage statistics and allowing for interface design.

Watermarks and other protections

Earlier it was mentioned that the user's computer is inherently capable of copying any digital material on it. One protection against this practice is to introduce watermarks into the library's digital material. A watermark will not prevent copying, but it will mean that the owner of the copied material can be recognized. Modern systems can do this even if only part of the material, perhaps a part of a picture, is copied. It is also not possible to overwrite one watermark with another without a special key.

The same protection can be provided to all digital material. There are various methods of watermarking., However, none of them are foolproof and they are often incompatible. Some require user side software for full protection, and meaning users are limited to where this software can be enforced for access to the library. This is possible within an organization and may be possible where the collection is unique and valuable enough.

Material may be disseminated in degraded form or it may be only partially disseminated. In these cases either further verification of the user is required before the full copy of the material is delivered, or the material is delivered by some other means, usually as the physical delivery of a CD of the digital material.

Technology

Standards?

As with all matters to do with computers, there are standards which impinge on the area of digital libraries. Unfortunately, since these libraries are at a cross-road, there are a number of standards which might be appropriate. Of course, some of these standards are mutually contradictory or even exclusive. The standards fall into three areas: material description, user access, and systems architecture.

Material description

In terms of material description, by far the strongest standards come from the library profession. Two forms of description have to be considered: the abstracted information (or metadata) which constitutes the bibliographic description in conventional library systems, and the material itself. In a truly multi-media digital library, it is also necessary to consider the relationship between the various items and pieces of material and their different forms and formats.

Descriptive standards, such as AACR2 and MARC from the library side, compete with SGML and HTML from the web part of the computer industry, and with document description standards such as Page Description Format (.PDF) from the document handling community. These standards are not mutually exclusive, but there is a lot of overlap and converting from one to another is a function to be considered at the design and acquisition stage.

Recent entrants are the re-vamping and rationalizing of MARC to MARC21, the increasing use of the Dublin Core set of descriptors (attributes), and the conversion of both of these and the full material to document types within XML (eXtensible Markup Language). These changes are promising to bring digital library systems closer to commercial systems in terms of interchanging actual material, but the difference in approach at the cataloging and processing (circulation vs. sale) stages is still large.

Non-bibliographic materials (pictures, sound, etc.) are handled by the MARC format, but there are competing standards. For instance, for geographic information, there are descriptive standards coming from the cartographic professions. Many of these are actually more interested in describing the original (the terrain) than in describing the physical material (the map) or its digitized equivalent. This strongly suggests that until universal description frameworks (standards) are in place, it is very important to decide what the material is, what needs to be described, who it is intended for, how it will be retrieved, and how it will be processed and used before deciding on a scheme for its description.

The logical format of the digitized material and how convertible it is from one form to another is an important consideration because the wrong choice could limit the number of users who can read your material. This applies to how the material is held in the database or files as much as how it is described for retrieval.

> *A good example here of where an early decision may later prove costly is in the area of multi-lingual texts. If they are not encoded in a unified encoding scheme, such as Unicode, they may not be readable except by specialized client software.*

User access

Basically, there are two methods by which users may access your digital library. One is via a dedicated network and the other is over public networks. Within both of these, it is possible to have users access via dedicated clients or general purpose browsers (see section entitled *Future Possibilities*).

Where the network is private and the client software is dedicated, the standards used are not important. However, any protocol that is not extensible and only supports the current functions of the library is unlikely to be a sensible choice because it will become obsolete very quickly.

Where public networks are concerned two standards for system access exist in the catalog search area. One is the HTTP standard from the web and the other is the Z39.50 standard from the information retrieval and libraries. They are actually standards for different purposes from different backgrounds, but they can be made to perform the same search and display functions. They are seen as competitors, and a system which supports only one may limit the types of users who can access your library. For general access from the web, an HTTP interface is needed. For access from other library systems, a Z39.50 system is needed. There are also gateway computers on the Internet which convert from one to the other, and services which can handle both.

General purpose browsers, such as Microsoft's Internet Explorer or Netscape's Navigator, are widely available, often for free. Access by them is a requirement if the desire is to have the library accessible by the widest possible audience. However, they are page-oriented devices and are not ideally suited to the material structure and list-oriented nature of much library searching. By their nature, they are not specialized. Their capabilities come from the plug-ins or Java programs that can be added temporarily to them through the downloading of the program. Thus they are not as suited to specific tasks as specialized clients and software. However, the capabilities of Java-enabled browsers are increasing at an extremely rapid pace.

It may be that the library offers a number of alternative methods of access depending on the requirements of the user. The alternatives may provide a better service for the user, but at the cost of the development and maintenance of the alternative access methods.

Systems architecture

In most important respects, a digital library is no different than a conventional library automation system. As such, all the remarks which can be made about the system architecture of library automation systems in general apply.

The major differences are in the volumes of material to be stored within the computer and to be disseminated to the users in real time. These requirements suggest specialized subsystems to handle the work: independent computers to act as the servers, and appropriate networking to ensure the information is delivered. These specialized servers have to work in conjunction with the regular library catalog and other modules. The software must be designed from the outset to link and control these servers with minimum input from the user.

Architectural practices rather than formal standards are normal here. The majority of systems are client/server, distributing the workload across the library's server computer and the user's client computer. An extension of the architecture splits the server tier into two so that there are three tiers. The two server ones are the database, repository, or resource tier, and the application, business rules, or intermediate tier. The resource tier handles the storage and retrieval of the raw information, indexes, image files, etc. The application tier handles the processing of this information into a form suitable for the user.

There are a number of important questions. Can the software support these architectures? Can the server tiers all be held on a single physical computer useful for smaller installations? Can they be distributed across multiple computers to handle growth? Can they be distributed across a wide area network or the Internet?

If the software does not have a multi-tier architecture does it have sufficient capacity and resilience to handle the whole of the expected traffic on one computer? And what happens when that computer goes down?

The current trend is in distributed, widespread computing. This tends to keep the capital costs down by allowing an organization to buy equipment incrementally and to utilize existing equipment and capacity.

The de facto networking standard is TCP/IP. It is the standard for Internet traffic and as such has permeated most other networks. TCP/IP is essential for any serious digital library unless the audience is very small and tightly networked on a different protocol. Similarly, the de facto operating system for mission critical projects today is UNIX.

Proprietary solutions

Many of the components of a digital library can be bought or produced in-house. This applies to the creation of the digital material from the originals as much as to the system software. In both cases, it is important to consider the economics of producing in-house vs. buying a solution. Another aspect to consider in this debate is the issue of “proprietary solutions”. Essentially a proprietary solution is one where the organization does the work itself, either using its own staff or commissioning a solution from an external supplier.

A proprietary solution has a number of advantages: 1) the solution is exactly fitted to the organization’s requirements, 2) the organization has absolute control of future development, and 3) there are no license fees and conditions. However, there are a number of negative points: 1) the organization is on its own, 2) there are no other users, 3) the external world may adopt standards or conventions which bypass or conflict with the organization’s solution, and 4) development has to be done by the organization.

While many of the activities of creating a digital library naturally fall to the organization, such as the creation of the digital material and the cataloguing of it, much of the infrastructure does not, such as the design and programming of a DBMS and retrieval system. Many of the questions to ask here are very similar to those concerning standards.

Is the digital library to be publicly available? Will it be accessed by unskilled users? Will they use standard client software such as Web browsers? Will they be unfamiliar with how the material is organized? Will they need or be allowed to download material?

If most of the answers to the above are yes, then the system should be standards-based and that generally means commercially acquired, or at least produced by a systems house knowledgeable about the standards in use and in prospect. The time and effort in re-inventing many of the wheels needed for a digital library are not worth it. Compliance and continued development are a large drain on resources.

Use of commercial solutions means they will be externally developed and conform to standards. The organization can concentrate on building the digital library where it has the expertise. The components which should be considered for purchase include Database Management Systems, Information Retrieval Systems, Library Automation Systems, Web Server, Delivery and Accounting Systems, and Rights Management Systems. Not all of these are necessary and the list is not complete.

Purchasing components trades off an initial capital purchase against a longer term saving on running costs. If purchasing components seems to be the way to acquire some or all of the pieces of your digital library, it will be important to utilize a systems integrator who is skilled in this area to ensure that the components fit together.

ASPs are essentially systems integrators, possibly providing a middle path where the ASP provides the software and services from standards compliant suppliers, and puts them together in a customized fashion for the digital library. Perfect customization is still some way off, but the trend is moving in that direction, and standards are essential to keep it all together.

Scalability

Whatever the initial size and predicted growth for your digital library, everyone hopes it will be an instant success and the world will beat a path to its door. While sober judgement acknowledges this to be unlikely, it is something that must be considered.

How would the organization handle a phenomenal success? Does it have the infrastructure to handle it? What departmental restructuring would be needed if the digital library was 5 or 10 times more successful in terms of visits, revenue, or workload than predicted? Could the organization capitalize on this success?

How would the staff handle a phenomenal success? What sort of increase in traffic and workload could the existing staff handle? How much extra traffic could an extra member of staff handle? Are there positions which are now doubled up onto one person which would require more staff? What about vacations and other absences?

How would the library systems handle a phenomenal success? Does the hardware have sufficient capacity? Can it be upgraded or must it be replaced? Can the software handle the traffic, store the data, retrieve the data, and handle the requests? Will the software have to be replaced? How difficult will that be?

Most capacity planning exercises in the library field size a system (hardware and software) for a five year life at the projected growth. Having done that, the library should now contemplate re-sizing at a growth rate of 50% greater and consider the effect of initial capacity at three times to five times the assumed value. The library should try to accommodate the largest of those figures.

Future possibilities

Within the technology area almost anything is possible. It is, after all, the advent of technology which has allowed the concept of a digital library to start being fulfilled.

Faster and more powerful computers are available from suppliers such as Sun. This is good both for the servers and for the users' desktop computers because the software producers will find more and more things to do, all of which will demand more processing power.

The advent of the network computer (or Sun's JavaStation or SunRay) allows a new architecture to emerge where the users' computers are not themselves heavy powerful computers, but are the display devices for a user server which provides shared resources at the client end. The new architecture allows better matching of requirements to hardware and also allows for the automated distribution of software. This latter point should not be underestimated because the automation can save both library time and resources. It is a feature you should ask your potential library automation vendor about.

New hardware for data capture (image scanners, video capture, etc.) will allow the real world objects to be digitized in greater detail and more quickly. The extra detail will result in better representations, but will have downstream implications where storage and bandwidth may become the bottlenecks.

Improved networking technologies will bring 1Mbit bandwidth (as opposed to current 0.05Mbit (56Kbit)) to users' homes via dial up lines. Internal LANs will become 100Mbit (now 10Mbit) or even 1Gbit. This means that static computers will be able to handle multi-media requirements. 1Mbit will play videos in real time.

Wireless networks will become faster and cheaper, allowing users to access the information stores from more places. Background retrieval of information will probably become more common.

More complex data structuring will become possible within mainstream applications. This means that the library's material may be more completely described and linked to its immediate and broader context, allowing relevant answers and better information to be supplied to the user. However, it requires an order of magnitude increase in the storage and processing performance.

Preservation/Handling

Is material irreplaceable?

If the material is unique to the organization, can it be replaced? Is it subject to decay? Is it a collection of one-of-a-kind objects? Does it need to be handled to read it? Would an image provide a suitable substitute for most purposes? Do copies exist for security, such as photographs of manuscripts?

Physical handling is one of the most destructive things that can happen to a fragile object. One of the best ways to preserve it is to limit physical access to it. This makes a very strong case for creating a digital library of such objects because most use does not require the actual object. If it is irreplaceable, then undertake a preservation and security plan regardless of the decision about making it available in digital form.

Is the material multi-use?

A number of problems related to multiple use can be solved through a library of digitized forms of material. The first is that unlimited numbers of copies can be made available. The copies can be subject to commercial or legal restrictions and there are some technical caveats, but it is generally true that as many people as want can have a copy of a digitized object.

The second problem solved is that the users can view these objects wherever they want. Again, some technical and imposed legal restrictions limit the universality of this statement somewhat. This is more convenient for the user, more convenient for the library, and generally more cost effective.

Physical limitations of the material or library can be overcome. Since users do not have to be in the physical library to use the object, there is no restriction on numbers placed by the buildings or equipment. Of course, if the material is only available through equipment in the library, then the limit is re-imposed, but probably with higher numbers. Preservation considerations of bright lights and acid fingers are no longer a concern.

Material can be simultaneously accessed. Thus a whole class can see an image in whatever detail is required during a lecture. Of course, the digitized form has no physical substance and so some physical characteristics cannot be studied.

Material can be simultaneously interacted with. This use extends the current boundaries of multi-media and what is included in a digital library. For example, an interactive computer game can accommodate hundreds playing against each other, a feat which could not be achieved in the real world. Educational programs which involve the whole class in role playing are being developed, and these can only be experienced in their digital form.

Material can be modified from the user's copy. It is very easy to cut and paste images from a digitized library book into a school report. With suitable technology, the link can remain and live digital material, such as stock exchange prices, found through the library can be incorporated into reports which reference the original source in real time.

Part 2

Planning and Implementing

Part 1 of The Digital Library Tool Kit contains questions to ask yourself before creating a digital library. Review them if you haven't already and make sure you know what you're getting into and have a real need or desire to do so.

Once the decision is made to create a digital library, this “Tool Kit” will help you get through the traumas of undertaking the planning, design, installation, and initial running of your digital library. Having started, you will find yourself very much at the forefront of this form of library technology and you will be mostly on your own. But don't despair — this document will help you through most of the things you have to achieve.

This section attempts to show you the way and provide help and guidance. However, the whole task is much too big to encompass in this section. Part 3 provides a large number of resources and references where you can find further information, help, and advice, as well as other projects struggling with the very problems you are facing.

Selling the Concept to... 2

This chapter addresses the issues involved in getting a project accepted. Once the questions have been raised and discussed and answers found, then the project has to have all its numbers added up and the business case has to be made. This is not a simple task. It is even more difficult if some of your management or staff and not wholeheartedly behind you.

Selling the concept to yourself

You have to be the biggest believer of all in the correctness and practicality of the project for your organization. You need to analyze the potential benefits and disadvantages involved in proceeding with the project. The benefits accrue if the project is completed successfully. The disadvantages happen if the project is started and is then abandoned or fails.

The benefits can be:

- Promotion
- Management of the new digital library
- Financial reward
- Job satisfaction
- New skills
- Peer praise

The disadvantages can be:

- Promotion prospects
- Frustration
- Peer envy (only if the project is successful)

You need to consider each of these with respect to your particular position and determine whether the benefits outweigh the disadvantages. If they do, then you need to commit to the project to achieve the benefits.

You are accepting responsibility for the project's feasibility. If you have reservations, now is the time to lay them out very clearly. Do this first for yourself, and if you can't see a solution, then include your reservations in your proposal to management.

Selling the concept to management

For the complete project you will have been asked to do some or all of the following things:

- Devise and plan the project
  - Define the scope of the project
  - Evaluate the feasibility of the project
  - Determine the benefits
  - Determine the costs
  - Determine a time scale
- Implement the project
- Manage the resultant service.

This list covers all the stages that have to be gone through. You may not be responsible for all of them. For example, the decision to undertake the project may already have been made and your task now is to implement it.

You will have to submit to management, with solid arguments and facts and figures to back it, a proposal that answers the following questions:

- Can it be done?
- If not, how much can?
- What will it cost?
- What are the benefits to the organization?
- How likely is it to succeed?

For most libraries, the feasibility relies on the existence of tools (software, hardware, etc.) and some expertise in their use. The tools will be brought in and existing or new staff will be trained in their use.

The total cost comprises the costs of the tools, training, staff time, and any services required such as analysis, design, digitization, project management, and installation.

The benefits are less easy to find and quantify. The questions in Chapter 1 cover most of the issues and possibilities. However, it is the case that unless the library is planning to sell the digitized information, the benefits are mainly intangible and cannot be priced.

The likelihood of success is a different question than the first listed above (Can it be done?). Success involves the organization's environment as well as the purely technical feasibility of whether it can be done. Items to be considered are the organization's commitment to:

- Make resources available as required
- Continue when problems arise
- Try a new technique
- Move to a new service or business area
- Undertake a new business model.

The external environment raises such questions as:

- Is this a race to market — to be the first with a new product/service
- The effect of new technology being introduced during the project
- Competitors appearing
- The long term viability of suppliers
- External services being able to deliver (quality, price, time)

Whatever the environment, if there are untried steps involved, then the proposal must highlight them so that the organization's decision to proceed can be made in the light of the best information and most informed opinions available — yours.

Selling the concept to staff

Your intention must be to show that the project is not threatening, not a waste of time, and not an attempt to re-organize the organization by subtle means. The positive aspects of job advancement, new skills, and new business areas should be emphasized. The benefits to individuals as well as to the organization must be publicized, such as easier access to information, more complete information, reduced number of steps to obtain information, and access to other more comprehensive resources.

Keep the project staff as a team, but not too isolated from the rest of the organization. In all cases, disseminating accurate and timely information, including bad news, is better in the long run than trying to hide things. Good news can be allowed to leak as long as it is not perceived that you are keeping things to yourself at the expense of others.

As a source of information on project and staff management there are any number of books and training courses at all levels. Your organization may even have the materials you need in the library or may offer training courses. Build some time into the schedule for this for yourself and senior members.

Planning the Project 3

Like any project, much of the work has to be done before any obvious start date. Even the assignment of a start date needs planning! Background research and fundamental decisions are needed so that wheels can be put into motion.

Planning

Stages of Planning

Careful planning at an early stage can save much time and heartache later. The amount and type of planning necessary depends on the size and scope of the project, and you don't know those until the planning is done. So, like many of these activities, the planning is an iterative process. A first rough approximation gives you a feel for the size, complexity, difficulty, and hence for the areas where more detailed planning is needed.

Detailed planning is always needed in two circumstances. A piece of work may be complex in itself or intricately linked to other activities. It becomes a critical task in the logistics sense. A small change in it can have large effects outside. Secondly a piece of work may be of unknown scope. It may be that the size of the work (e.g. volume of material) is unknown, or it may be that the extent of the work (e.g. how can these two subsystems be made to work together) is unknown. Only by a detailed analysis of the problem, successively breaking it down into more quantifiable pieces, can an overall number be obtained to relate back to the project as a whole.

The major function of the rough cut or first draft plan is to cover all parts of the project and to identify the amount of planning work needed for each part. The first draft should be broad but within the limits given in the management project brief. Try to include anything which may have a reason to be in the project. It is much easier to remove things from the plan later than it is to add them in once work has started.

For example, the system is to contain the full text of company information. The original management idea may well have been limited to annual reports, technical reports, brochures, product specifications, and press releases. However, in the first stage you should talk to Human Resources about personnel records, Manufacturing about process manuals and production reports, Finance about credit information, and so on. Certainly consider all the material in the library. Contact every department head for material they would like to make available to the public, customers, staff, and management and also for material they use from external sources, both inside the organization and outside.

Even though the original brief from management was essentially for a publicity system, looking widely enough showed that the same system could serve internal and external users with publicity, process, and confidential information. Your report should state that you studied the expanded capability even if it was rejected, and say why.

Trade-offs

As in any planning process, it is necessary to compromise some desires and to modify others. The usual reason is lack of resources. Resources may manifest themselves as staff, equipment, software, or marketing effort, but they all can be reduced to cash terms in the final analysis. If it becomes clear all the goals cannot be achieved, the major planning question is whether to go for a completed, less grandiose project, or to produce a partial version of the same grand plan.

If this is a one shot project and new funds are unlikely to become available, then a reduced scale project is the more sensible option. It will allow you to produce a complete service or product which will serve the requirements of a complete audience. Some people will be left unsatisfied, but you will have a chance to perform useful services for part of the original audience. Below is a list of trade-off areas. If you have to trade some of your audience, either directly by not providing access or indirectly by not supplying the material or services they want, then you have to consider carefully the organizational influence of the various possible deleted segments as one of the factors in deciding where to reduce the scope of the project.

- General — cash vs. time
- Functions — drop whole modules vs. reduce level of service
- Content — leave out collections vs. reduce level of description
- Markets — drop sections. vs. restricted membership
- Quality — cheap & nasty vs. exquisite
- Products — simple vs. frills

If further funding can be expected, either from subsequent budgets or from generated revenue, then it may be sensible to extend the development/implementation phase of the project so that it achieves its original goals, but over a longer time scale. The initial services/products to be offered must be carefully chosen, taking into account their usability to the intended audience and the difficulty, resources, and time scale for future expansion. After all, it is no use providing access to all the library's collections if none of the material can be delivered. Users will be no better off generally and will feel frustrated. That will translate into negative reports and the project may never get to the second stage.

Trade-off areas usually come in pairs as shown above. Cash can be paired with any other trade-off. However, it is usually seen as the salvation for a late project. While this sometimes is the case, it is more often true that money does not bring the project back up to schedule. The simple reason for this is that only relatively simple tasks can be run in parallel, and then only in certain circumstances. The process of creating a Digital Library is generally not suited very well to parallel actions. The processes are generally too complex or need too high a level of expertise.

Resource limits

Some limits are already set. Perhaps the organization or library has certain collections which are to become the content of the Digital Library. Others such as the timetable are set by you as the planner. Still others such as the project budget or the availability of certain software are set by external forces.

These limits have to be factored into the overall plan. The two biggest constraining resources are equipment and expert staff time.

Lack of equipment can have an effect from delaying initial schedules to calling into question the actual technical feasibility of the project. While it is unlikely that you will wish to undertake anything which is technically more demanding than currently available hardware (servers and workstations, disk drives, networking, etc.) can handle, it is possible. This is a new field and the limits are constantly being pushed.

An example of where you could go beyond what is technically possible, or what you can afford to do, is in the area of playing videos to users across the Internet. Suppose you have a collection of videotaped conversations with famous people. It would generally not be possible at the moment to play these videos to users without expensive server and client equipment. The normal servers for a digital library, such as personal computers, are not capable of playing multiple video streams to multiple users while still providing the search and housekeeping services to other users and staff. Such functionality requires either a larger general purpose server or a special Video-On-Demand (VOD) server. These require careful sizing to match demand to capacity.

In the broader sense equipment can extend to other pieces of hardware, such as scanners, video capture cards, audio equipment, etc., and to software, such as library automation, video editing, and web server software.

An example could be a collection of documents in multiple languages where the search capabilities of the on-line catalogue do not allow for mixed language or character set input. This would mean that free text access would be as if all documents were in English with all the problems of homonyms, stopped words, wild characters, and concept search algorithms applied incorrectly. Even simple restriction of a search to a given language's terms may not be possible.

Expert staff time may not be a resource which you lack, but it may be lacking for one of your suppliers. The lack may be in the number of staff or their level of training and expertise. It may also be an unforeseen lack if people get sick or leave the project for whatever reason. Most projects of this nature are small and cannot afford to have many spare staff to provide strength in depth. Some capacity can be built in by training more than one person for a task even though only one person will be working on it. The backup people must be kept up to date on progress and must get some experience so they are not novices if they have to take over.

The biggest problem is lack of experience. This requires that staff learn on the job, meaning mistakes will be made. Thus work has to be re-done or corrected and that means running late and usually over budget. Staff will not be experienced because they will probably never have done these tasks before and theoretical training does not substitute for experience. Planning has to take account of this by allowing time for training and for the learning process afterwards. Alternatively some experienced staff could be hired for the project. This would reduce the need for re-doing work. It is important that permanent staff gain experience by working with these experienced contractors. This will detract from the contractor's productivity and must be allowed for.

Market

The market for the library's services may have already been determined. An existing library within an organization will be expected to continue to serve those users.

Even in this apparently static situation, there is the possibility of increasing the audience for the library. The advent of new material or new ways of accessing or manipulating the existing material is a great reason to market the library to the whole organization. New service possibilities such as campus bulletin boards or corporate Web sites are a way to promote the library within the organization.

In a new library, the possibilities are even more open. For a library which has decided to market its services and content to the outside world, advertising those services becomes a business necessity. This is an area where new or revitalizing opportunities can open up for the library. It is also an area where caution and prudence must prevail if the new digital services are to be justified on the grounds of increased use of the library. Realism must reign when estimating the number of new users and amount of new revenue.

The hi-tech glamour of the end result of creating a digital library can easily hide the costly hard work necessary to create it. It can also blind proponents to the real need for the new digital information. Advertising can alert users to the existence of the library and its new facilities and information. It probably will not convert many possible users who have already found alternatives to the library. Unless they have been consulted in the design process and their reasons for shunning the existing library have been overcome, they will stay with their old sources. These reasons may be as simple as not having desktop access and having to walk to the library or as complex as wishing to have the material from the library directly incorporated into the user's production process (as in a picture morgue within a newspaper). The issues and their resolutions must be enumerated and assessed before the predicted user population and usage is given.

Products

The various products the library could offer must be compared to the requirements of the users, both captive organizational ones and casual public ones, as expressed in user surveys.

It is possible to query all or a representative sample of an organization’s workforce to find their needs and desires. It is not possible to do the same for public users. For them, certain models of user requirements and behavior must be assumed and the library products aimed at those models. The distribution and numbers of those model users have to be estimated. The number of products must be tailored to the needs and wants of the users within the constraints of the available resources.

For example, a TV station news library may have video stock footage for use by the news teams. Ideally, they could digitize the complete library and make the clips available across the network so the production staff could digitally splice them into the current production. However, the quality of information required for broadcast transmission means that the 15 MB for a 1 minute clip discussed later is too low by a factor of about 32. Thus, that one minute clip will require nearly 500 MB. This increase in size may make storage impractical. While the simple 15 MB clip would enable the production staff to verify the correctness of the clip, direct delivery would not be a product that can be offered. As an aside to this example, it is imperative to verify that the editing systems can accept the video in the library’s storage format, and that the two systems can co-operate in the delivery, otherwise the whole digitization process may be an expensive waste of time.

The simplest products are for desktop accessibility and may constitute 80% of the solutions for most users. Anything beyond that may not be worth the effort, even if the resources are available. It is then a case of deciding if the extras should be done for other reasons (preserving material, in expectation of future upgrades elsewhere in the organization, etc.) or not at all. Remembering that the whole exercise will take longer than expected, now is a good time to tailor expectations to reality.

Access

For a digital library to be useful, there must be a user community and a means for those users to reach the library. Since the essence of the digital library is that all the material is machine held and manipulated, the digital library does not have a physical presence in the same way that a conventional library does. Its users will be connected to it for research and delivery via computers.

The simplest, closest, and most restrictive access is via a desktop station connected directly to the server on which the digital library is held. This limits use to users in-house and constitutes a model which is simple to maintain, but not necessarily desirable in this age of networked information.

The most closed access in practice is across a Local Area Network (LAN) serving the organization’s campus. This provides remote access but within the geographical limits of the organization. From the library's point of view, it matters little if the network is a LAN or a Metropolitan or Wide Area Network (WAN) — the technology and management are the same.

Remote public access (from users not of the organization’s closed user community) can be achieved through a direct dial-up connection. Since this offers very few advantages over an Internet connection, and requires a much higher telephone cost, it appears to be a method not worth considering.

Public and private access can be easily provided across the Internet as long as the library makes its services available that way. Given the graphical nature of most digital library material and the popularity of the medium, the World Wide Web would seem the outstanding choice for any library at this time.

To make the services available the library must run a piece of software called a Web server that interfaces with its Integrated Library System (ILS). Most ILS vendors have such an interface and many will provide a specially tailored Web server as one of their components.

The administrative mechanics of setting up a Web site can be handled easily by the library and its suppliers. For Web site design and management, it is advisable to either hire external professional services or to hire specialist staff if the size of the site warrants it.

A Web site can be as open or as closed as the operator requires. It may be free to all or it may require sophisticated passwords to enter. Alternatively, parts of the site may be free and parts private. A completely private site is known as an Intranet when it is available only to members of the organization.

One of the advantages of an ILS is that it provides specialized clients for the performance of specialized library tasks (cataloguing, serials, check-in, etc.). Many of these functions exist in the digital library and their efficient operation is a requirement. By using Java applets and / or network computers, the library can have specialized applications running on staff terminals across the Internet to allow efficient processing.

Operating a digital library through a web site across the Internet provides the complete range of user access options. It is the only method of access that will be considered in this paper.

Volumes

One of the most important planning exercises for any library is the estimation of required storage space. A digital library needs this planning just as much as a conventional one. Just because the data is stored on computer disks and does not take up much physical space doesn't mean storage space can be ignored. Disks do take up space, consume electricity, require back up procedures and equipment, and cost money.

Because of the nature of the information, the delivery mechanism (a network) becomes a planning consideration in a way that the main doors to a conventional library never did.

Storage

Since the essence of a library is its accessible store of material, it is reasonable to expect that the digital library will hold at least some of the material to which it provides access. This material will have to be stored on one or more server computers. The amount of storage required can be a large part of the cost of the computing infrastructure required.

In addition to the storage for raw data (text, image, video, etc.), there is the overhead required to index the material so that it may be retrieved in the desired fashion. This can add an overhead of anywhere from 50 percent to 600 percent for text material. For other material type it is likely to be much smaller because the indexing will generally be of a textual description of the object and is small compared to the size of the actual data.

Security of the data must be assured in both the immediate and longer term. Immediate security can be provided by a Redundant Array of Inexpensive Disks (RAID) array which spreads the data across a number of disks in a way that allows one or more to fail, and the system to still function while the failed component is replaced. In the longer term, security is ensured by regularly taking and checking backups of the data base.

Some approximate figures for the storage requirements for objects of the different types are discussed below. Bear in mind that any decisions about resolution, color depth, sampling rate, and character encoding (all discussed in the Capture section of Chapter 4), can change the numbers below dramatically.

In all cases, remember that any databases (either for storage, transactions, or indexes) will need extra space to grow and to accommodate temporary files for housekeeping, etc. Storage requirements will have to be calculated for a reasonable period of service, taking collection growth, transaction, administration, and user files into account.

Text

Text, in general, is stored at one byte per character. This will be doubled if raw Unicode encoding is used, but will be reduced to about 1.2x if the UTF-8 format for Unicode files is used. Note that with some languages and scripts (particularly Chinese) the UTF-8 scheme is actually worse than holding the raw Unicode. If your data are likely to be multi-lingual, be safe and assume 2 bytes per character.

Indexing overhead can be as low as 50% of the document for structural components (author, title, etc.) and can be as high as 600% for full positional and stemming free text searching. It is reasonable to assume that the overhead is 100%.

Records for the actual text of a document are simple and incur only a small amount of database structuring overhead. However, unless each page is held as a single record, the problem of the variable length of the documents may be a significant factor. Assume a minimum record size of the average length of the documents in pages, plus one page. This allows for the record to be stored in page size increments most efficiently.

Bibliographic and other metadata records are structurally complex and the database and indexing overhead for them may be as large as 800%. However, they are small, averaging about 500 bytes, compared to the full text of the document. Assume a 200% structural and indexing overhead.

Compression can be used on the raw text files and will give about 50% on average, with the original being perfectly recreated from the compressed record.

The following table illustrates the storage required for a small collection of 100,000 articles averaging 5 pages, all in English, to be stored in full text, and indexed for proximity and structural searching. Although 100,000 documents is a reasonably sized digital collection, the amount of storage calculated is well within that offered by most entry level personal computers. The actual disk storage space is unlikely to be a serious bottleneck unless the collection is very large or has some special characteristics, such as multiple languages. Some of the DLI projects discussed in Chapter 7 and projects like JSTOR (Chapter 6 for reference) address these issues of large volumes of text and how to store, manipulate, and deliver them.

Item	Size	Comments
Characters/page	2,000	
Characters/article	10,000	5 pages/article
Characters/collection	1,000,000,000	100,000 articles/collection
Raw data bytes	1,000MB	1 byte /character
DB structure overhead	200MB	1 page/article = 2KB/article
Index overhead	1,000MB	100% of raw data
Bib records overhead	150MB	500bytes + 200%/article
Subtotal	2,350MB	
Processing, RAID, etc.	780MB	33%
Total	3,000MB	= 3GB

Images

Images will generally be stored as simple database records or in independent external files. In either case, these Binary Large Objects (BLObs) are stored quite efficiently. Images tend to come in standard sizes because of the editorial decisions made during capture and processing and the desire to display the images on a fixed resolution display device. Thus, a number of pre-defined record sizes can be used within a database to store the image data, and the overhead can be kept very low (<1KB).

Indexing will be of the bibliographic or metadata records and will thus be the same as for the equivalent text data. If any extensive narrative descriptions accompany the images, they should be treated as text objects and sized accordingly (minus the bibliographic / metadata component).

Indexing of visual features is usually done by recognizing the features and storing them as keywords. The overhead is then much the same as a simple keyword index on a relatively small piece of text, since only a small number of features (about 5/6) are usually recognized per image. Indexing by keywords is partially an editorial decision, and after 5/6 features in an image, the remaining ones tend to be of little significance. This type of indexing would add an overhead of only about 200 bytes per image.

Resolution and color depth of the images are the biggest variables in the image record size. 640 x 480 pixels is a common small size for images. Even at this size, each image needs 300 KB (at 256 colors, it becomes 3x bigger for true color: 16.7 million colors). A thumbnail (64 x 64 and 16 colors) will take only 2 KB. A full screen size (1280 x1 024 is recommended for the high definition resolution for most 17" monitors) with true color (16.7 million colors) will take 4 MB (1280 x 1024 x 3).

Compression can make a very large difference because a compressed image can be almost 10x smaller than the raw version. Two cautions need to be born in mind about image compression. The achieved compression is dependent on the actual image and the compression is lossy. Information is lost during compression and cannot be recovered. A safe figure for compression, if it can be used, is about 50%.

The same small collection size of 100,000 images captured at 640 x 480 in 256 colors, with a bibliographic record (no commentary or description) for each, and indexed for structural searches will need:

Item	Size	Comments
Bytes/ image	300,000 Bytes	
Raw data bytes	30,000 MB	100,000 images
DB structure overhead	100MB	1 KB/image
Feature index overhead	20 MB	200bytes/image
Bib records overhead	150 MB	500bytes + 200%/image
Subtotal	30,370 MB	
Processing, RAID, etc.	10,115 MB	33%
Total	40,460 MB	= 40GB

Compression of the raw image data can reduce this to about half (20 GB).

Audio

Audio data will be stored as files or as BLObs and the database overhead for them can generally be kept down to about 10%. Indexing and bibliographic/metadata considerations are as for images.

Direct feature indexing of audio data is almost non-existent. If the audio is converted to text and then indexed, the resultant text files should be sized as such.

Data size is affected most by sampling rate, sampling size, and number of channels. Thus, the spoken word in mono (using 8-bit size and 11 Khz rate) will take about 1 KB/second, whereas stereo music (16-bit and 44 Khz) will take about 17KB/sec when stored as .WAV files.

Compression can be applied to audio using much the same techniques as for images. The compression is also lossy and the high frequencies are usually lost. The signals may also be processed to suppress hiss or boost the bass as with any audio recording. This has no effect on the record size.

Audio data will tend to be kept in individual files, so there will be no database structural overhead.

The same small collection size of 100,000 audio recordings, half sound (8-bit, 11 Khz & mono) and half music (16-bit, 44 Khz & stereo) of 10 minutes, with a bibliographic record (no commentary or description) for each, and indexed for structural searches will need:

Item	Size	Comments
Bytes/ sound clip	600 KB	10 min @ 1 KB/sec
bytes/music clip	10,200 KB	10 min @ 17 KB/sec
Raw data bytes	540,000MB	50,000 sound & 50,000 music
Bib records overhead	150 MB	500bytes + 200%/article
Subtotal	540,150 MB	
Processing, RAID, etc.	180,000 MB	33%
Total	720,150 MB	= 720 GB

Compression can reduce the raw data size by about half so the compressed size is about 360 GB.

Video

Video is a sequence of images and an audio track. However, the images are only slightly different from frame to frame so that a special form of compression can be used. Without this, the raw data sizes are enormous. One second of video at 30 frames per second (fps) of the 640 x 480 image size (256 colors) considered above requires 9 MB. Even with good compression, this amounts to about 1 MB/sec. Thus storage for a 90 minute feature video at this size would require (90 x 60 x 1 MB) 5.5 GB. Lower sampling rates (15fps) and smaller sizes (320 x 200) can be used in conjunction with modern graphics cards to yield large images from reasonable amounts of storage.

Recent advances in image extraction have allowed videos to be indexed by selected images and these to be analyzed for features. This indexing would add somewhat less overhead than the same number of images because there will be much common content. Videos would typically be stored in individual files rather than a database so there is no structural overhead.

As an example, consider a small collection of 100,000 video clips of 1 minute each at 320 x 200 and 256 colors at 15 fps. These are to be feature indexed at 10 image frames per clip. They have spoken dialogue, and a bibliographic record (with no commentary or description) is required for each. They will be indexed for structural searches. The whole collection will need:

Item	Size	Comments
Bytes/ video	15 MB	0.25 MB/sec assuming 4:1 compression
Raw data bytes	1,500,000 MB	100,000 articles/collection
Feature index overhead	200 MB	10images/ clip and 200 B/image
Bib records overhead	150 MB	500 Bytes + 200% /article
Subtotal	1,500,350 MB	
Processing, RAID, etc.	500,000 MB	33%
Total	2,001,350 MB	= 2,000GB = 2TB (Terabytes)

This is an already compressed figure. Better compressions techniques, or a decision to lower quality, could halve this figure to about 1 TB.

Bandwidth

The bandwidth needed to deliver the amount of data above becomes a serious consideration. The delivery requirements for one of the sample objects considered above are:

Object	Typical Size
One text article	10 KB
One image	300 KB
One audio clip	600 KB (1 KB/s)
One video clip	1,500 KB (250 KB/s)

These sizes have to be compared to the available capacities of the delivery channels:

Delivery Channel	Typical Capacity
Internal PC disk channel (DMA)	33,000 KB/sec
24x CD-ROM	3,600 KB/sec
Ethernet LAN (10Mbps)	1,000 KB/sec
ISDN connection	128 KB/sec
56.6 modem	5.7 KB/sec
28.8 modem	2.9 KB/sec

It becomes clear that the actual delivery time for each of the objects is considerable when networks are used as part of the delivery channel. In addition, public networks have other traffic, and the system is unlikely to achieve the above theoretical capacity. Public network (Internet) connections should be assumed to provide only 50% of their rated capacity with any reliability.

The problem is at its worst when the continuous materials of audio and video are delivered. They are the biggest files, so the download time is the longest (say 7-8 minutes for a 28.8 modem for a video clip). They can be played without a complete download using streaming technology so that the download will finish at about the end of the playing. For the video above, this would only mean that the initial wait was reduced to 5-6 minutes. However, streaming technology uses even more efficient compression and more of the facilities of the accelerator video cards to shorten this time and improve delivery speed and quality. For small videos, the technology almost works now and will improve rapidly in the next couple of years.

Processing

The amount of processing for delivery is not particularly large for the text and images. However, the requirement to move video or audio data from disk storage to a network connection requires significant processing power. Some amount of compression is being done in real-time, but mostly it is just the movement of large amounts of data.

Special hardware, such as a video server, has been developed. If delivering video is a significant part of the functioning of your digital library, then one or more video servers are a must because the load that video delivery places on a normal database or application server (especially if a web server is added) causes all the search and housekeeping routines to slow to an unacceptable rate. Optimized server hardware, such as Sun's Enterprise servers, helps ease the load, but the calculation of retrieval requirements and delivery requirements must be done on a case by case basis.

Where very high bandwidth channels (such as 1 Gbit/sec = 100 MB/sec) are available, the limiting factor in performance can easily be either the processor or the hard disk. At 66 MB/sec, a modern high performance hard disk cannot keep pace with a modern high performance network connection. The fact that there are likely to be multiple users on the network evens things out, unless they are all waiting for downloads from that same server.

Systems

Two forms of systems need to be considered; hardware and software. While the software provides the functionality to make the digital library work, the hardware provides the underlying resources and processing.

Hardware

There are two components to any modern distributed client/server system; the server and the clients. Since the clients are the machines that reside on the users' desks, there is generally little the library can do to enforce minimum levels of resources or performance. The library's system can contain a recommended or required minimum level of equipment and software for the user to correctly and efficiently interact with the digital library, but users will still operate with whatever they have, and expect to get some sort of response.

If the library does have some control of clients such as staff machines or those for use in-house, then there are two scenarios. The first involves ordinary PCs or Macintoshes as clients, and the second uses network computers such as SunRay enterprise appliances

The advantages of the PCs are that they already exist in many situations, they can have a wide range of peripherals (hard and floppy disks, modems, etc.), and they are familiar. The disadvantages are that they are more expensive, the peripherals allow data to be removed or other programs to be run, they are of fixed performance, and they have to be individually upgraded.

The advantages of Network Computers are that they are simple, inexpensive, do not have the peripherals, can utilize the processing power of a server, and are automatically upgraded every time they are run. The disadvantages are that they need a local server, applications have to download, and they must make use of network peripherals for file copying, etc.

JavaStations are an attempt to address the maintenance, performance, and upgrading problems of individual PCs. What their model does provide is an easy way to centrally maintain and distribute applications. These may be full blown retrieval workbenches or processing tools, or they may be Java applets running within an Internet Browser session. They can be loaded when needed, which impacts the way software for these systems is written as the software becomes more object-oriented and open. Individual applications have to work with each other. This feeds back to the whole development process and provides the environment for more controlled software development.

The servers for the digital library are pieces of hardware that the library controls. The number and power of the servers needed must be addressed for each installation. It is now possible to think of using the specialized servers for different tasks so that there is some spreading of the workload and some redundancy.

Servers are basically specialized into three classes: database servers with large high speed disks and very fast local communications, applications servers with fast processors, and communications servers with fast communications peripherals. They are usually adaptations of the same basic range of machines with specialized equipment and larger capacities added. This means that a good basic platform can be utilized for all three classes. If the basic platform server is scalable, such as the Sun Enterprise Server series, then each of the specialized servers will be scalable, and the library will be able to grow as needed.

The real point of the specialized servers is to allow the library to buy capacity (whether it is storage, processing power, or networking) where they need it without having to over purchase. The flexibility is there to grow and the redundancy provides security in case of failures.

Overall there are many pieces of hardware that are needed for a computer server site, but these are not special for a digital library, with the possible exception of video delivery servers if they are needed. These may involve not only normal computer network connections, but also the delivery of their video by TV cable or even satellite.

Since digital libraries require large amounts of storage regardless of their content, it is a good idea to pay particular attention to the storage solution. Particularly important is the future flexibility of the subsystem. In this respect, something like Sun's Intelligent Storage Network (an example of a SAN – Storage Area Network) shows the direction of the future, where the physical storage devices are intelligently controlled and made available to a number of application and database computers. The data then become independent resources that can be accessed with permission from any system.

Software

Like the hardware, there is a division between the clients and the server(s). At each of these, there is the operating system and the application software to consider.

For the clients, the operating system is likely to be either a version of Microsoft Windows (3.x, 95, 98, NT, or 2000), a system based on a Java virtual machine, or Linux.

Windows has the advantage of being familiar and has a large base of software. The Java VM allows all the promise of the network computers to be fulfilled and constitutes probably the only viable alternative to Windows as a user platform, especially when running dedicated applets and general purpose browsers.

For the clients, the application software is likely to be supplied by the supplier of the whole automation package. Individual stand-alone applications may be required, but the majority of the end user interaction with the digital library will come either through specialized client software or through a generalized web browser interface.

For the server operating system, there are really only three alternatives: Microsoft Windows NT server, Linux for small installations, or a version of UNIX for larger systems. UNIX in various forms is the operating system used by most web servers and by nearly all large library automation systems. Of the UNIX alternatives, Sun's SOLARIS is by far the current favorite. It continues to gain market share each year, although Linux has a very respectable showing in the Internet servers in general and is available very cheaply.

The major decision to be made here is choosing the basic application software and all its components. The package may be a system supplied by a single vendor, or it may be a system with components added onto an open architecture frame work. Of all the myriad pieces of software needed, the central one, and the one which needs to be chosen first and most carefully, is the library automation system (or Integrated Library System).

A number of digital libraries are being constructed at present utilizing a mix of information retrieval, media management, and web server packages. If these are not tied together with a unifying underlying framework, then the whole system will have problems with growth and expansion. These systems are also generally no more than catalogues and do not address any of the housekeeping issues of conventional automated libraries or their systems. The digital libraries today are where library automation was about 20 years ago. They have started to tackle the front end part without considering the implications of long-term maintenance and management.

Although an ILS should be the core of a digital library system, the problem is that the field is moving very fast and is being driven not by the library community, but by academic research. The traditional ILS vendors are struggling to keep up with what is required. This makes for difficult choices that depend on a vendor's future plans and flexibility as much as its present offerings.

The resources chapter (chapter 6) lists all the types of software which are likely to be needed and gives a selection of suppliers for each. For the fundamental ILS software, the list contains the dozen or so largest vendors in the world and is essentially complete. There are small companies which can offer possibly even better solutions, but their corporate factors (stability, growth, support, coverage, etc.) have to be carefully weighed.

Resources

The most important resource for the whole exercise is staff time and expertise. Although there is a lot of technology involved in creating and running a digital library, most of the effort is hard work.

In particular, because access to the library is so much easier, people will visit more often. If what they see is always behind the times (last month is the latest issue of a journal) and initial problems do not get corrected (images appear in false colors on some workstations), then they will quickly stop coming back.

The following advice belongs in the next section as well: do not publicly set too aggressive a timetable. Allow time (another scarce resource) to produce things, test them, correct them, and then do it all again.

Data will always be converted in less than perfect form. If it is keyboarded, there will be typos. If it is converted by OCR, then there will be mis-matches. If images are re-sized during capture, some will be cropped instead, and heads and feet will be lost. All these things have to be checked either on a 100% or a sampling basis.

After the data have been converted, the biggest skilled job of all is still to be performed: the cataloguing and indexing. Editorial decisions and cataloguing rules have to be developed as well as applied. It is certain that the exceptions will not appear until near the end of a batch of material requiring at least another review of all the previous objects.

Even with sufficient staff and people, there are the mundane resource problems, like the main catalogue database computer developing a fault and stopping everyone. The resources for emergencies need to be considered and contingency plans (stand-by machines), access to a remote machine, a loaner, etc.) need to be made.

Time

Whatever other resources you have available there will never be enough time.

Problems will arise and will set the timetable back. All that can be emphasized here is to plan as thoroughly as possible and to be conservative. Some things to keep in mind:

- Do not plan parallel activities.
- Assume that even off-the-shelf computers will need installation.
- Assume that packaged software will need to be installed.
- Assume that complex software (ILS, DBMS, IRS, etc.) will need modification once installed.
- Assume that the next software version will not fix all the current shortcomings.
- Remember that people take vacations, get sick, and don't work 24 hours/day.
- Plan for NO weekend working (strictly 5 days/week).
- Remember public holidays (including overseas, if that's where suppliers are).
- Look at history and calculate an ACCURATE number for staff who will leave.

- Assume ALL new and replacement staff will know NOTHING about what you have been doing.
- Remember on-the-job training takes time from the trainer.
- Assume nothing useful from the trainee until fully trained.
- Plan at least one major delivery with a one month delay.
- Remember you will be away for periods of time — allow for them.

Accommodating these concerns may lengthen the timetable considerably compared to what management is expecting, but defend it as best you can as early in the project as you can. Get the suppliers working on a faster plan. It is better for you to have things sit on-site unused for now than for them to be holding you up. Reconsider the plan regularly even if all appears to be going well. Inform people of problems and successes.

Getting Started 4

Having planned what to do, who to use to do it, and how to do it, it becomes time to actually get started. This section takes you through some of the major aspects of what to do.

This section is strongly biased towards a library which is digitizing a collection which it already owns and is planning to make it available to both its organization's staff and the public in some form. It assumes that an ILS will be used as the basis for the library functions, though this is by no means necessary if all that is required is to provide an open catalogue with direct delivery through the network. It is further assumed that access to the library will be provided over the Internet (probably the Web).

Administration/Management

A digital library project has all the problems of automating a conventional library plus a few of its own. The extras center on the need to digitize the existing material as part of the project.

The additional activity means that another group of staff, a contractor, or both have to be managed, and the results of their work integrated with that of others. Coordination is the biggest problem in a project of this nature. There are a large number of tasks of differing duration and complexity to bring together.

For anything except the very smallest project, it is almost essential to use a project management tool if not full blown formal methods. A project management tool which reports conflicts, allows tasks to be scheduled and to be assigned to resources, makes it possible to:

- Avoid the worst of disasters
- Re-plan when things do go wrong
- Give a coherent overview of the project
- Allow easy management reporting.

The project should be broken down into successively smaller tasks until the resultant task requires either one resource or involves only one activity. The smaller tasks can be estimated for work and duration, and then the bigger groups of tasks can be created as work units for a team of staff. Each of these group activities should be given a team leader to oversee its progress.

Once the atomic and group tasks have been identified, they should be entered into the project planner. The most important output of this planning is the resultant time scale and resource requirement, but the most important inputs are the tasks and their dependencies.

Along with any activity where something new is being done or being delivered, a test / repair / test triplet of tasks should be added. The same tasks should be added at the next level up when the results of the new activity have to be incorporated with something else.

Tasks should be entered in the logical groups used to define them in the first place. Dependencies should always be set so that the first of a pair of tasks is completed before the second is started. This, is in many cases, unrealistic for the final result, but it makes checking the logic of the plan much easier in the early stages.

Once the plan has been outlined with all the tasks and their dependencies, check it with the team leaders who will be responsible for those group activities. Use the whole plan rather than just the part for that team. This way the team leaders get an appreciation of the scope of the whole project and may notice things being done in other groups which overlap with theirs or which have been omitted in theirs. Finding things at the paper stage is a lot better than after things have started. Involve the team leaders in all the stages of planning either individually or as a group.

Given the diverse nature of the whole project it may well be that a major activity for all staff and groups is training. This must be arranged in advance of when it will be needed, of course, but there is a danger in arranging it too early. Staff may forget what they learned, confuse it with other recently learned skills, or even leave before the task commences.

Since there will be new skills and they will be diverse, it is important to ensure that there is sufficient staff to cover these skills, both for formal occasions, such as when annual leave is being taken, and also for when things get behind and more hands are needed. Try to complement training so that it builds on previous skills, bearing in mind that a highly skilled person can become very vulnerable, especially if working in a support role in a public institution. Make sure that none of the teams is left out of the training.

Once underway, things will become very hectic because the library will probably have to keep functioning through the implementation of the digital library project. Thus preparation and house cleaning before the official start can be very useful. Data should be checked and as many corrections as possible entered into authority files and the like. Remember that the current library operations have to continue in parallel.

It is easier for staff to learn a new activity on a familiar piece of equipment than to learn both at once. If computers are going to be introduced for cataloguing, then introduce them well before the cataloguing starts so that people get accustomed to how they operate. However, it is essential to give the staff something useful to do with the equipment, otherwise it will not be used and the training benefit will be lost.

Utilize your planning tool to produce regular internal project team reports and discuss them at meetings. Involve vendors, contractors, and consultants. It is good for the staff to get to know them and to see that they are not alone in this venture.

Regularly use the tools to predict for/with your team leaders how the project is tracking according to the schedule. Be honest and if the timeline has to change, do it earlier rather than later. Time lost at the beginning is never made up later, however good the rationale for believing it may be.

Purchasing

You will almost certainly need to purchase some things for the project. The only situation when you will not is if you have done it before and are merely enlarging an existing system. In that case, you should know how to go about it.

Broadly, the things you will have to have are:

- Hardware
- Networking
- Library System
- Multi-Media
- Content

Some of these you will already own and others you may have no choice as to what is acquired (e.g. the organization has a policy and contract for networking services). In these cases you have to learn about the products you will be using and make sure that they have the functions and capacity to serve your expected needs. If they appear not to, check again and then contact senior management about an alternative or enhancement.

The requirements of each of these components is discussed in other parts of this document, and lists of suppliers are in Chapter 6. Each situation is different and you will have to make up your own list distinguishing among what is mandatory, highly desirable, or just desirable.

Make a very full list of requirements before shopping around. Even if the process is not a formal bid or tender process requiring a Request For Proposal (RFP), it is sensible to list all you think you might want before finding what is available.

New technology

This applies to both hardware and software. New is good, newer is probably better, tomorrow's technology is possibly worse. This is not to say the technology is bad, just that very new things (especially software things) have a habit of not working properly for quite a while. A home truth in the software industry is to never buy a version x.00 of anything, but to wait for your purchase until x.01, when the bugs have been corrected. It may be that you have no choice, that what you want may have only just become possible or available. In case you have to go with very new technology, build in a lot of testing time, get to know the developers well and decide if you can trust them, find out how important your project is to them, try to get any development done jointly, ask for a development discount, and get something in return if you agree to be a beta test site. Then make sure you do test it thoroughly, because if you say it is okay without proper testing, it is much more difficult to get it fixed later. Testing may well become your major activity so be prepared for it, and tell your management so that they are part of the decision.

Too good to be true

If one vendor offers a deal which appears to be too good to be true, then suspect it. Any price which is less than those of the competitors' for the same product by more than about 25% of the average needs careful consideration. Ask the vendor about the price and listen skeptically to the answers. Get them in writing. If nothing appears to be wrong, consider how the vendor can be in business with prices so much lower than their competitors' prices. How is it that they haven't captured 100% of the market — after all no one wants to pay more than they have to.

Consider two things. Companies often buy business by selling to prestigious sites at less than cost. Do you qualify as one of these? Are all the others padding their prices for discounts later?

The lesson here is to have a skeptical approach to prices. Remember always that the vendor is in business to make a profit. And they will only stay in business if they do make a profit. Their prices must reflect this.

You will be a partner with your chosen vendor for a long time to come. Consider the long term stability of the vendor and the product line as well as the initial deal. Also consider the benefits of long term loyalty to a vendor from whom you will get preferential treatment and access, benefits that you will not receive if you continually swap from brand to brand.

Total Cost of Ownership (TCO)

One way prices get to differ is that things get forgotten, sometimes legitimately, or have not been asked for. Thus, make sure that you consider the costs of your purchases for a period of time, not just the initial purchase price. Usually three or five years are the time to use.

Make sure all the following are included:

- Maintenance
- Support
- Training and re-training
- Help services
- New releases
- Bug fixes or upgrades
- Back up facilities or loan equipment.

Not all of these will be included in the base cost, but get the per year or per incident costs and estimate the Total Cost of Ownership (TCO) and compare these.

It's not enough

Make sure that the number of licenses are sufficient to cover the users you have to serve. Check if they are simultaneous or connected or “seats”. What underlying software is being used and what is the license situation for that. Get a figure for increasing the size of the system, including the number of users of all types, the size of the database, and anything else which affects the licenses and hence the price. Ask if the licenses are in perpetuity or annual.

Apples and oranges

If you are in a competitive purchasing situation, then you will get prices for the various vendors for a particular item. Although you gave each the same set of requirements, you will be offered a variety of products which will generally fit your requirements, but may not be the same.

What you hope to get are a number of products that meet or exceed your requirements. This will not always be the case and you will have to be diligent in ensuring that things have not been overlooked in the response. All your questions must be answered. Beware of missing answers. Take a hard knowledgeable look at “it's the same as”, but do not rule out an alternative until you have thoroughly investigated it. It might actually be better than what you asked for.

The numbers game

If you give numeric quantities to the vendors and they come up with sizes, capacities, or numbers (e.g. disk size, number of processors, number of OPAC licenses, etc.) different from yours, ask them for their assumptions and arithmetic. For example, a smaller hard disk capacity for the database may not be wrong if the database software includes compression or is very space efficient.

Fair's fair

If you find, after talking to a number of vendors, that you have a changed requirement, then go back and give the changes to all of them. It is only fair to them and to you. They may otherwise bid on the wrong thing because you forgot to ask for something.

If you do go back to a vendor to ask for a better offer (in any way — it does not have to be price) then give the same chance to the others. After all, they are all in business to get you as a customer, and you want the best product at the best price.

A bigger picture

Don't get blinded by the bottom line cost of the product, particularly if it crucial to your project (like ILS software or database server hardware). Look at the vendor as a partner you will have for a long time to come.

Do you like their approach; are their people knowledgeable; do they treat you properly; are they legal, decent, and honest; is the company well managed; do they have experience; are they committed to this industry; do they have a good reputation; and do you think you can work with them?

Answer all of these questions and avoid all of these pitfalls, and you should be well on the way to having the equipment that you need at the right price from a vendor you can trust.

Capture

Capturing the essential components of the original material in digital form is the heart of the process of setting up a digital library. It is creating the information for the library.

Based on each type of original material the important decisions are:

- What elements of the original to capture?
- How to capture them?
- At what level of fidelity?
- How completely?

Many of the original material types (e.g. books, videos, tapes, reports, etc.) are actually multi-media in terms of the simple categorization of the media types commonly in use. Thus a book has text and images, videos include audio and can have images extracted. Since most of the media types will have to be separately captured (only images and text have the same initial physical capture process — scanning or digitizing), it is necessary to consider the workflow for each of the material types in the collection.

Consider, for example, a normal printed book or report.

> At a media level, it has both text and images. Are both of these important? Is it worthwhile capturing both of them? Is it worth capturing them separately, or would a simple image of the whole of a page suffice?
>
> At the structural level the book has covers, a title page, a verso page, possibly frontispieces and probably index and contents pages. Are all of these required as well as the body of the book?
>
> Having decided what to capture, you must decide at what level and how completely to capture it. Perhaps the index contains meaningful words and phrases which would be useful for subject retrieval, whereas the contents page does not. Possibly the contents page is captured as an image only and the index is converted to text.
>
> The problem arises that not all books are created equal and so either a blanket decision according to material type must be made or a complex series of procedures and rules must be set up. Of course, a mixture of the two, or broad categorization (such as “scan indexes only from text books”), is also possible.

The designs for the workflow depend on factors such as:

- How the material will be searched for (full text vs. indexes and cataloging)
- How the material will be used (read and transcribed vs. cut and pasted)
- How precisely material must be targeted (book, chapter, page, paragraph)
- The functionality of the software (capturing text is no use without full text searching)
- The system capacities available (disk space, processing power, network capacity)
- The capture equipment available
- The staff available (or the services that can be bought)
- The time available.

Having decided on the components of workflow for the various material types, it is necessary to consider how each type of medium can be captured. This enables a physical workflow to be laid down so that components of material are not missed and can be related back together once completed.

Since all the efforts of your capture will end up as computer files, it is worth spending a little time on thinking about file names. Although the contents of these files will be accessed via a library system, most of the original images or audio will stay in their files. These files will be referenced from within the library system and will be retrieved and played at the appropriate time.

The file names must be unique. This can be achieved by two processes: name the files by material type, and give them some form of sequential number. The file type will be automatically determined if you use name extensions since the extension denotes the type of file. This is a generally adopted convention, although both three and four character extensions are in common use. Since both Windows and Unix will recognize a 3-character extension, it is sensible to stick with that.

The body of your file name can be any length (which often means up to 32 characters), but it makes sense to adopt a simple classification and coding scheme to keep file names to a manageable size. Many capture programs will take a set of prefix characters and pad them to 8 (the limit on file names under DOS) with numbers and automatically increment for each file created. This is advantageous as long as you remember that it will be necessary to manually relate the generated file name to the physical document (or film, etc.) at the time of capture, and for this information to return with the captured files. Some capture programs allow this information to be entered into a computer record, for others it will have to be on a worksheet. This forms an essential link in the processing chain and must be part of the quality control process.

Remember also that 8 numbers represents only 100,000,000. This seems a lot unless you want to put your institution's initials at the front. With two initials the number of files is reduced to 1 million; with three initials, to one hundred thousand. These are not large numbers so, if you have to use 8 character names for even part of the process (they can be expanded later if it seems worth it) choose succinct prefixes.

Text

Text comes in two forms for the purpose of capture, as print on a page and as a machine readable computer file.

Text — printed

Text is first processed physically as if it were an image. The image is then processed to convert it to encoded machine readable text. Scanning paper or other physical material for text extraction has some differences from scanning for images.

Most text is black on white and the Optical Character Recognition (OCR) programs need black and white. So the capture should be black and white. Most scanner software has a text setting which gives optimal black & white images for OCR conversion. In fact, the setting usually produces a gray scale image rather than a stark black & white one. This allows for smoother edges and more rounded corners, a feature which makes OCR more accurate and also makes the text more readable. The advantages here are faster scanning, better OCR performance, better display, and smaller files.

Even color text should be reduced to black & white images for consistency of conversion. If it is desired to keep the page image for display to the user, then this will have to be re-scanned. For any size volumes, it will be faster to have scanners dedicated to black and white and to color, and move the documents between them. Make sure the process assigns similar file names to the two files.

Since text tends to come in large volumes (many pages), it is very beneficial to set up the physical scanning so that it can be automated as much as possible. All flat bed scanners have Automatic Document Feeders (ADF) that feed pages in exactly the same way as a photocopier; indeed the whole process is very similar. For the smaller scanners the feeders are limited to about 50 sheets, so they must be continually fed.

Even this capability is of no use for bound material. The processing of bound material may be by direct scanning (there are special scanners for bound books which do not require the spine to be to be fully opened) or you may decide to photocopy all the material for subsequent scanning. This ensures the copied pages are then all of the same size, orientation, paper weight, and quality, and are all black and white. Photocopying the original makes the scanning process more reliable at the expense of the extra step and taking the care of the physical material at that stage. It is also possible to batch and control number the copied pages for later use. Scanning can then also be carried out in parallel and even be outsourced without concerns about the handling of the originals. Any repeat runs are against the copies and so the originals are further protected. This protection is probably only warranted for expensive, delicate, fragile material. However, the improvements in paper handling and general efficiency are worth considering under all circumstances.

When scanning multi-page documents it will be necessary to decide how to consider them. The individual pages of a book will be scanned one by one and each will be an individual image. As part of the scanning process these single page images can be combined into one file which holds all the images of the whole book or some logical part. This is where bibliographic theory comes face to face with practical reality.

If the pages of a book (or article or report...) are scanned as one object and stored in one file then they must be treated as one in the retrieval system or catalogue. Even if individual chapters of a book are catalogued and appear separately in the catalogue, when the link to the full text is made, the book will be opened at page 1.

If the individual chapters of a book are scanned as separate objects then they must be catalogued as such and retrieval will start at the beginning of the appropriate chapter. However, there will generally be no obvious way to have the chapters linked together so that the user may just page forward through the whole book. Even if the bibliographic record for the chapters are linked in the catalogue, most library software is not capable of making the leap from Chapter 2 to Chapter 3 of a title.

If each page is scanned and stored separately then display of the relevant page to the user will be immediate. However, something special will have to be done to allow that same user to read the next page of the chapter, let alone the next chapter of the book.

At present, it is necessary to make this user-oriented decision at data capture time. The next generation of library systems and document readers should start addressing this issue. The good news for the future is that however you decide to serve your users now, the technology exists to split or merge the image and text files to provide the desired level of granularity when the presentation systems allow.

Once the text has been scanned, it needs to be run through the OCR program to convert it to a machine readable encoded form. This can be done as part of the scanning process if the computer configuration is big enough to allow the files to be sent around a network automatically. If not, then the files must be processed after the scanning. In any event it is necessary to have some human intervention to review the conversion and perform editing where necessary. The problem is that OCR conversion is not an exact science and the quoted conversion rates of better than 95% are not useful, except for running text that will only be read, not indexed.

Consider an accuracy rate of 99.7% — this is very good for the software, but it means that three characters in 1000 are wrong. Since the average English word is five characters, it means every 67th word has a spelling mistake on average. These words will be indexed, so the spelling mistakes will get into the index. This leads to confusion for the users and can be a monumental task to correct.

Errors take two forms: a character cannot be recognized, or a character is incorrectly recognized. The former problem is addressed by the OCR software when working in interactive mode by displaying the image and the piece of text to an editor, and asking for the correct character to be entered. The second case is not recognized as a problem by the conversion software. However, most of the software has an editing component which runs a spelling check against the text and this will catch many of the replacement characters. But even a spelling check doesn't catch all the replacements, e.g. CAT becomes OAT because of a smudgy C. A further stage can be run with the more expensive software to attempt a context match (this should catch the OAT if the article is about cats, unless, of course, it is about cats in fields of cereal. This is only of limited use in subject specific literature because the dictionary has to learn the terminology. For mixed languages its more of a waste of time than a help.

Knowledgeable editors are a must for this stage of the work. That is why specialized conversion services exist. For a more extensive description of the problems visit the site of Access Innovation Inc. at *www.accessinn.com*.

Once the OCR has been run, then the text exists in machine readable form Other than the problems of conversion errors mentioned above, you must be aware that obtaining OCR programs for character sets other than Latin, used in Western European languages, is a very difficult job, and is an area where conversion is probably best left to a service bureau. Even if the conversion can be performed, the problem of character encoding (see below) remains.

Text — machine readable

Machine readable text results either from the above scanning and conversion process or from originally created files from a word processor or some other computer program.

For a digital library two things have to happen to the text file. It has to be stored so that it may be displayed to users when they request it. It has to be processed and indexed so that its content is available for searching.

The problems to be overcome arise from basic character encoding and document formatting. Character encoding is the assignment of a computer code to each of the letters in the document and is done during the word processing creation or during the conversion of a scanned image. Document formatting comes mostly from word processed documents, where different pieces of a document, such as the title, are given different typographic characteristics. The title is printed in a larger font and in bold. The codes that control the encoding and formatting have to be included within the document file, yet they have no impact on the content of the document and must be ignored for indexing.

Character encoding

If all the text files come from a single source and are from originals in the same language, then there is no reason to expect any problems with character encoding because all the characters will have the same encoding.

If, however, the documents come from different sources, and particularly if they are in different languages, then they may use different encoding schemes and will appear as gibberish to all but the reader and the indexing program.

There is a unique universal encoding scheme called Unicode, which is the international standard ISO 10646. Unicode allows almost all of the characters from the world's languages to be encoded unambiguously. The problem is that at present, Unicode is not widely implemented. It is rapidly gaining popularity and will become the future standard. Both Netscape and Microsoft web browsers will recognize it and display it if the correct fonts to give the character shapes are downloaded.

Multiple languages and character sets will have to be re-encoded into Unicode (or another unambiguous scheme — there are others, but they are not universal and are not recommended). This has to be done on a file by file basis and requires suitable software, mapping tables for the encodings, and an operator who can look at the original text file and determine which character set it is in. Again, this is a time consuming specialized task which is best undertaken by a service bureau.

Formatting

Once all the text has been encoded, the text must be processed so that only the content will be indexed.

In considering how to display the document, it is necessary to decide if the formatting of the displayed document will be as in the original, or if the document will be displayed in a standard consistent for the whole collection, or if this is a user option.

Whatever the decision, it will be necessary to identify the formatting conventions and structural elements of the text. These items can then be marked in a consistent way so that the indexing can ignore them and the display program can either ignore them and apply its house style, or else obey them. In some instances, this is a non-issue because there is no formatting. In others it is quite easy, although time consuming, because the originating program, especially for word processors, is identified and the pre-processing can then use the control codes of that program to seek out the required content. In the case of allowing the user to decide, there is no such algorithmic method available. It is a skilled manual process to mark up the text in a special editor that introduces the codes that the indexing and display programs need. Again, this is a job often best left to specialists unless the volumes are low and the formatting simple.

Indexing

Once the text is cleaned up, then it is a relatively straightforward process to feed the text files into a database. The database may store the files for retrieval, or it may just index them for searching. The following decisions need to be made before starting the indexing program:

- Which areas (or components) of the document are to be indexed?
- How are they recognized?
- Is a stop list to be used?
- Is more than one stop list to be used?
- Are phrases as well as words to be indexed (how will they be recognized)?
- Are the extracted terms to be processed (against a go list or a spelling checker)?
- Are term positions to be recorded, if so at what level (for proximity searching)?
- Is morphological analysis to be performed (word stems, different vowel forms)?
- Are browse lists to be created as well as direct access indexes?
- If so how many and where do the elements come from?
- How are diacritics to be handled?
- Is language to be taken into account?

This is not a complete list. The list of decisions depends on the capabilities of the library system or information retrieval system being used as well as the characteristics desired for the eventual digital library catalogue.

Fortunately, text catalogues have been around by far the longest and have developed the most sophisticated mechanisms. Thus, the other material types will not present as many problems to be solved and decisions to be made. Equally language is our most important communications medium, and users of a digital library will spend much of their time interacting with a system operating in a text mode. This is the most important underpinning of the whole operation.

Images

Before any capture starts (except experimenting) there are a number of decisions to be made. It is assumed here that images will be viewed as images rather than processed, although this is not always true. The image may be viewed in a number of environments and it is necessary to relate the quality of the capture to the display environment.

First consider scale. At two extremes are a postage stamp and a sheet map. There are bigger and smaller examples, but these will do. The stamp is physically small, but may need to be viewed at high magnification. The map is physically large, but may only be needed at an overview resolution.

The problem is that the resolution of the image is fixed at capture time, not as with the physical object where a magnifying glass can give any required resolution within the limits of the printing, etc. process. If the stamp is captured at a resolution of 300 dots per inch (dpi) then that is the maximum amount of detail you can see. Any attempt to magnify the image just produces bigger dots, not more detail. Having said that, there are programs which can manipulate the captured optical image and enhance it to greater resolution. This is done by a process of mathematical interpolation and gives a series of higher resolution (smaller) dots between any two that were actually scanned. This process gives better color gradations and can give the appearance of sharper edges, but it cannot invent features. It merely enhances the details already there.

For flatbed scanners, resolutions go up to 1200 dpi, except for very expensive ones that almost double this rate. Drum and other special scanners can achieve resolutions of over 10,000 dpi. Flatbed scanners tend also to have two resolutions: one along the bed with full resolution, and the other across it at half the resolution. Even the 1200dpi resolution is generally as much as is required.

The problem of resolution is that the higher it is for a given picture size, the larger the file needed to contain it. If the file is only capturing black or white then one bit would be enough for each resolved point and an image of 1 inch square would contain only 1200 x 1200 bits = 1,440,000 bits = 180,000 Bytes = 180 KB = 0.18 MB).

Add to this the fact the stamp is actually in color. If the realistic minimum color depth of 256 colors was used, the size of the file jumps by a factor 8 (to hold the color information for each resolved point) to 1.44 MB. For a higher resolution image, each pixel would use not 8, but 24 or even 30 bits, bringing the file size for one stamp to about 5 MB.

Thus, a collection of 1,000 stamps would take 5 GB of space just for the raw data. Even at today's prices, this is a lot of hardware and becomes costly for a moderately sized collection, if the more costly high performance disks are to be used.

As with all capture, the matters of encoding and formatting are important. A number of pieces of information have to be recorded about the image so that it may be viewed (technical), adequately described (cataloguing), or so that the ownership rights may be properly protected and observed (IPR).

Some of the technical information required is:

- Its file format (not always clear from the file name),
- Its image type (bit-mapped, vector),
- Its compression (if used) and scheme,
- Its dimensions,
- Its color encoding (RGB, CMYK, etc.),
- Its color resolution (color depth, luminance, etc.),
- Its completeness (detail, complete, part).

This information is distinct from that which describes the image and allows the viewer to form an opinion about the image. For example, to discern the original colors, the information about the spectrum of the scanner, any filters, any color processing, etc. would have to be recorded.

The amount of technical and associated information that has to be recorded depends on the expected use for the material. The more the objects themselves will be studied and scrutinized, the more information will have to be retained.

Audio

Like all the other media, Audio can be presented to the library as an original analogue object or in a digital form. The first stage is to digitize the analogue and then process the digitized form.

Digitizing

Audio objects will almost certainly be recordings (tapes, CDs, wax cylinders). To capture them is as simple as playing them on the appropriate player and recording the result into a digital recorder. This may be a self contained physical process where a tape is played on a tape player connected directly to the sound card of the computer. Or it may involve recreating the sound waves and then capturing them with a microphone attached to the computer sound card.

Whichever method is used, there are obvious requirements to preserve both the fidelity and purity of the recording (no coughing, only one input source running). The most obvious editorial decisions to make here are:

- Sampling rate (11 K/sec for speech, 44 K/sec for music, etc.),
- Mono or stereo or quad or any other special scheme,
- Number of tracks (or channels),
- Noise processing (Dolby, etc.),
- Digital format (.WAV, .SND, .MID, etc.).

Most of these decisions depend on the desired use of the audio track. The sampling rate determines the highest frequencies captured. Mono obviously loses any spatial information, but not many computer systems can (or in the near future will be able to) re-play in quad sound. If the sound is being recorded for use in a music studio, then making individual tracks or channels available may be much more useful than just the combined final effect.

Noise processing, or any other form of signal processing or generation, may be beneficial or it may completely ruin the utility of the digital recording; it depends on the use that will be made of it. If in doubt, capture at the highest quality and do no processing.

The final format is purely a matter of the user capabilities. Formats can be converted, but it takes time and processing power and so it is sensible to store the digital sound in the form in which it will most often be used.

Processing

Currently there is very little that can be done to make a sound clip directly searchable. Text files have been searchable in sophisticated ways for many years and now images may be searched for form and visual content. However, it is not possible in general to whistle or hum a tune into a computer and have the computer identify it. Audio files are almost entirely a display only medium.

There is one just emerging exception to this, and that is the spoken word. Voice recognition software has recently become capable of reasonably accurate recognition of direct continuous spoken input. Voice recognition is intended for interaction with the computer, but is equally capable of recognizing, and converting to machine readable text, a digital recording. This allows the spoken text to be searched for meaningful content in the form of words. This is just text searching performed automatically, but it is an important advance over transcribing spoken recordings.

It is not generally possible within a library system to search directly for frequency signatures, intonation patterns, etc. However much of this technology does exist in special systems and even in some retrieval systems. The capabilities of those systems could be mated to the general organization, storage, administration, and delivery mechanism of a library system to meet a special need.

Video

Video is the other major medium considered as part of a digital library. Its processing combines the worst aspects of images and audio, since that is what it is composed of.

Capture

Like audio, video capture consists of playing the object and feeding the output into a video capture card in the computer. If the original is in the form of film then a special piece of equipment must be used which effectively shows the film to a video camera and feeds the resultant signal into the capture card.

For video tapes, the process is physically similar except that a VCR, VDR, or laser disk player is used. The result is still fed into the capture card on the computer.

Here again editorial decisions have to be made such as:

- Black & white or color
- Color depth
- Frames per second
- Digital format (.AVI, .MOV, etc.)

The arguments are much the same as those for audio and relate mostly to intended use of the material and the expected capabilities of the audience's playing equipment.

One extra dimension here is the actual volume of data recorded when a video is digitized. Achieving the best optical quality of a 35mm film takes such an enormous amount of storage space and bandwidth that this is an impossibility, although larger disks and satellite and cable delivery are rapidly changing this. Thus, video compression is used, leading to another editorial decision, which CODEC to use? A CODEC is a ``compressor/decompressor” (or a ``coder/decoder”) and is a piece of software which compresses and then decompresses the video data.

The problem with video compression, like that for still images, is that it is lossy. This means that the compression loses some data and leaves the decompressed image degraded from the original in some way, usually sharpness of detail. This may or may not be important depending on the final use of the material.

Except for special cases, such as a film studio video library where absolute fidelity to the original is required, most video is compressed and it is originally captured according to the dimensions of the computer monitor on which it will be played. The problem of storage and transmission bandwidth is being alleviated by graphics cards in the workstations which can decompress and expand the images in real time from their small transmitted size to a full screen display.

To achieve real-time video displays across a network like the Internet is not really possible at the moment without high speed links and a lot of luck. Other traffic on the net can cause unexpected interruptions.

Processing

Processing of video for direct searching has made great strides recently (see the UCSB and CMU projects in chapter 7). Techniques such as key-framing and subsequent image feature recognition mean that a video clip can be summarized and even searched directly. The process is automatic once the relatively simple decisions about the type of summary and feature recognition have been made. Index storage is not a space problem compared to the storage required by the original video.

Other

The above four material types constitute the totality of what most people consider to be the compass of the digital library. However, there are other material types which may have to be handled by a library and could probably benefit from the rigors of library discipline over their care, maintenance, and administration. These are listed below, with a couple of brief comments on each.

Computer programs

These are in one form only, text files like any other, and can be stored and indexed as such. The problem with the text of a computer program is that it says very little about the function of the program. Simple keyword extraction would list the variables used, but not anything about what they are used for.

Interestingly, the programs have a second form when they are running in a computer. In this form they have visual characteristics (screen shots) or possibly audio (sound effects) which may give an indication about what they do, and may be a more sensible way to categorize them. As far as the author is aware there are presently no digital library systems which deal with programs at this level, even though there are definite advantages to be obtained.

Computer presentations

Presentations which are produced on and shown through a computer are another material type having peculiar characteristics. They generate the images, sound, and possibly video of a program, yet they have none of the logic which a program would need to create the same display. The intellectual content can be easily extracted from the text of the screens, but it is merely a shell and does not really have content without the accompanying verbal and/or printed presentation.

"Multi-media" packages

These may contain elements of all the above. Almost by definition they can contain any other thing that can be imagined. Thus, storing and processing them can be done according to their components. The problem then becomes how to draw those components together to represent the whole. More work is needed on this.

CD-ROMs & DVD with multi-lingual sound tracks

The interesting aspect here is not the medium, but the fact that the capacity of the medium allows for not only different language sound tracks and sub titles if desired, but also alternative endings (or middles or beginnings theoretically).

The questions are how to handle this from a descriptive point of view. Is there a master version which defines the content or is it the sum of all the variants. Is each language version treated as a separate work and catalogued separately? This is one which will be here before we know it, and we are not ready.

Cataloguing/Loading

Cataloguing has been touched on in the preceding section, because some of what has to be done is material specific. The big issues are the completeness of the physical description part of the catalogue record and the granularity of the cataloguing.

Much digital material has been loaded into retrieval systems and the result called a digital library. Since the extraction of the data for the bibliographic record is usually done automatically, the resultant record is skimpy, to say the least. The development of the Dublin Core specification was an attempt to address this problem by defining a set of attributes which could be extracted automatically or be assigned by unskilled people (such as the author). This means the bibliographic record is now the descriptive data not the content designation. Certainly controlled vocabulary and other quality control measures are greatly reduced.

This is not to say that automated assistance for cataloguing is a waste of time, far from it. Automatic extraction of data and information can be a great time saver. However, the thrust of library automation systems has been towards sharing the results of human cataloguing rather than developing computer assisted cataloguing in the above sense. The vast amounts of data on the web and in the new material types mean that automation will be coming to library systems or they won't be able to keep up.

However, for now, cataloguing is a highly skilled manual process where each item is considered on its own. Thus the degree of granularity of the new material types becomes an important question in terms of the workload of creating and maintaining a digital library.

The granularity required depends on the users and their requirements. If they are different from those of a traditional library then the granularity must change. Traditionally the cataloguing description has been at the level of a complete work. Its components have not been described. Users who can now retrieve a single image from a document may want to be able to search directly to the level of the image, not via the level of the document. However, the majority will require what is done now in the well working model of the conventional material library.

As with any library, standards and rules must be strenuously applied to the cataloguing of the material. This does not change. The strength and utility of the catalogue depends directly on the quality and consistency of the cataloguing.

Loading and indexing the records has been touched on above in the capture sections. The indexing which is performed from the bibliographic record is a part of the library automation system, and constitutes a series of decisions no different from those of a conventional library.

Indexing from the original material is material type dependent and end user and use dependent. What results from a completely mixed material library is a series of indexes and search tools which are each organized around the particular material type. Thus, images and videos may have an index of the material by the type and number of shapes in them. However, they can share a subject description index in text form with all the other material types. The common denominator of these is the textual description applied or extracted during cataloguing.

In all cases, the capabilities of the library and/or retrieval software will determine the scope of what can be offered to the users. In most cases it will fall short of what is theoretically possible.

Services

The library is not merely a searching tool for people to log onto over the web or some other access medium. Conventional libraries provide a large number of other services. Many of these can and should be continued or extended in the digital library. Below are listed some of the major library services and how they could appear in a digital library.

All provide benefits for the library's users. There is nothing to say that these benefits have to come free. If the library has the remit and the software capabilities, it may charge for all or some of the services it offers including basic access to its catalogue if it wishes.

Searching

Catalogues and their access are the most visible aspect of libraries, particularly when they are on-line. In the on-line case, they may have virtually no other presence. This is a shame since libraries generally have a lot more to offer than this.

The capabilities of the search system are generally going to be fixed by the software that you purchase. How you implement them and how the users use

Vocabulary control is an essential part of the cataloguing process and is almost completely absent from full text searching. Searching using a controlled and well known vocabulary is a service which is particularly useful in the subject descriptions and makes for much better search precision than simple keyword searching. It also reduces user frustration at the extremes of “0 hits” or “3,465,789 hits” results. When controlled by a sensible thesaurus with descriptions and relationships, it makes the user's job of finding the required meaning of a word much easier. It also allows for translation and thus the consistent use of the catalogue in a number of languages.

Natural language search statements are accepted by some systems, but are handled much better if processed by a human rather than a system. A service to users could be a librarian mediated search service. This could derive the search from a written description e-mailed to the library with results sent back the same way. It is not a feasible real-time service, but can have a rapid turn around. An extension of this would allow searches to be spoken into a phone and then converted to searches as above.

Rather than mediate, the search library staff can filter the results to produce better output from the user's own input. Removal of duplicates is one very useful service.

Delivery

Results of searches are generally delivered on-line, but may be offered via e-mail or hard copy if the volumes are large. The other delivery possibility which exists in a digital library is that of delivering the final object to the user. This would generally be on-line, but may also be by some bulk transfer (such as e-mail attachment, ftp, CD-W, etc.) if the object is large or if access is restricted.

Format/quality

The quality and format of the items may vary considerably, particularly where results, whether they are hit lists or the final required objects, come from a number of sources. Lists could be post-processed to yield a uniform format. This is performed by some search engines, but not by all. If results are across different search protocols, such as Z39.50 and http, then the results will come back looking very different. Often these results are displayed separately for each source, which leads to problems identifying duplicates, etc. Post-processing of these lists is a possible service. The only search engine that the author is aware of which addresses all of these issues is that produced by his company (called Muse). It is used to provide a searching portal service by WildWild, Inc. (*www.wildwild.net*).

For the final objects there is little that can be done about the quality, since that is dependent on the quality of the original object. However, re-formatting may be possible to a limited extent. Certainly most times a uniform header for the objects can be extracted from the original data. This can provide a useful description of not only the object, but also where, when, and how it was obtained. Future improvements in encoding may allow more re-formatting into a house-style so that results may be presented almost as one-issue journal or report.

Bibliographies

This leads directly to the creation of “bibliographies”. This is in quotes because the contents of the bibliography probably will not be books, but some other material. Bibliographies may be *ad hoc* just for a single user (who may well have to bear the processing costs), or may be standard ones prepared and run at specified intervals in anticipation of demand. The extent of coverage, the depth of research, and the volume of these bibliographies will depend on their intended use and target audience.

Research

A research or reference service is a composite of some of those services mentioned above. However, it is a way to add value to the library's products by utilizing the expertise of the library staff. A more extensive form of searching, with more initial contact to determine the user's requirements and feedback of initial results, this service may result in a beautifully presented bibliography or merely in a list of references. The results may be annotated or analyzed by the library (or external specialist) staff to add further value, and may utilize resources well beyond those of the library.

Discussion groups, forums, news

Since the library is on-line, it is possible to run chat rooms or list servers for discussions on topics where the library has expertise. These are best run as mediated groups so that they library staff may add value to the discussions. They can be on any topic, but are most likely to center on the specialties of the library. These may be reactive in response to user request for discussion on a topic, or they may be proactive in that the library starts a group and sees if anyone joins in.

Variations on these groups are things like a video-of-the-week club or a top-ten page. These are vehicles for the library to advertise its content as well as providing a useful service.

A newsletter, weekly news page, or similar notice becomes another way for the library to bring its services notices to the attention of a wider public. These may be subscribed to or may be pushed to peoples’ desktops depending on library and organizational policy.

Support

There are many reasons that the library should consider a help desk or support for its users. Primarily, the library staff members are the experts and have an in-depth knowledge of the material in the library.

Legal

The biggest legal issues for libraries of any type are Intellectual Property Rights (IPR) and Copyright. Digital libraries are no exception to this. In fact, they have a worse set of problems than those of a conventional library.

Legal issues do not stop at IPR. Libraries have to arrange contracts for the right to use content which is not their own. Libraries have to contract with their users for supplied services and associated charges. There are the normal legal/contractual matters of hardware, software, and other suppliers to deal with.

There are staff and other human resources legal matters to arrange.

Many of these are normal business matters and can be dealt with adequately by a corporate legal department. However, in matters pertaining to the data, the ownership, and use thereof, a specialist is really needed. In the resources chapter (Chapter 6), there is a section which lists a number of places where specialist help and advice may be obtained as well as lists of some lawyers and legal associations. In the interests of yourself and your library be sure to seek help from these sources or your advisors if you are at all unsure of you legal position.

This section raises issues and briefly discusses them. It does not offer legal advice or any interpretation of laws in any part of the world. Remember that an Internet-based service is available in any part of the world and that your business practices, including the legal ones, must recognize this fact.

Intellectual Property Rights (IPRs)

IPR and copyright issues boil down to one question; “Who owns the content?” Subsidiary to that is the question of who is able to do what with the content. The reason for this is obviously that the owners of the content may place a value on it and do not want to see it distributed indiscriminately without them getting suitable compensation for its use.

This requires that you are aware of every piece of information on the system and keep track of what use is made of it. Even if you or your organization own the content for all you material, it is very good practice to know what you have and what has been done with it.

Knowing what you have is mostly a matter of ensuring that your software allows you to make the necessary lists and reports so that the material can be counted in the right way. Such accounting could be structured according to the requirements of the IPR/Copyright owner, and so it may be necessary to incorporate fields for this data in the database structure.

If the situation is at all complicated then it is best to move to a rights management sub-system right from the beginning, rather than struggle along until you find yourself in a quagmire. Such sub-systems are very new and are evolving rapidly. However, they will handle matters like:

- Different types of use,
- Different classes of users,
- Dates of use,
- Number of times,
- Levels of fees and discounts,
- Promotional and educational use.

These functions tie in very closely with those of measuring access discussed in the next section. Note that for the legal aspects, it is important to record a user's class if not the actual user identification itself. The reporting requirements are very similar, but the emphasis here is on making sure that only those users who have permission are able to use an object, and this must be authorized on an individual user/object basis.

One of the requirements of good business, and a legal requirement of many reseller contracts, is that the material is adequately safeguarded. This is particularly interesting in the digital environment where the notion of a copy of something is just that much more difficult to control.

In 1993, the European Copyright User Platform was set up by the European Bureau of Library, Information and Documentation Associations (EBLIDA) with funding of the Libraries Programme of the European Commission (DG XIII-E4). Its aim is to encourage discussion of the legal issues in electronic services and has drawn up a model licensing document. It has set up a Copyright Focal Point on the World Wide Web to host a moderated discussion list on European copyright issues, and to provide access to documents on copyright issues and legislation. The Web-site can be found at *http://www.kaapeli.fi/eblida/ecup*. The ECUP secretariat is at: *ecup.secr@dial.pipex.com*.

Digital Watermarking

Even when a user has the right to view an object, he or she might not have the right to make a copy of that object. They almost certainly will not have the right to freely distribute copies of that file. All of this requires some policing. It is generally impossible to prevent an object displayed on the screen from being saved to file. Thus enforcement must reside in marking the object so that it is clearly identified.

This process is known as digital watermarking and the added data is the watermark. The watermark is both a proof of ownership and an authentication of the origin of the material. Thus, it serves the interests of the owner, the distributor, and the reader. The watermark may only identify the owner of the object or it may contain other information such as a serial number, information about use of the object, rights and fee information, or even a description of the object.

All of this has to be done in a way which cannot be removed without destroying the copy, is readily visible to a user without requiring special software, and does not destroy the object for the original legitimate copier.

There are a number of techniques for this for text, images, audio and video. All use different techniques, although those for video and audio are similar, and these are continually changing. New techniques are developed, and as old ones are circumvented, they must be replaced.

This is a specialist area and it is one of the subsystems that you will have to add to your ILS or basic retrieval system to achieve a working digital library. It is an area of much current research and consequently there is an active discussion about it on the web. See the section in the resources chapter for both discussion and journal information, and also for suppliers.

One particular adjunct to the digital watermark is of interest. The Digital Object Identifier (DOI) is a unique digital ID which can in principle be attached to any digital object. It has been created at the instigation of the American Association of Publishers and others as a means of electronically tagging each digital object so that it may be tracked. Through a remote database the user may ascertain the owner of the IPR and the type of rights associated with the object.

Measuring and Charging

Whether your library is a commercial venture or not, it is important that you are able to measure the use made of it. It would be even nicer to measure the benefit of the library to its users, but that is almost impossible to judge outside of laboratory conditions.

For most libraries, the number of users and the amount of use made of the library's services constitute the measure of success or failure. This section discusses some of the ways these measures may be taken for a web-based system and for general library functions.

The major public access to a digital library is to the catalogue and it is this usage which is the main measure of its effectiveness. Since the catalogue is likely to be web-based the measure of activity becomes very similar to those used by the web advertising industry and these measures may as well be used. In addition to being correctly applicable, their use allows libraries, which may or may not carry advertising, to record activity in a consistent fashion and to make use of the sophisticated reporting tools increasingly becoming available.

The basic way of recording access is to record the number of pages retrieved. Web server software logs all hits on a site. A hit is a single request for an object, which may be a page of information, but may also be an image on a page. Most pages have between 5 and 6 objects on them. Reporting software is able to combine these hits into pages either in real time or by analyzing the transaction log of the web server. Since a page represents a piece of information and its context it is a reasonable measure of information delivery.

The software also extracts and reports “click-through”, which occur when a user navigates from one page to another by means of a link on the first page. The combination of these two measures allows a library to measure the full use of its site.

A conventional web site is considered to consist of a number of pages, each of which is essentially the same in importance. The hits on a page determine which ones users looked at most often (and hence, presumably, found most interesting). Note that the length of time spent on a page can also be captured, and this is another measure of interest, although it may only record that the user went for coffee and did not read any of it!

The problem for libraries is that all pages are not of equal value. A query formulation page is not the same as the page of full text results in terms of user satisfaction. Also confusing the issue is that many page designs will involve dynamic elements, which change each time according to what the user has requested. Good examples are a hit set list page and a record display page. Heavy use of the former may indicate not that the user has found the item of interest, but is frustrated with scrolling through lots of unwanted titles because there appears to be no faster way of getting the desired record.

More is not necessarily better in all cases. However, the numbers do provide a fund of raw data for careful analysis. And they do provide a positive indication of user activity.

For a library that is intent on actually making money out of its site, two possibilities are available. The simplest is to allow advertising in its pages. This may or may not prove popular with the users, or it may be of no interest at all. If this route is followed, access to one of the web advertising services is probably the best way to go about it. Useful lists and information about what to do are on *www.iab.org* and *www.cnet.com/Content/Builder/Business/Advertising/*.

Remember that not only can you display advertising on your site to help fund it, but you can advertise on other sites to promote yours. Directory and list sites are the main ones here, along with specialist hosts for micro-sites', which are effectively a specialized shopping mall concept. Look around.

The other possibility is to sell the content of your site. To do this you must first either own the content or have an agreement with the owner which allows you to sell it (see the previous section). After that, you will need to decide what and how to sell. The most obvious is the content of the records in the digital library when they represent the full content of the original material. You can either sell the content on a pay-per-view basis or you can sell a subscription that gives unlimited access to all, or some section, of your library collection.

The web server can accommodate an e-commerce application, which will link to your library system as its product warehouse, and handle all the details of the sale for you. Beware that this is a new area and most of the ILSs will not connect to most of the e-commerce systems. Linking these to an accounting system and possibly to on-line credit card payment systems is an area where you will need to put together a specialized set of software. Such systems are not currently available off-the-shelf. Remember that whenever you sell data that is not your own, you will have to account for that sale to the owner and pay a fee.

If the ILS that you use for the library has a client which can be loaded onto the user's workstation, then keeping track of user activity is relatively easy and the overall system functionality can be enhanced over that provided from a generic browser. If running through a web browser, then to keep track of the usage of the system it will be necessary to utilize “cookies”, which are small files that the server stores on the user's computer to keep track of their identity. Since this is an aspect that worries some people, your use of and policy on cookies, and the information you gain from them, should be detailed on your site so users will co-operate.

Currently all metering is done in software. However, there are products on the horizon that may take this function into hardware in the future. For now the major systems are listed in the resources section.

It is worth remembering that the conventional library services, such as reprints and loans, are valid services in an electronic medium and can be chargeable services also. In fact, almost all of the services discussed in chapter 4 can be charged for if a way can be found to charge for them easily and efficiently.

Pitfalls 5

Things can go wrong and they will! Here we look at some of the things that can go wrong and see what can be done to alleviate the problems or even bypass them altogether.

Essential tools don't arrive, are late, or don't work

Like many problems — once it has happened it is really too late. So the first things are advice on avoidance:

- Choose reputable suppliers
- Choose suppliers committed to the industry
- Choose existing products
- Defer any development to another project

The biggest problem here is that the tool you want/need is about to be announced by a small start-up company. In fact you have been trying a beta version for a couple of days, and it seems just right for the job. It may be hardware (a faster scanner, a more powerful server, etc.) or it may be software (a database that lets you hyperlink documents, a video player that gives full screen over a 14.4 modem connection, etc.). You decide to use it and re-build your workflow around it.

Here you can see the problems because they are so obvious, but what about a new version of a software package from your existing supplier. It can cut the image color editing time by 33%, but it won't be ready until next month. This is a calculated risk. If the gain looks big enough then you may decide to trust the supplier, especially if you are an important customer of theirs and can get problems fixed quickly.

The safe course is to go for the standard solutions. They are the ones that have been around for a long time and that everyone is using. This is both the good and the bad point. The tools will work, but your collection won't stand out from the others. This is all a consequence of the rapid rate of change of the whole IT industry where almost everyone is taking a chance on someone else getting things right on time.

Generally the larger the investment, the more conservative you should be. For your database software choose Oracle, Informix, or Sybase. For your servers choose Sun. For the exciting frills, you can be more adventurous, but make sure that there is a fall-back position so that when (not if) some of the tools fail, you can still deliver a product, even if it is without all the balloons you would like.

When the inevitable happens, as in all crises, don't panic! Undoubtedly someone has been here before and there will be a way to salvage some, if not all, of the project. Unless the original material has been damaged (see the next section), you are no worse off than if you hadn't yet started. Of course, you are some months down the line with nothing to show.

Unless this tool is absolutely unique there are probably others that have been around for a while, that do essentially the same job. It is unlikely that you are doing anything so new that others have not tried it before, so there must be a solution. Look around for an alternative. If you did a rigorous selection of the tools, there will always be the second and third place candidates. If not, look at the web shopping sites and journals for advertisements, and ask colleagues or your consultant. Make sure your new selection does actually have a working version of what you want, and try it out if you can. Of course, you should have done this for the first choice, but the newness of it may have overcome better. If you have any significant proportion of your data processed (as may be the case if your server proves to be inadequately powerful once you start real volume loading), then make sure the new tool can allow you to use that data without having to start from scratch again.

If you have multiple problems all occurring at once, attempt to solve them one at a time. Part of the failure may be a cascading effect from one to the other. When you are now late, you must lengthen your time line and do some things serially rather than attempt them in parallel.

You need to be in control and allow things to proceed at a pace, and in a fashion, where you can show some small progress over a small time. This is essential for everybody's morale and for the project's credibility. It is essential that you are honest about the problems and realistic about their effect. Virtually all projects slip a couple of times, but when a project is seen to slip at every progress meeting management support soon evaporates. It is better to exaggerate the extent of the delay so you have time in hand later, than to minimize the slippage and have to ask for more time next week.

In some cases a complete re-design of the work or plan may be needed. This doesn't mean that what has gone before is necessarily wasted, just that it should be used in a way that doesn't require the late / missing tool!

Data Capture/Conversion is late, or wrong, or incomplete

The answer here is prepare and plan, then test, and then do it all again. Here are some of the safeguards to put in place to see that the time and money spent on data conversion isn't wasted.

General problems and safeguards

- Divide the material into batches of the same type.

  Put all the color 35mm mounted transparencies together for processing. Make a batch of all the newspaper clippings. This is the first step. To do it successfully you must know exactly what material types you have to deal with. Do a thorough inventory of the types of material and the volumes. Make sure the materials actually are the same. It is worth having a second person or group do the same inventory check independently of the first.

  > *A client thought that they had 6500 audio tapes in boxes that would need capturing with only a tape number on the outside of the box for identification. A chance opening during a project meeting showed that some of the boxes had a descriptive sheet inside the box. So, now there were two types of material where there had been one. Fortunately, this was discovered before the tapes were sent off for processing, where all the information on the sheets would have been ignored or lost.*

- Divide the material within a type into small batches and test rigorously.

  Small batches allow you to test all of the facets of conversion against the original. If three maps are to be scanned in parts, it is possible to ensure that all sections of the maps are covered and that there are no gaps. The degree of overlap depends on the type of capture decided on. The purpose of this is to verify that the method decided on for this particular material type actually captures the required information.

  It is also easier to load the small numbers of records into the final system, and to determine whether or not the information is captured adequately. Use of the map images may show that an overview image of the whole map at reduced resolution is required. It is then possible to revise the procedure and resubmit the batch without having to wait weeks for the data to be returned.

- Insist test batches be returned exactly as for the production.

  This enables you to test loading times and procedures as for the production. It also enables you to determine that a delivery mechanism works. For example, a devised scheme of returning one image on one floppy disk may make the idea of physical backup sound attractively easy. However, when the first batch of ten images comes back on 15 disks, it soon becomes clear that there will be a handling problem and probably a data corruption problem if there are thousands of images to handle.

  You also need to test things like the postal delay for batches of material being shipped to the converter and being returned. These times can be significant and the problem of out-of-sequence returns of data must be considered. For most material it does not present a problem unless sequence numbers of some type are being assigned on return. What it does affect is the process of batch control to ensure materials and / or data are not missing.

After the whole batch conversion is working, send one more. It is too easy for the project committee to decide that everything is working perfectly “with one small change that won't affect anything else”. The time spent verifying loading times and procedures is small compared to that if the “small change” does affect something else.

- Whatever the initial time scale is for the conversion, double it!

  With a number of organizations involved things will go wrong. Even if everyone is an expert in what they do, they are not experts in what the other people are doing or in how to put them all together.

Since the capture/conversion is a labor and time-consuming operation, it is a natural for parallel operation and it does work that way. Of course, it does not work at all when people are on holiday. Be sure you calculate working days and not elapsed days when setting up schedules. Make sure you know where the material is going.

It only takes one missed piece of data to be discovered halfway through a big material type for the whole schedule to be thrown badly off. Check all the initial batches on a random sampling basis and then randomly sample the later ones at a rate consistent with the throughput. This means the early days will see a lower throughput than the later. But this is sensible for the people doing the work because they have to learn the material and what is required. This is particularly true if the material, techniques, or information required is new to them.

On the other side, do not assume that the early production rates will speed up dramatically and allow you to catch up later. Use the test batches to time production as well as get the procedures right.

- Thoroughly document all the procedures.

This will happen automatically if you use a professional conversion company. They will insist on documented procedures as well as acceptance criteria for the returned data. You must do it even if it is your own staff undertaking the work. Set acceptance criteria (permitted number of errors, number of missed images, number of video clips without sound, etc.) and devise ways to test for them. Make sure that everybody knows the procedures and the tests, and that if a test has failed then the whole of that batch will have to be re-done.

Staff will get sick, will leave, and will be rotated. If procedures and standards are not written down as they are to be performed, then the new staff will have no chance of getting things right and quality will suffer.

Remember also that the processes will probably be ongoing, so someone will have to digitize an annual report once a year. Even if it is the same person, he will have forgotten the decisions that were made last time.

The documented procedures must be the ones used, not the ones the consultant suggested that are mainly bypassed. Change the documentation as the procedures change.

The procedural documents and the testing documents are the key to the quality and timeliness of the data. An iterative process is required in the early stages to refine the procedures and the amount of testing (and hence rejection), so that an acceptable quality is achieved within an acceptable time. The values here are ones that only you as the head of the project can decide on. Time to market, market acceptance, and cost of production are the factors to juggle.

Data specific problems

Different material types have different special areas where they can go wrong. Here are some of the areas to check on.

- Images
  - Covers of reports or books, and the spine are captured.
  - Both sides of pages are captured.
  - All the edges of pictures are captured.
  - All the required formats and resolutions have been produced.
  - Color has not been lost.
  - Optical corrections have been applied (or not depending on what is required).
  - Size and aspect ratio has been maintained.
- Video
  - Both beginning and end are there — it is easy to stop converting at a black frame near the end.
  - Check the content for a short clip because file names are easily mixed up, especially if they are sequential numbers.
  - Check color match with original.
  - Check for sound.
  - Check that edges of image have not been lost due to differences in movie, TV, and computer screens.
  - Check that not too many frames have been dropped.
- Audio
  - Check for the wrong sampling rate because high frequencies will be lost.
  - Check stereo vs. mono vs. 3D vs. surround sound, according to what is required and the original.

- Check for end of recording since it is easy to stop at a quiet period near the end.
- Check for audio processing (such as bass enhancement) if required.

These are the main material types for digital libraries. Other material can be included but is currently much less frequently used. Some of these tests are very technical and may not be required and some are just checks against sloppiness.

Part 3

Resources and the Future

Here you will find a large number of references to other sources. Some are paper, but most are electronic and available on the Web because they are likely to be more current and easier to access. This does presume that you have Internet access. If you don't, then seriously consider getting it for the sake of the project.

The references are a mixed bag and you will find both beginners' texts and advanced discussion papers. Use the navigational facilities of the web and your librarian skills to move from the starting points we give to those areas that you find you need to read.

Some resources contain useful information, others are places where you can start to look for what you need. Many of them supplement and extend what is contained in this document. Some are commercial supplier sites and they will be, understandably, touting their wares, not those of the competition. Still, there is much useful information to be gleaned from these sites, particularly about technology advances, but be mindful of their ultimate motives.

In addition to the resources listed here, you might like to utilize the search engine at the WildWild site. This is a meta search engine which allows you to enter advanced searches (including Boolean logic, brackets, and proximity operators) and have the search applied to about 3 dozen search engines of your choice. These include both web search engines and libraries, so the results are a mixed bag. They are re-formatted and interfiled so they are easy to peruse. A free web-search-only service is available, or you can register and use the full power of the system, still for no charge at the moment. The resources for Chapters 6 and 7 were partly culled using early versions of this engine.

Chapter 7 is not really about resources in the same sense as Chapter 6. Chapter 7 discusses places on the Web where you can visit digital library projects or related research work. Some are complete, but most admit that they are works in progress. Whatever their state, except for those that have been abandoned and deleted, you will find ideas you can adopt and modify. You will find people behind the projects you can talk to and ask for help.

Resources 6

This is the reference section where all the pointers to other resources are located.

Standards, Formats, Protocols

These are the rules by which objects are described, their data are stored, and the systems communicate. This is an eclectic mix of such rules and is not exhaustive. The members are chosen because they are useful, fundamental, or illustrative.

There is nothing in this section that you can buy. The items are here because you will have to make some decisions, or ask some questions of your suppliers, and these are the names that will come up.

Some are international standards set by bodies like the International Standards Organization (ISO) and the Internet Engineering Task Force (IETF). Some are national standards set by bodies like the National Information Standards Organization (NISO) in the U.S., or the British Standards Authority (BSA) in the U.K. Some are industry standards set by industry bodies. Some are corporate standards produced by a single company and accepted by widespread usage. Some are not standards but are in widespread use.

In all cases, the function is to try to unify the representation, manipulation or transmission of some piece of information so that two or more different systems can understand it the same way. The standards are the basis of interoperability, portability, modularity, building blocks, objects, and all the other names invented to describe how two pieces of software should be able to simply work together. Be very wary about claims of easy and complete conformance, and ask to see examples or a demonstration.

Generally, standards change fairly slowly, some would say extremely slowly at the official National and International level. A superseding version will usually require conformance to the earlier version. This is not always the case, but the exceptions are rare and are documented in the standard. It is well worth the effort to access these documents on-line to make sure that the ones you are interested in are not about to become obsolete or to change their function radically.

Commercial or de facto standards, however, do change rapidly and often in a way that is deliberately designed to block systems conforming to an earlier version. These standards are often devised and promulgated in an attempt to gain market advantage, so it is in the interest of the promoting organization to lock in other users and to lock out their competitors. The Microsoft / AOL war in late 1999 over the standard used for access to on-line chat rooms is a classic case. The de facto standard was changed every day over a period of about a week to a form which was incompatible with the earlier version so that the competition could not access the service. This is currently a rare occurrence, but may become more common as the Internet is commercialized more and more. You can't do much about it except to be aware of the possibility of it happening with proprietary ways of doing things.

Bibliographic

These are concerned with the description of the material, both as to its content and its physical and descriptive attributes. Bibliographic standards are generally very complex (MARC has some 800 field definitions), and cover the most difficult, intellectual, part of the object definition. These definitions are necessary for processing the material and also for searching for it. These definitions are all a form of metadata in that they are information about the basic record (the data).

MARC

This is a standard for recording bibliographic data at the logical level. It contains elements for content and for physical and process description. It is not a single standard, but rather a framework within which each country has developed an individual standard. USMARC is the closest thing to a universal standard that there is at present. Generally maintained by an office within the relevant National Library, USMARC is maintained by the USMARC office within the Library of Congress.

A new MARC format, MARC21, has become a standard within the last year and is being adopted as a common format by the Australian National Library, the British Library, the Canadian National Library, and the Library of Congress. It is hoped that this will be adopted by other national libraries, many of whom base their existing standard on those of these four libraries), and that it will become the international standard.

lcweb.loc.gov/marc

Dublin Core

This is another standard for record content and descriptive data. It is much simpler than MARC, comprising only 15 elements. It was devised for use across the Internet to allow a common description for professionally catalogued material in libraries and for amateur material at other Web sites. MARC and Dublin Core data elements can be interchanged according to a prescribed scheme for user display purposes.

Dublin Core is undergoing an evolution from its simple 15-field form to a more comprehensive qualified-fields form. Within this, the original fields are qualified for more precision, so ‘Creator’ could become ‘Creator.personal’. This allows a better mapping to the more comprehensive and specific MARC records. It also allows flexible extension, so that other data elements (fields) may be added as needed. This would be valid even for private use through the idea of ‘NameSpaces’, in which a particular set of fields and qualifiers is given a name and deposited in a well known place so that any application can find out about them, their syntax, and rules of use. This is a similar idea to the use of schema in XML rather than a DTD in each document.

purl.oclc.org/metadata/dublin_core

BIB-1

This simplified record structure for on-line transmission is essentially a sub-set of MARC. It is the original format for transmission of records within a Z39.50 dialogue between two systems. BIB-1 has elements that can be mapped to both MARC and the Dublin Core.

http://lcweb.loc.gov/z3950/agency

Text Encoding Initiative (TEI)

The initiative provides a scheme to encode text so that parts of it such as the start and end of lines, paragraphs, pages, chapters, and acts can be marked. Such text can be processed to produce accurate indexes for searching. Grammatical and linguistic features of the text, as well as content indicating things such as the actors in a play, can be identified allowing for a rich analysis. These rules require that the actual text be marked up with SGML encoding.

A brief introduction can be found at *www.dsu.edu/~johnsone/tei.html.*

Electronic Archive description (EAD)

EAD is an encoding scheme devised within the SGML framework to define the content designation of documents and other archival objects, with a minimum number of descriptive elements, but in an extensible fashion. It is designed to create descriptive records that will assist in searching for the original material in a number of ways.

http://lcweb.loc.gov/ead

Federal Geographic Data Committee (FGDC)

FGDC is a metadata standard for the description of the elements of maps and other cartographic objects, including such attributes as scale, projection, co-ordinates, and co-ordinate scheme. This is just an example of a number of specialist descriptive schemes for different objects and material types.

Metadata

This is not a standard or even a description. It is a currently popular word that correctly describes the class to which all the above descriptions belong. It is literally data about data and thus, is the description of the structure of the record that actually holds the data. Since it is a class of things, it can have no single useful description. However, it is being used by a number of vendors as a flashy buzzword, as in the phrase “Our system incorporates the latest bibliographic metadata paradigms for internal object representation.” A translation for this is “Our system uses MARC for its record structure.”

Anglo-American Cataloguing Rules (AACR)

These are a set of rules that define how an object is to be described. The rules are entirely intellectual and are concerned with such things as the consistency of people's names and subject descriptions. They are not tied absolutely to any standard format, although they are developed in conjunction with MARC records. They (or a close derivative) are in use in libraries around the world. Russian and German libraries developed their own similar rules for the same purpose (GOST and RAK), but AACR2 is by far the most common.

Classification Schemes (Dewey, UDC, BSO, etc.)

These are intellectual schemes for the organization of information and are used for assigning a work to a class along with works of similar content. They are also used as the basis for the organization of physical objects (books, tapes, etc.) on shelves. They could be used for assigning a location to an electronic object, most likely as a way of deriving a unique file name for the object. Dewey and UDC are the most common schemes.

Uniform (or Universal) Resource Locators (URLs)

URLs are used to define the addresses of objects within the Internet. As such, they satisfy the requirement for “Uniform”, but because they are limited to Internet use, and more generally World Wide Web use, they are not “Universal”. They allow the linking (or hyperlinking) between sites or pages on the web, thus providing the navigational functionality of the web. They are not bibliographic in nature, but can be used to provide a non-linear logical structure to documents on the Internet or on Intranets.

Resource Description Framework (RDF)

RDF attempts to define resources, such as databases, search engines, and library catalogs that are available within the Web, in a way that allows applications to identify them and their properties. The actual RDF records about a resource are formatted in XML for wide interoperability.

RDF is a framework, and actual collections of fields within the framework have yet to emerge for most applications (including bibliographic), so it is too early yet to expect to see RDF data available.

www.w3.org/RDF

Record structure

These define the physical and logical structure of the record that holds the data. The very simplest of them hold only a single type of data (such as an image). They are listed later in the section on formats. The records considered here are complex in that they contain multiple fields of variable length that may occur more than once. Except for proprietary structures, there is only one structure used for bibliographic data of any complexity. These formats are for exchange of data between systems and are not intended for human consumption.

ISO 2709/Z39.2

This defines a very flexible structure for individual records as well as whole batches of records (originally for tape storage). The flexible structure is exceptionally well suited to handling the MARC format. While they were developed together, the 2709 can be the structure of almost any type of record. The main strength of 2709 is its ability to easily handle variable length fields, and records where the occurrence of fields is also variable. It is much too complex and time-consuming to use for standard business records, where all data fields have fixed lengths, positions, and occurrences (even if they have no data).

Simple Unstructured Text Representation Scheme (SUTRS)

SUTRS is a format for structuring bibliographic records. In essence, it is a method of displaying MARC (q.v.) records, in an expanded form, with English text tags and no structure other than that of a piece of text. It is human-readable, can be edited with a simple word processor, and is easily parsed by receiving systems to extract the information content. It can be used with other forms of records (such as Bib-1 or Dublin Core), but usually is used for MARC records.

Generalized Record Structure (-1) (GRS-1)

GRS-1 is a very flexible format for representing bibliographic and associated data, such as holdings information, and museum and archive information. It is a fielded structure which is human-readable and easily parsed by receiving systems.

Extensible Markup Language (XML)

XML is a general purpose scheme for defining the content of documents and other record types. It is derived from SGML and is specialized for defining content rather than layout or design (see HTML). Each record structure is defined in a Document Type Definition (DTD) which indicates what fields may be present, and what rules govern their use. The DTD may be contained within the record or it may be externally referenced. XML is the current preference for exchanging information between applications across the Internet. There exist XML versions of MARC and other record descriptions, that Z39.50 servers and clients should be able to deliver and receive.

Hypertext Markup Language (HTML)

HTML is a scheme for describing the layout and presentation of a document. It is a derivative of SGML, specialized for its layout function. It is the format in which web pages are defined and transmitted. With minimal exceptions (<TITLE>, <KEYWORDS> and <DESCRIPTION>) it does not define content, merely layout and decorative aspects of the document.

It should be a complement to XML, but the two are something of rivals, though for most purposes, it is not obvious. Browsers will display XML documents as well as HTML ones and both have the ability to define a document in the others terms. It is possible that XML (the newer format) will replace HTML as the de facto standard for web record formatting as more and more applications exchange data.

Encoding

This section concerns the way individual characters are represented in the files and records. It is concerned with text within records almost exclusively. Although other material objects, such as images or sound, could be encoded within a complex record, where there could be a text field, an image field, and a sound field, it is very rarely done. The more complex combinations are dealt with either in a meta-record, such as the bibliographic record, or within the text record itself. The other records are referenced, as in an HTML page with a reference to an image file. However, not only are text data combined in complex records, they are also represented in different ways. The most obvious example is a record that contains two pieces of text in different languages. Additionally, they could be in different character sets. This is what character encoding is about.

Characters have long been represented by one byte, which is composed of 8 bits capable of representing 256 different values, per character. This is quite sufficient for all Western European (Indic) languages taken one at a time. However, when wishing to encode characters of two or more different character sets there are not enough numbers (called code points) to represent all the characters needed. Thus, for completeness in a multi-lingual, world it is necessary to enlarge the number of available code points.

A number of attempts were made at a national and international level. Various Double Byte Sets (DBS) were developed, particularly in Asia where the problem is acute. Various schemes for adding bytes where needed by shifting from one character set to another were developed (such as ISO-2022). These had the problems that they were local and/or cumbersome to manipulate, and hence slow.

Unicode

This is a universal encoding scheme using 16 bits to represent each character. It has the advantages of being simple, complete, and is being widely adopted. Its disadvantage is that all characters take twice as much space even for single language data. However, disk storage is getting cheaper (text is very small compared to images and video) and there are ways of quickly and easily compressing the data in storage. Unicode is controlled by the Unicode consortium and is the operational equivalent of the ISO-10646 standard. Note that 10646 also defines 32-bit characters, but these are not in any general use.

Although Unicode is a 16-bit encoding, there are a number of variants of this value that are used for compression or, more importantly for Unicode acceptance, for compatibility between existing 8-bit character sets and variable width encoding. UTF-8 in particular is useful because the ASCII characters are encoded in one 8-bit byte, exactly as in the ASCII encoding. Thus software designed to handle UTF-8 encoding can read and write old fashioned ASCII files from legacy systems.

www.unicode.org

ASCII

There are a wide variety of 8-bit character encodings in use around the world, but the most common is that of the American Standard Code for Information Interchange (ASCII). This defines all the characters necessary for English and many special characters. This code has been used as the basis for most other 8-bit codes. The lower 128 are left alone (they contain the Latin alphabet, numbers, control codes and some special characters) and the top 128 characters are used for a second language. Thus there is almost universal compatibility at the “low-128” level and almost none for the rest. IBM / Microsoft produced a number of National variants for the PC DOS operating system and these have a large measure of acceptance through wide distribution. However, they are only a manufacturer's standard.

Communications

There are many layers of communications (seven if you consider the OSI seven layer model), most of which do not concern us here. The one that is important is the level at which the computer systems connect to each other to pass our messages back and forth. There is one protocol for this level that is by far the most common. It is also the protocol of the Internet.

Transmission Control Protocol/Internet Protocol (TCP/IP)

TCP/IP is for controlling the creation of transmission paths between computers on a single network, and between different networks. It is in almost universal use for public networks and many in house local area networks. It is the protocol of choice for all UNIX servers (Sun uses it universally) and most workstations. The only reason not to specify it is if your system will be entirely in-house and the existing network uses something else.

Protocols

These constitute the language of the messages passing between systems connected via a TCP/IP or other protocol. There are a variety of protocols for different purposes, which may be used at different times by the same two systems, or by one system communicating with two others.

Hypertext Transfer Protocol (http)

This is the protocol of the Web. It is used for carrying requests to the web server and returning pages to the user client. It is also used for requests from one server to another. It is limited to a fairly simple request — supply structure, although this has been extended by encoding search and processing data within the request (and sometimes the reply). This protocol is usually not directly supported by ILS or DBMS, and needs a web server connected to the background system to provide an Internet presence for the library.

File Transfer Protocol (ftp)

This protocol is used for exactly what its name suggests. It is a file transfer protocol and is universally used across the Internet for shipping files whether they are large program downloads or small e-mails. Note that your e-mail actually is sent from your client machine to the postmaster using either Post Office Protocol (POP) or Simple Mail Transfer Protocol (SMTP). From there, it may be batched to the destination and sent from post office to post office by ftp.

Z39.50, ISO 23950 (ISO-10162/3)

This is a NISO and ISO standard for searching and retrieving across more than one library system. The protocol is used primarily between library and information retrieval systems. It is not used by the Internet search engines; they use http. It is more complex, more comprehensive, and more powerful than searching through http. This protocol has been extended to allow system feedback and intersystem dialogue. Thus it is being considered for non-search functions such as interlibrary loans.

The current version is the 3rd in this continually evolving standard. However, most ILS vendors support only the second version features or a very patchy sub-set of version 3. As it is a protocol for searching between systems and is not used by humans directly, it is syntactically complex. It also attempts to be wide ranging and, in particular, to support a number of search languages (such as RPN, support for which is mandatory in all Z39.50 search engines) and a number of data formats for the retrieved records (such as BIB-1, SUTRS, GRS-1). Currently, there is debate about how the protocol may be extended to accommodate XML structured records.

http://lcweb.loc.gov/z3950/agency

Z.39.63 (ISO-10160/1)

These are the NISO and ISO interlibrary loans protocols. Unlike the Z39.50 (ISO10162/3) protocols, they are not identical, but merely functionally equivalent. Most ILSs support these functions through a stand-alone module, and some through access to third party services.

http://www.nlc-bnc.ca/iso/ill/

http://www.niso.org

An example of a third party ILL service is: *http://www.cps-us.com*

An EC funded document delivery project with a good bibliography and list is AIDA at *http://liber.cib.unibo.it/aida/AIDA_letter0.html.*

Formats

Unlike those described above, these are not formally ratified standards. They are the forms in which the information of the digital library is held. Many are set by commercial organizations and come into common use through the success of their parent organization in sponsoring them and encouraging their use. They are for low level physical data organization and, as such, deal with only one type of data each.

They are listed by their file name extensions. No attempt has been made to describe them since this is very adequately done in many books. A search on the Web for the three letter groups will bring up many documents describing the formats, their use, and their restrictions. Some of the programs used for manipulating the files contain descriptions and references.

Images

.BMP .TIF .GIF .PNG .WMF .PICT .PCD .EPS .EMF .CGM .TGA .JPG ...

Animation

.ANI .FLI .FLC

Video

.AVI .MOV .MPG .QT

Audio

.WAV .MID .SND .AUD

Web Pages

.HTM .HTML .DHTML .HTMLS .XML

Text

.DOC .TXT .RTF .PDF

Programs

.COM .EXE

Associations

These are groups with various degrees of formality, that are active in the library, computing, digital library, and associated areas. The most visible groups are the American ones. Virtually all nations have a library association and a computing association. Organizations like IFLA contain such directories within their web sites. All these organizations have web sites that are extensive and contain a number of sections that may be of interest.

For more complete and updated information and directories visit the web site for this paper at *http://www.edulib.com/directories/* or link through the sun site at *http://www.sun.com/edu/*.

Library

These are associations that are concerned with libraries and librarians in general.

IFLA	International Federation of Library Associations	*http://www.ifla.org*
ALA	American Library Association	*http://www.ala.org*
SLA	Special Libraries Association	*http://www.sla.org*
LA	Library Association	*http://www.la.org.uk*
RLG	Research Libraries Group	*http://www.rlg.org*
CNI	Confederation for Networked Information	*http://www.cni.org*

Digital Library

These organizations are either associated with the computing and information science aspects of digital libraries or are funding research into this area.

NSF	National Science Foundation	*www.nsf.gov*
DLI	Digital Library Initiative	*www.dli1.nsf.gov*
SIGIR	Special Interest Group - Information Retrieval (ACM, BCS, etc.)q.v	
ASIS	American Society for Information Science	*www.asis.org*
DLF	Digital Library Federation	*www.clir.org/diglib*
UKOLN	UK Office for Libraries and Networks	*www.ukoln.ac.uk/services/elib*

Computing

These are general computing associations.

ACM	Association for Computing Machinery	*http://www.acm.org*
BCS	British Computer Society	*http://bcs.org.uk*
IEEE	Institute of Electrical and Electronic Engineers	*http://ieee.org*

Standards

ISO	International Standards Organization	*http://www.iso.org*
NISO	National Information Standards Organization	*http://www.niso.org*
IETF	Internet Engineering Task Force	*http://www.ietf.org*
W3C	World Wide Web Committee	*http://www.w3.org*

User Groups

These are informal groups of users, researchers, and even vendors who discuss digital library topics. They are ever-changing and can best be reached by contact through a particular vendor's web site, a particular library, or via one of the organizations listed at the start of this section. They can often provide the real world addition to a vendor's subjective view of its products. They are also a source of experience and a forum for raising questions.

Many of these groups have active participation from their respective vendor. Often other vendors will participate (such as a hardware vendor like Sun participating in the user group of one of its partners such as Geac) and many will monitor what is said. This adds benefit to the users in that their suppliers remain aware of their needs and grievances.

Publications

These are publications that have content of interest to digital library projects. There are many more which deal with libraries, information science, digitization, computing, and digital library topics. Note that Highwire Press is included as it is actually a digital publishing house. A search of any library catalogue will reveal many journals that are suitable in whole or in part for information and ideas on digital libraries.

D-Lib	*http://www.dlib.org/dlib*
Highwire Press	*http://highwire.stanford.edu*
Journal of Electronic Publishing	*http://www.press.umich.edu/jep*
Digital Library Newsletter (of IEEE)	*http://cimic.rutgers.edu/~ieeedln/*
Current Cites (Berkeley)	*http://sunsite.berkeley.edu/CurrentCites/*
Marketing Library services	*http://www.infotoday.com/mls/mls.htm*
Journal of Digital Information	*http://jodi.ecs.soton.ac.uk/*
Biblio Tech Review	*http://www.biblio-tech.com/biblio/*
Library Hi Tech	*http://www.mcb.com/*
LJ Digital	*www.ljdigital.com*
Scholarly Electronic Publishing Bibliography	*http://info.lib.uh.edu/sepb/rdiglib.hmt*

Vendors

These are organizations which sell all or part of what is needed for a digital library. With the possible exception of the "ILS" and "Digital Library" sections, there is no attempt to be complete. There are many hundreds of vendors in some sections, which constitute either the dominant ones or a representative selection. There will be local manufacturers in many countries, and many of the companies mentioned will have offices or distributors world-wide.

Hardware

Servers

These are the larger computers needed to hold the database of material, run the searching and processing applications, and handle communications with the users. The users are always considered to be using remote clients, even if they are running on JavaStations in the next room. In computing terms, they are remote and distinct from the servers.

A server needs to be computationally powerful, have adequate main memory (RAM) to handle the expected work load for the given software, have large amounts of secure disk storage for the database(s), and have good communications capability. In the totality of a digital library design, a number of specialized servers are needed. However, for a smaller library, many of these logically distinct servers may be combined into one machine. Thus, the ability to grow and to distribute the processing, storage, and communications load across more than one computer is important. A family of servers, such as Sun's Enterprise server range, is what you should look for to ensure there is sufficient depth to allow for growth without pain.

Sun Microsystems	*Enterprise servers*	*http://www.sun.com*

Desktop Workstations

These are the personal computers used as the clients for the users to work on. They are strong in display and communications, and are relatively powerful computers. They may be regular PCs running a graphical or text interface through special software loaded on each PC, or they maybe network computers (Sun JavaStations or SunRay appliances) which automatically download software from a local server to run as required, or even run it on the server. The requirements for different digital libraries will vary enormously. Some libraries will have no requirement for workstations because they will expect all their users to connect remotely, using their own computer and a standard interface like a web browser.

Capture devices

This is a small selection of suppliers chosen more to show the range of capture devices available than as a complete list.

Umax	*flatbed scanners*
Logitech	*single sheet scanners*
Creative	*video cards , audio cards*
Diamond	*video cards*
Matrox	*video cards*
ATI	*video cards*
Turtle	*audio cards*
Kodak	*digital cameras*
Polaroid	*digital cameras*
Olympus	*digital cameras*
Xerox Imaging Systems	*scanners, cameras*

There are the normal large amounts of peripheral hardware necessary for a digital library as for any other installation.

- LANs
- Routers
- Modem / ISDN / terminators
- RAID arrays
- Tape / disk backups
- Uninterruptable power supplies (UPS)
- Printers
- Consoles and test computers
- Fax machines
- Telephone system

The size and amount of such devices depend on the size of the operation and the types of activities undertaken.

Software

This section only lists some of the available suppliers. Some sections contain essentially all the suppliers, as measured by market share, in the section; others are merely a representative sample. A search of any software catalogue or on the web will yield many more.

Remember that in a number of the categories, there are programs available, either free or as shareware, that equal the capabilities of some of the much more expensive offerings. It is well worth spending some time reading the product descriptions and even trying some of them from the download sites listed. Again, this listing is not complete.

The software is broken down into two groups: that which you will need to digitize your data, and that which you will need to run your Digital Library. The digitization group comes first.

Capture

This software allows you to capture either audio or video from a suitable peripheral device (microphone, tape player, VHS camera, VCR, etc.) and store the result in a computer file. Image capture from documents is usually performed by the software that comes with the scanner used for the purpose. This is produced by the scanner manufacturer and is specific to that piece of equipment. Thus you really don't have much choice. However, for a large scanning job, consider the functionality, ease of use of the scanner capture software, and the optical characteristics of the scanner.

Bear in mind that digital cameras can be used for image capture and single frames can be captured from a played video. Digital cameras almost have sufficient resolution to capture documents to process them to extract the text. If you want pictures of people, places, and actual objects, they will probably be the best solution.

Modern video cards are capable of capturing images and video from an input source. Thus, a special video capture card is not necessary. These cards (see above) come with their own control software just like the scanners. However, the existence of standardized systems interfaces to the cards means that you can consider using a piece of third party software to run the video capture process. All the companies below make video capture and editing software programs.

Creative	Video Blaster	Audio, Video	*http://www.ctlsg.creaf.com/*
Matrox	Rainbow Runner Studio	Audio, Video	*http://www.matrox.com/*
Microsoft	Video for Windows	Audio, Video	*http://microsoft.com*

Manipulation

These are just a few of the programs which will allow you to manipulate your images, sound files, and videos after they have been captured. This manipulation may be as simple as cropping unwanted edges off an image, or producing a thumbnail version. It may be as complicated as editing a number of video and audio elements into a video presentation.

There are many other programs which can perform these functions, and some of the best are shareware. A good place to download and try out software is at *http://www.download.com*. This is the download site of *http://www.cnet.com/*.

The audio studio software is usually bundled with a sound card, that the software controls. The image and video may be bundled with hardware or may be generic.

Adobe (*http://www.adobe.com/*)	Photoshop	Images
	Acrobat	Documents
	Frame Maker	Web sites
JASC, Inc. (*http://www.jasc.com/*)	Paintshop Pro	Images
	Media Center	Media management
Metacreations (*http://www.metacreations.com/*)	Bryce 3D	3D worlds
Creative (*http://www.creative.com/*)	Ensemble--, Wave studio	Audio

Macromedia (*http://www.macromedia.com/*)	Director, Shockwave	Video, Animation
Matrox (*http://www.matrox.com/*)	Rainbow Runner Studio	Video

Integrated Library Systems

The following organizations represent the major suppliers of Integrated Library Systems, but they are not the only suppliers. The majority of smaller, and possibly more innovative, suppliers have not been included in this printed listing.

All of these companies provide systems which will automate all the major functions of a library, whether conventional or digital. Many have special modules for non-book material and even for digital material. Many also have web access facilities to make the catalogue (and sometimes other library services) directly available on the Web.

The systems are all extensively described in their web sites. A more thorough listing, and a detailed comparison of their architecture and more specialized features, can be found on a number of the library journal sites or through the associations.

Ameritech Library Systems	(see epixtech	
Data Research Associates	*Taos*	*http://www.dra.com*
Endeavor Information Systems	Voyager	*http://www.endinfosys.com/*
EOSi	*Q Series, T Series, GLAS*	*http://eosintl.com/*
epixtech (formerly Ameritech Library Systems)	Dynix, Horizon, Sunrise	*http:///www.epixtech.com*
Ex Libris	*Aleph*	*http://www.aleph.co.il*
Geac	*Advance, Plus, Geo-*	*http://www.library.geac.com*
III	*Innopac*	*http://www.iii.com*
Sirsi	*Unicorn*	*http://www.sirsi.com*

The Library Corporation	*Library.Solution, its.MARC*	*http://TLCDelivers.com*
VTLS	*Virtua*	*http://www.vtls.com*

Delivery

This is generally software added to the client (e.g. a browser in the form of a plug-in) to support the playing of the particular data format.

Real Networks	Real Player G6 Real Audio Real Video	(*http://www.real.com*)

Audio, Video delivery and Browser plug-ins

Cartesian Inc.	CPC View, Tools	(*http://www.cartesianinc.com*)

Text compression and delivery server software with delivery to a browser plug-in.

Web Servers

These servers and other programs provide the essential connection between your ILS and the rest of the world on the Web. Until ILSs have built-in http capability you will need a web server. The other programs are examples of utilities that add either to the web site creation process or to running it.

Sun Microsystems, Inc. ((*http://www.sun.com*))	Netra i Server	Web Server Platforms

This is the most widely utilized commercially available Web server product. It has a very comprehensive range of features and is maintained and developed at the forefront of Web standards and functionality by Sun.

Apache Project ((*http://www.apache.org*)	*Apache 1.3 Web Server*	Web Server Software

This is the most popular public domain server. It is supported by a co-operative group of its users.

Web Publishing

There are some hundreds of web page authoring tools available. All of them include some form of publishing capability, possibly just to upload your completed web pages to a server, or they may contain a server in their own right.

Web Access

These pieces of software can prevent browsers from accessing undesired sites, or they can positively direct access to sites to create a resource universe for searching.

URlabs (*www.urlabs.com/public)*	*IGear*	*Access control, filtering*
EduLib (*www.edulib.com)*	*STOPit*	*Access control, filtering*

Information Retrieval

These search engines may be used on their own or may be connected to an Integrated Library System or DBMS to provide a fully searchable collection. All the systems are basically free text search engines in that they index each and every word in a document. The web search engines are so named because they do not allow for segment searching (other than possibly “Title”), and generally do not provide the advanced search facilities of the free text search engines. They are much easier to use and are more familiar to users, but sometimes their retrieval performance is poor.

These systems generally run on UNIX servers. They usually are accessed via another piece of software (such as a web server or a Z39.50 server) that makes their answer lists available to the user, and also handles the user's eventual selection of the material to view. These systems do not store the data themselves; they are only indexing mechanisms.

ILSs often have their indexing built in. If not, then they will probably handle all the necessary interaction with the user for the external search engine(s) they support.

Excalibur (*http://www.excalibur.com*)	Excalibur	free text search engine
Yahoo *(http://www.yahoo.com)*	Personal Yahoo	web search engine
Excite (http://www.excite.com)	Excite	web search engine
DEC (*http://www.altavista.com/*)	Alta Vista	web search engine
Verity (*http://www.verity.com*)	Verity	free text search engine
Fast (*www.fast.no*)	Fast Search & Transfer	web search engine
Open Text (http://opentext.com)	Open Text	free text search engine
Fulcrum*(http://fulcrum.com)*	Fulcrum	free text search engine
CNIDR *(http://vinca.cnidr.org/software /Isite/Isite.html)*	Isite	web search engine

Web indexer and search engine including Z39.50 access to other engines and as a client to itself from other engines.

University of California (*http://sunsite.berkeley.edu/SWISH-E*)	SWISH-E	Web site search engine
Magnifi (*http://magnifi.com*)	Magnifi	image search engine
ISLIP (*http://islip.com*)	Media---	video search engine

A web site containing details of the major web search engines is at *http://www.lib.ua.edu/oinetres.htm*

A new class of search engine, the meta search engine, is becoming more available now. This allows a library to broadcast searches to one or more search engines at the same time. The vast majority are single protocol search engines and are designed to search multiple Web search engines or multiple Z39.50 catalogues. These search engines may have their own indexes or not. They all return results from more than one search engine, but the results may not be combined, and usually are not in a consistent format.

Web meta search engines reside on a server on the Internet and act as a service which can be accessed by any authorized user with a browser. Personal search engines are software loaded onto the user's personal computer and run from there.

The one multi-protocol search engine can search both web search engines (http) and library catalogues (Z39.50) simultaneously. It re-formats and combines the results lists and removes duplicates. It is run as a web service for libraries and other portals to access in order to provide a service for their users.

Meta-crawler (*www.metacrawler.com*)	Metacrawler	*web meta search engine*
Copernic (*www.copernic.com*)	Copernic 2000	*personal meta search engine*
WildWild (*www.wildwild.net*)	*Muse*	*web multi-protocol search engine*

Conversion

These programs are for conversion of scanned text into machine readable encoded text. They are the essential second step before indexing the text with a search engine to make it retrievable.

These programs run either on PCs or on UNIX servers. The PC versions are designed for single tasking operation rather than large batches. Batch operation is undertaken on a central server. General error rates of about 0.5% - 2% mean that anywhere from 10 - 40 characters will be wrong per page (2000 characters). Thus, it is usually necessary to manually edit the results. This is best done immediately after the batch conversion while the original page or image is at hand.

Xerox (*www.scansoft.com*)	Text Bridge	*OCR*

DataBase Management System

These provide the basic storage and retrieval functions for the rest of the system. All library and information retrieval systems have a DBMS underneath them. Sometimes they are standard ones like those listed below, and sometimes they are specialized for the particular function. The Relational DBMSs listed below can all be accessed by using SQL (Standard (or Structured) Query Language) so the data are accessible by programs written by the library's own staff or third parties (such as Decision Support System suppliers).

Oracle (*http://www.oracle.com*)	Oracle 8	
Informix (*http://www.informix.com*)	Informix Universal Server	Multi media object database
Sybase (*http://www.sybase.com*)	Sybase	

Digital Library/Multi-media Modules

These may be stand-alone systems or may be an integrated part of an ILS or DBMS. If they are stand-alone, they may still only operate with the particular vendor's other software.

Support for other vendors’ systems usually comes in the form of a protocol interface, such as Z39.50 or http, or as an Application Programming Interface (API) which means that programs will have to be written to interface the two pieces of software. This is not an absolute prohibition, but time and resources must be allowed for in planning the project, or a third party interface tool must be sought.

Sirsi (*http://www.sirsi.com/Dma/digimedia.html*)	Hyperion DMA	*digital media archive*
Endeavor (*www.endinfosys.com*)	Image server	*digital documents*
	ENCompass	*digital library system*
epixtech (*www.epixtech.com*)	*iLibrary*	*ASP library modules*

Works stand-alone and with other vendors' systems through an external API. This is a multi-media module from an established ILS supplier.

Magnifi (*http://www.magnifi.com*)	Magnifi

A multi-media web search engine

ISLIP (*http://islip.com*)	Digital Video Library

An image searching system (by color and shape, as well as by text description for example) which is based on research from Carnegie Mellon University and its DLI project.

Mediaway (*http://www.mediaway.com*)	MediaAsset 2.0

This system has an asset repository which stores multi-media objects and uses the Verity search engine to allow full text-based access to them. Searching is against notes or memos added to the object and includes topic, date, or location. Data are stored and transmitted in compressed form for speed.

Project Management

These programs allow projects to be defined, a timeline to be created, and then progress to be tracked. They run either on PCs or on servers and most allow more than one user to view the project at any time. They allow the project to be re-scheduled when needed, and can produce time and resource reports.

Computer Associates (*http://www.cai.com/products/bas/spj4.htm*)	Superproject V4.0

Metering

This software measures the traffic on a web site mostly by analyzing the log that all web servers keep of all traffic. Some analyze the traffic in real-time and thus provide current figures. All have a report generator so that many views of the traffic can be generated, and some allow custom reports to be produced. Others connect to browsers for display, or to spreadsheets for further analysis.

Andromedia Inc. (*http://www.andromedia.com*)	Aria

Provides real-time reports.

Marketwave Corp. (*http://marketwave.com*)	HitList Enterprise Live

Works by log analysis of extensive variety of logs. Very versatile reporting.

WindDance Networks Corp. (*http://www.windance.com*)	WebChallenger

Real-time reports using a packet sniffer, with a less extensive range of reports.

Another method of metering usage is to have the traffic recorded at a more logical level, according to the site or pages visited, and to record this as part of an access control and monitoring system. These are usually installed at a gateway, which may be the entrance to the digital library, a service it provides to link users to other library sites, or to content providers for electronic distribution of material. The access control software mentioned above will generally have a metering component, as will some search engines (meta search engines will record by the individual search engines they use, not specific sites).

Rights Management

This software offers ways of controlling access to content and keeping track of who uses it for what. It also provides ways of protecting the content from theft or misuse.

InterTrust, Inc.	*http://intertrust.com*

The InterTrust System Developer's Kit addresses many of these issues and provides the foundation for the creation of practical digital content distribution systems.

DigiMarc	*http://www.digimarc.com*

Provides digital watermarking software for all types of media.

Content Delivery

Electronic delivery of content is becoming more possible and commercially feasible. The technology has become reliable both for delivery and for metering usage for rights management. In addition to traditional publishers who make the full text of their journals available to subscribing libraries or directly to clients, there are special sites which deliver the electronic content of monographs either to computers (usually to be read through a proprietary piece of software), or directly to e-book hardware.

netLibrary (*www.netlibrary.com*)	netLibrary	On-line delivery of books

Help

This section contains references to useful resources which don't fit into any of the other categories. Some are resource lists and others are discussion groups. Some are sites devoted to digital library matters. They will all reward browsing through them with information and ideas.

Remember also that the journals listed in chapter 6 contain many articles that discuss the issues surrounding digital libraries. Many of them are referenced in the resources in this section.

Digital Library Federation

(*www.clir.org/diglib*) Fifteen of the United States' largest research libraries and archives have agreed to co-operate on defining what must be done to bring together, from across the nation and beyond, digitized materials that will be made accessible to students, scholars, and citizens everywhere, and that document the building and dynamics of United States' heritage and culture.

This site, which contains resources, discussion papers, and committee activities, is now an independent web site (formerly hosted by the Library of Congress).

Digital Library Resources and Projects

(*http://lcweb.loc.gov/loc/ndlf/digital.html*) One of the pages of the Digital Library Federation, still available through the Library of Congress web site or the DLF immediately above, links to a large variety of projects and to other resources, including papers and software.

Beyond the Beginning: The Global Digital Library

(*http://www.cni.org/regconfs/1997/ukoln-content/repor~t5.html*) This is a report of a very prestigious and useful international conference held in 1997 in London. It contains papers which address many of the issues of digital libraries, as well as discussions of experience.

This HTML version is hosted by the site of the Confederation for Networked Information, a very useful organization whose aim is to make the interconnection of information systems more feasible.

Berkeley Digital Library SunSITE

(*sunsite.berkeley.edu*)

This is a site sponsored by Sun Microsystems, and hosted and maintained by the University of California at Berkeley Library. It was created as part of their Digital Library project and contains a large number of collections, special library projects, and information for digital library developers. It is a full digital library and has a number of components, a few of which are highlighted below.

The site is a gateway to the digital collections of UC Berkeley maintained by departments or the library for special collections. It shows the potential for single access and collaborative organization. The collections are not unified in any way, but are available through a common access point.

Librarians Index to the Internet

(*http://sunsite.berkeley.edu/InternetIndex*) This is an index to items on the Internet of interest to librarians. It is not limited to technology or digital libraries. This is, in fact, a web catalogue of material collected from the Internet.

Current Cites

(*http://sunsite.berkeley.edu/CurrentCites*) This is a monthly bibliography of articles, books, and electronic documents on information technology. The material is selected and reviewed. Specific virtual bibliographies can be created from the site for given subjects.

Index Morganagus

(*http://sunsite.berkeley.edu/~emorgan/morganagus*) This is a full text index to about 70 library-related electronic journals.

Image Database Information

(*http://sunsite.berkeley.edu/Imaging/Databases*) This site contains a large amount of useful image information and links to a large number of other image sites. These may contain articles or actual collections of images.

The Clearinghouse of Image Databases and IMAGELIB Listserv Archives

(*http://dizzy.library.arizona.edu:/images/image_projects.html*) The clearinghouse and list serve are hosted by the University of Arizona Library. This is a directory of image collection sites, including films and video. The collections are described in technical detail (scanning methodology, server computer, etc.) as well as their content.

The IMAGELIB is a list serve for all aspects of imaging from the technical to the legal.

Geographical Information Center (GIC)

(*http://www.lib.virginia.edu/gic*) Run as part of the University of Virginia Library, the GIC gives a view of some of the future directions of a digital library. In addition to a catalogue of its maps and spatial data, the GIC provides an interactive mapper and a references desk on-line.

The interactive mapper allows users to specify a county map and the features they wish to see on it. The map is then customized for them. The Reference Desk builds lists of links to articles, web sites, and databases that answer (or at least refer to) the user's query.

Both of these are specialist facilities that the library can offer because it is digital. They are indicators of the future of library services in the post-processing of information for the user in an automated environment.

Sun style guide

(*http://www.sun.com/styleguide/*) This is a document detailing a number of very good rules and pointers to follow for the creation of an effective user-friendly web site. It is the result of a large amount of experience and is a very good place from which to learn.

On-line catalogs with 'webbed' interfaces

(*http://www.lib.ncsu.edu/staff/morgan/alcuin/wwwed-catalogs.html*) This is a site listing catalogues with world wide web interfaces and contains links to other useful sites.

Scholarly Electronic Publishing Bibliography

(*http://www.info.lib.uh.edu/sepb/*) This selective bibliography has over 1000 articles, books, and electronic documents about publishing on the Internet and in other electronic media. It is itself an interactive electronic document. It is updated regularly.

Future Trends and Research 7

This is a rapidly moving field where today's developments are obsolete tomorrow. However, it is worth looking at what is being done by researchers at the moment, as they will be pointers to the resources and requirements of tomorrow.

There are a number of places where appropriate research, development, and forward thinking, are being done. Universities are an obvious choice. However, even they have to pay for what they do, and thus, many are part of research initiatives or projects funded by government agencies. The Library and Information Science Department, the Computer Department, and the Communication Department are all candidates for suitable research. Also, look at the individual departments as hosts for the development rather than the perpetrators of it. An Art History or Music Department may have a digital library since they have the material, but the Library Science and Computing Departments are the ones developing the tools and techniques.

Do not ignore the commercial sector. Many of the innovations that you will be able to use come from that sector. Some are originated there through their own research. Others are developed by businesses into viable product offerings from university research. It is likely that most of the software you use for your digital library project will come from commercial suppliers. The alternative is to take a research idea and develop it yourself. This is a long and dangerous route (setbacks, money, false starts, money, delays, money), which is only very infrequently crowned with success.

As far as major systems thinking and software are concerned, the above are the most likely places for the future to emerge. However, in the area of organization, workflow, marketing, administration, and management, the place to look is at those who are practicing. These are areas where incremental good ideas and best practices, rather than developmental breakthroughs, are the way to the future. Here you can mix and match what you see from those who are doing. Of course, it will be much better if you combine ideas with a unique twist of your own and can start someone else off on the next circuit of the spiral. Listed in these sections are some of the major research efforts and some of the more interesting library systems.

Digital Libraries Initiative

The Digital Libraries Initiative is a funding exercise of various agencies of the U.S. government to promote research into the technologies and implementation strategies underlying future digital libraries. Phase I was funded by the National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), and the National Aeronautical and Space Administration. (NASA). Phase II is funded by the National Science Foundation (NSF), the Library of Congress (LoC), the Defense Advanced Research Projects Agency (DARPA), the National Library of Medicine (NLM), The National Aeronautics and Space Administration (NASA), and the National Endowment for the Humanities.

The Initiative has completed its first phase and is starting the second. Six university led consortia were funded in 1994 for four-year research projects for the first phase. The second phase has called for proposals and the first projects have been funded.

This Initiative arguably constitutes the largest amount of research funding for digital library research in the world. As such it bears some investigation. The remainder of this section gives a brief description of each of the first six projects. The descriptions are all taken from the individual project sites. The description of the aim of Phase II comes from the Library of Congress site and gives some context to both phases as well as the intent of the second phase.

From these descriptions it is clear that the intent is for the first phase to concentrate on the investigation and development of underlying technologies. The second phase is intended to look more at applying those technologies and others in real life library situations.

Phase I

Six projects were funded and were led by major universities. This section lists the research direction of those projects with descriptions from the individual project Web sites. For more details on each project, visit the appropriate Web site.

The following description of the first phase goals is from the NSF web site.

> Six research projects developing new technologies for digital libraries — storehouses of information available through the Internet — have been funded through a joint initiative of the National Science Foundation (NSF), the Department of Defense Advanced Research Projects Agency (DARPA), and the National Aeronautics and Space Administration (NASA).
>
> The projects' focus is to dramatically advance the means to collect, store, and organize information in digital forms, and make it available for searching, retrieval, and processing via communication networks — all in user-friendly ways.
>
> A common strategy in all of these projects is to emphasize research partnerships. We view building partnerships between researchers, applications developers and users as essential to achieving success in generating new knowledge, promoting innovative thinking, and accelerating the technology transfer process.
>
> The initiative will both capitalize on advancements made to date as well as promote research to further develop the tools and technologies needed to make vast amounts of useful information available to large numbers of people with diverse information needs.

Further information can be found at the following web sites:

NSF Digital Libraries home page (*www.dli1.nsf.gov/* or *www.dli2.nsf.gov*)

National DLI synchronization page (*http://dli.grainger.uiuc.edu/national.htm*)

Many of these projects utilize Sun hardware in a wide variety of configurations. Most of them have undertaken application development utilizing the architectural and programming advantages of Java as their language of choice.

In each of the following, the original project description, as it appears on the NSF Web page (above), and the current contents of the project web site, are given so that the changes (if any) can be seen.

Since these projects are now completed, many of the web sites will be moving or will disappear as the project information becomes obsolete or other work is started. Not only is this true for the sites, it is also true for the contact personnel. Probably half of the people mentioned in the following section will no longer be there. However, the authors of reports and papers still provide a valuable access point to the literature generated by the projects.

University of California, Berkeley

The Environmental Electronic Library

Principal Investigator: Robert Wilensky (*wilensky@cs.berkeley.edu*)

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http://elib.cs.berkeley.edu/

NSF page

> This project will produce a prototype digital library with a focus on environmental information. The library will collect diverse information about the environment to be used for the preparation and evaluation of environmental data, impact reports and related materials. The research prototype is intended for eventual full-scale deployment in the State of California's CERES production systems. To create the prototype, researchers will need to produce technologies which allow untrained users to contribute to and find relevant information in other world-wide digital library systems. Research areas include automated indexing, intelligent retrieval and search processes; data base technology to support digital library applications; new approaches to document analysis; and, data compression and communication tools for remote browsing.

Web site

The UC Berkeley Digital Library project is part of the NSF/ARPA/NASA Digital Library Initiative and part of the California Environmental Resource Evaluation System. Research at Berkeley includes faculty, staff, and students in the Computer Science Division, the School of Information Management &

Systems, and the Research Program in Environmental Planning & Geographic Information Systems, as well as participation from government agencies and industrial partners. The project's goal is to develop the technologies for intelligent access to massive, distributed collections of photographs, satellite images, maps, full text documents, and “multivalent” documents.

University of California, Santa Barbara

The Alexandria Project

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http://alexandria.sdc.ucsb.edu/index.html

NSF page

> Project Alexandria will develop a digital library providing easy access to large and diverse collections of maps, images and pictorial materials as well as a full range of new electronic library services. The project is centered at the University of California, Santa Barbara, with its major collections of maps and images and its strong research focus in the area of spatially-indexed information. It also involves the State University of New York at Buffalo (SUNY-Buffalo), the University of Maine and several industrial partners. The project will begin with collections of digitized maps, images and airphotos relating to Santa Barbara, Ventura and Los Angeles counties using software developed for geographical information systems. Over four years, the project will grow to include other components at UCSB, SUNY-Buffalo, Library of Congress, the United States Geological Survey and the St. Louis Public Library, as well as other interested libraries. Each site will include, as necessary, facilities for geographical information interfaces, electronic catalogues, and information storage and acquisition.

Web site

Welcome to the home page of the Alexandria Project. We are a consortium of researchers, developers, and educators, spanning the academic, public, and private sectors, exploring a variety of problems related to a distributed digital library for geographically-referenced information.

Distributed means the library's components may be spread across the Internet, as well as coexisting on a single desktop. Geographically-referenced means that all the objects in the library will be associated with one or more regions ("footprints") on the surface of the Earth.

The centerpiece of the Alexandria Project is the Alexandria Digital Library (ADL), an on-line information system inspired by the Map and Imagery Laboratory (MIL) in the Davidson Library at the University of California, Santa Barbara. The ADL currently provides access over the World Wide Web to a subset of the MIL's holdings, as well as other geographic datasets

Carnegie Mellon University

Informedia

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http://www.informedia.cs.cmu.edu

NSF page

> The Informedia interactive on-line digital video library system to be created by Carnegie Mellon University and WQED / Pittsburgh will enable users to access, explore and retrieve science and mathematics materials from video archives. The Informedia system works by integrating speech, image and natural language understanding technologies. The library will initially contain 1,000 hours of video from the archives of public television station WQED / Pittsburgh, Electronic Field Trips on video from the Fairfax Co., Va., public school system and video course material produced by the BBC for the Open University, a British college without walls, with an enrollment of more than 200,000. Issues involving human-computer interaction, pricing and charging for digital video use, and privacy and security will be addressed as part of the research program.

Web site

The Informedia Digital Video Library is a research initiative at Carnegie Mellon University funded by the NSF, DARPA, NASA and others that studies how multimedia digital libraries can be established and used. Informedia is building a multimedia library that will consist of over one thousand hours of digital video, audio, images, text and other related materials.

Informedia's digital video library is populated by automatically encoding, segmenting and indexing data. Research in the areas of speech recognition, image understanding and natural language processing supports the automatic preparation of diverse media for full-content and knowledge-based search and retrieval. Informedia is one of six Digital Libraries Initiative projects.

University of Illinois, Urbana Champaign

Federated Repositories of Scientific Literature

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Contact: Susan Harum *(dli@uiuc.edu)*, (217) 244-8984

http://dli.grainger.uiuc.edu

NSF page

> This project is based on the new Grainger Engineering Library Information Center at the University of Illinois in Urbana-Champaign and will be centered around journals and magazines in the engineering and science literature. The testbed will include a customized version of NCSA Mosaic (TM), software developed at the National Center for Supercomputing Applications under NSF and DARPA sponsorship to help users navigate the World Wide Web. This testbed will become a production facility of the University Library with thousands of documents and tens of thousands of users across the University of Illinois and other Big Ten universities. Research, based in the Graduate School of Library and Information Science, will encompass sociological evaluation of the testbed, technological development of semantic retrieval, and prototype design of future scalable information systems (the Interspace).

Web site

The Digital Libraries Initiative (DLI) project at the University of Illinois at Urbana-Champaign is developing the information infrastructure to effectively search technical documents on the Internet. We are constructing a large testbed of scientific literature, evaluating its effectiveness under significant use, and researching enhanced search technology. We are building repositories (organized collections) of indexed multiple-source collections and federating (merging and mapping) them by searching the material via multiple views of a single virtual collection.

Our testbed of Engineering and Physics journals is based in the Grainger Engineering Library. We are placing article files into the digital library on a production basis in Standard Generalized Markup Language (SGML) from engineering and science publishers. The National Center for Supercomputing Applications (NCSA) is developing software for the Internet version in an attempt to make server-side repository search widely available. The Research section of the project is using NCSA supercomputers to compute indexes for new search techniques on large collections, to simulate the future world, and to provide new technology for the Testbed section.

The UIUC DLI is a recipient of a grant in the NSF/DARPA/NASA Digital Libraries Initiative.

University of Michigan

Intelligent Agents for Information Location

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http://www.si.umich.edu/UMDL

NSF page

> This project will conduct coordinated research and development to create, operate, use and evaluate a testbed of a large-scale, continually evolving multimedia digital library. The content focus of the library will be earth and space sciences. Potentially connecting thousands of users and information repositories, the library system will be designed to meet the need for systemizing the vast amount of information on an array of topics available

on the Internet. A critical component of the project is the testing and evaluation of the prototype system by a wide variety of users, including those from on-campus, local high schools and public libraries.

Web site

Much digital library work has begun from the centralized, structured view of a library and sought to provide access to the library through digital means. In the University of Michigan Digital Library Project (UMDL) we believe that this approach loses the advantages of decentralization (geographic, administrative), rapid evolution, and flexibility that are hallmarks of the web. In UMDL, we are instead embracing the open, evolving, decentralized advantages of the web and introducing computational mechanisms to temper its inherent chaos. However, we are also embracing the traditional values of service, organization, and access that have made libraries powerful intellectual institutions.

The challenges we face are providing an infrastructure that lets patrons (and publishers) feel like they are working within a library, with the traditional emphasis on providing service and organized content, when in fact the underlying space of goods and services is volatile, administratively decentralized, and constantly evolving. Moreover, the decentralized and flexible infrastructure can be exploited to allow information goods and services to evolve in a much more rapid, diverse, and opportunistic way than was ever possible in traditional libraries, for the good of consumers and providers.

In the UMDL we are meeting these challenges by defining and incrementally developing interfaces and infrastructures for users and providers such that intellectual work (finding, creating, and disseminating knowledge) is embedded in a persistent, structured context even though the underlying networked system is evolving. The infrastructure supports extensible ontologies (meta descriptions of collections and services) for allowing components in the digital library to self-organize, dynamically teaming to form structures and services that users need. Principles from economics are also being used to efficiently allocate resources and provide incentives for continual improvement to networked goods and services. This approach enables third parties to join or use UMDL technologies to define and manipulate agents, facilities, and ontologies so that the web of resources grows in an orderly but decentralized way.

The core of the UMDL has been the agent architecture that supports the teaming of agents to provide complex services by combining limited individual capabilities. In the early stages of the project, the architecture was defined, and has been in use for some time now. Our ongoing efforts have been to deploy the UMDL in real-world settings, which has stressed the need for advanced user interfaces, and on deliberately populating the agent architecture with a diverse set of services. Despite its open nature, the UMDL can already support inquiry by user communities (high school classes) that are very reliant on service and structure. The UMDL test bed is being used to support authentic "inquiry-based" approaches to science education in middle and high schools.

Stanford University

Infobus

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http://www-diglib.stanford.edu

NSF page

> The Stanford Integrated Digital Library Project will develop the enabling technologies for a single, integrated "virtual" library that will provide uniform access to the large number of emerging networked information sources and collections — both on-line versions of pre-existing works and new works that will become available in the future. The Integrated Digital Library will create a shared environment that links everything from personal information collections, to collections found today in conventional libraries, to large data collections shared by scientists. The research thrusts of the project include: information sharing and communication models; client information interfaces; and information finding services.

Web site

The Stanford Digital Libraries project is one participant in the 4-year, $24 million Digital Library Initiative, started in 1994 and supported by the NSF, DARPA, and NASA. In addition to the ties with the five other universities that are part of the project, Stanford also has a large number of partners. Each university project has a different angle of the total project, with Stanford focusing on interoperability.

Our collection is primarily computing literature. However, we also have a strong focus on networked information sources, meaning that the vast array of topics found on the World Wide Web are accessible through our project as well. At the heart of the project is the testbed running the “InfoBus” protocol, which provides a uniform way to access a variety of services and information sources through “proxies” acting as interpreters between the InfoBus protocol and the native protocol.

With the InfoBus protocol running under the hood, a variety of user level applications provide powerful ways to find information, using cutting-edge user interfaces for direct manipulation or through Agent technology. A second area of focus for the Stanford Digital Library Project is the legal and economic issues of a networked environment.

Phase II

The following description of Phase II is taken directly from the Digital Library Initiative Phase 2 web site at *www.dli2.nsf.gov.*

Note that it supplies context for Phase I as well and also contains (in the original) a number of links.

> Digital Libraries Initiative Phase Two is a multiagency initiative which seeks to provide leadership in research fundamental to the development of the next generation of digital libraries, to advance the use and usability of globally distributed, networked information resources, and to encourage existing and new communities to focus on innovative applications areas.
>
> Since digital libraries can serve as intellectual infrastructure, this Initiative looks to stimulate partnering arrangements necessary to create next-generation operational systems in such areas as education, engineering and design, earth and space sciences, biosciences, geography, economics, and the arts and humanities. It will address the digital libraries life cycle from information creation, access and use, to archiving and preservation.
>
> Research to gain a better understanding of the long term social, behavioral and economic implications of and effects of new digital libraries capabilities in such areas of human activity as research, education, commerce, defense, health services and recreation is an important part of this initiative.

Projects within phase 2 have been going for less than a year there may not be much information from them yet. The initially funded projects are listed below with the project web site link for further information (or look at the DLI2 page referenced above).

Funded Projects

Projects are ordered alphabetically by institution

University of Arizona

High-Performance Digital Library Classification Systems: From Information Retrieval to Knowledge Management

ai.bpa.Arizona.edu/go/dl

University of California Berkeley

Re-inventing Scholarly Information Dissemination and Use

elib.cs.Berkeley.edu

University of California Davis

A Multimedia Digital Library of Folk Literature

http://philo.ucdavis.edu/SEFARAD

University of California Santa Barbara

Alexandria Digital Earth Prototype

http://www.alexandria.ucsb.edu/adept

Carnegie Mellon University

Informedia-II: Auto-Summarization and Visualization Over Multiple Video Documents and Libraries

www.informedia.cs.cmu.edu

Carnegie Mellon University

Simplifying Interactive Layout and Video Editing and Reuse

http://www.cs.cmu.edu/%7Esilver/About%20SILVER

Columbia University

A Patient Care Digital Library: Personalized Search and Summarization over Multimedia Information

www.columbia.edu

Cornell University

Project Prism at Cornell University: Information Integrity in Digital Libraries

www.prism.cornell.edu

Harvard University

An Operational Social Science Digital Data Library

www.thedata.org

Indiana University Indianapolis/Bloomington

A Distributed Information Filtering System for Digital Libraries

http://sifter.Indiana.edu

Johns Hopkins University

Digital Workflow Management: The Lester S. Levy Digitized Collection of Sheet Music, Phase Two

http://levysheetmusic.mse.jhu.edu

University of Kentucky

The Digital Atheneum: New Techniques for Restoring, Searching, and Editing Humanities Collections

www.digitalatheneum.org

Michigan State University

Founding a National Gallery of the Spoken Word

www.ngsw.org

Oregon Health Sciences University

Oregon Graduate Institute of Science and Technology

Tracking Footprints through an Information Space: Leveraging the Document Selections of Expert Problem Solvers

www.cse.ogi.edu/dot/research/footprints

University of Pennsylvania

Data Provenance

http://db.cis.upenn.edu/research/provenance.htm

University of South Carolina

A Software and Data Library for Experiments, Simulations, and Archiving

http://econ.badm.sc.edu/beam

Stanford University

Stanford Interlib Technologies

http://www-diglib.Stanford.edu

Stanford University

Image Filtering for Secure Distribution of Medical Information

http://www-db.stanford.edu/pub/gio/TIHI/TID.htm

University of Texas at Austin

A Digital Library of Vertebrate Morphology, Using High-Resolution X-ray CT

http://www-ctlab.geo.utexas.edu/dmg

Tufts University

A Digital Library for the Humanities

www.perseus.tufts.edu

University of Washington

Automatic Reference Librarians for the World Wide Web

www.cs.washington.edu/research/diglib

Undergraduate Emphasis

University of California Berkeley

Using the National Engineering Education Delivery System as the Foundation for Building a Test-Bed Digital Library for Science, Mathematics, Engineering and Technology Education

www.needs.org

Georgia State University

Research on a Digital Library for Graphics and Visualization Education

http://canute.cs.gsu.edu/secdl

University of Maryland

Digital Libraries for Children: Computational Tools that Support Children as Researchers

www.cs.umd.edu/hcil/kiddiglib

Old Dominion University

Planning Grant for the Use of Digital Libraries in Undergraduate Learning in Science

http://dlib.cs.odu.edu

University of Texas at Austin

Virtual Skeletons in Three Dimensions: The Digital Library as a Platform for Studying Anatomical Form and Function

http://uts.cc.utexas.edu/%7Evskel

International collaborative projects

In addition to the domestic DLI2 projects there is an international co-operative series of projects:

INTERNATIONAL DIGITAL LIBRARIES COLLABORATIVE RESEARCH, (NSF 99-6)

Proposal Target Dates:

January 15, 1999 (first year competition)

January 15 (following years' competition)

NSF-JISC (US-UK) International Digital Libraries Projects

www.dli2.nsf.gov/internationalprojects/nsfjisc.htm

NSF-DFG (US-Germany) International Digital Libraries Projects

www.dli2.nsf.gov/internationalprojects/nsfdfg.htm

European Projects

The European Union has funded a number of research and proof-of-concept projects through its various Telematics projects. Its funding has tended to be more widely spread both in time and in the number of projects supported, than the US DLI. Projects such as ONE to provide a single European wide virtual union catalogue, and MALVINE, to provide a similar facility for libraries and archives, are multi-organization collaborations by their nature. EU funding also requires a multi-national make-up for its projects, which have ranged from infrastructure to user studies and collaborative delivery, as in the two mentioned above.

"Working" Library systems

This section lists a selection of library sites and projects. It is not comprehensive and will be continually out of date. Use the sites in chapter 6-help to view lists of libraries on the web and browse them, or look at *www.edulib.com* for the on-line version of this document where a more complete and up-to-date list is kept.

Remember that many general web sites will show innovative interface and presentation features. A number of the news services (BBC, CNN, ABC, DW, etc.) and the newspapers (Times, NYTimes, Tribune, ft, etc.) offer extensive searching of their back issues and archives. Most of them offer images and video, particularly the TV services, for display. Even the web search engines offer a view of the current state of the art for general web searching. These are the systems most users are familiar with, and anything which differs radically may meet with resistance in a mass market.

The descriptions of the projects or library sites primarily come from the sites themselves. Many of the sites contain references to other sites and thus the circle may be completed. The section on resources — help (chapter 6) contains URLs for some sites which themselves contain lists of digital libraries among other useful places to visit.

American Memory

(*http://lcweb2.loc.gov/ammem*) This is a Library of Congress project storing digital versions of documents, photographs, movies, and sound recordings that tell America's story. This site has audio and video digital recordings that can be downloaded and played. Some of the audio can be streamed (played across the Internet).

Making of America

(*http://cdl.cornell.edu/moa*) Materials accessible here are Cornell University's contributions to Making of America (MOA), a digital library of primary sources in American social history from the antebellum period through reconstruction. The collection is particularly strong in the subject areas of education, psychology, American history, sociology, religion, and science and technology. This site provides access to 267 monographs and over 100,000 journal articles with 19th century imprints. The project represents a major collaborative endeavor in preservation and electronic access to historical texts.

The Making of America collection is comprised of the digitized pages of books and journals. This system allows you to view scanned images of the actual pages of the 19th century texts. Optical Character Recognition (OCR) has been performed on the images to enhance searching and accessing the texts.

The Making of America is made possible by a grant from The Andrew W. Mellon Foundation.

Current on-line holdings: Pages: 907,750; Monographs: 267; Serial Volumes: 955

Cline Library

(*http://dizzy.library.arizona.edu*) This library is a Web-accessible image database, set up as a number of exhibits which link images into documentary text. This collection is hosted by Northern Arizona University.

Corbis Image Catalog

(*http://www.corbis.com*) The Catalog is a commercial site offering many of the most famous images in the world. The broad subject or thematic categories lead to pages containing multiple thumbnails, which in turn lead to the full size image. There are no descriptions beyond title and attribution.

Since this is a commercial site and the images are for sale, it is interesting to compare the terms and conditions for these images with those for the university and national library sites.

UC Berkeley Earth Sciences Library Digital Map Collection

(*http://www.lib.berkeley.edu/EART/digital/tour.html*) This provides a tour through the collections of this map library. It contains maps and map fragments of various kinds, including general, topographic, thematic, facsimile, and nautical charts. The tour is an interesting introduction to the topic for casual users, and leads to many resources.

National Library of Australia Images Collection

(*http://enzo.nla.gov.au/products/images1*) This collection contains historical images. The bibliographic record contains a thumbnail image which links to the full size (medium resolution) image. It is searchable in a variety of ways.

Tokyo University Digital Museum

(*http://www.um.u-tokyo.ac.jp*) The museum contains descriptive records with thumbnails and full size images. This site is in Japanese and loses something if your browser does not support Japanese characters (ISO-2022-jp is used). However, some of the images are worth clicking at random to find and view.

Chapman University InfoMagic Project

(*http://www.chapman.edu/library/services/ingomag.html*) Chapman University Library has a perfectly standard web-based catalogue (Innopac), but this is not the interesting item here. Explore the multi-media tutorial with students to teach them how to use the library. Follow the link to “Web Explorer” and experiment from there. It needs some powerful computing and a fast connection so it is not really practical over a telephone and Internet connection, but indicates what can be done. This project is a grantee of Sun Microsystems.

National Center for Science Information Systems

(*http://www.nacsis.ac.jp/nacsis.f-index.html*) This is a straightforward web-enabled catalogue of textual material, using a different piece of library system software.

Some sites in pictures

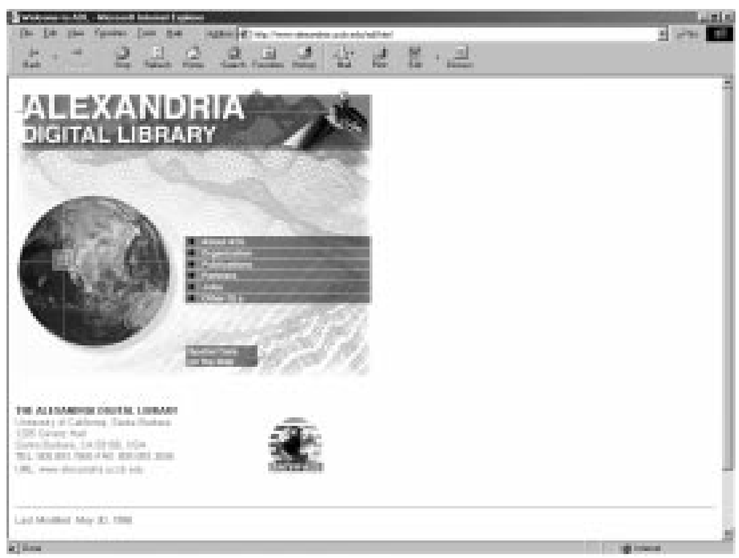
Images of the slides of some of the above sites and some others captured for a presentation of this work at the VALA 2000 (*www.vala.org.au*) conference in Melbourne, Australia, are presented on the next pages. The originals can be obtained from the author (e-mail: *peter.noerr@edilub.com*) or from the VALA site above.

http://www.acm.org/dl/

ACM's digital library is a typical text and digitized pages library. It is 'closed' (fee paying), and a small 'corporate' collection

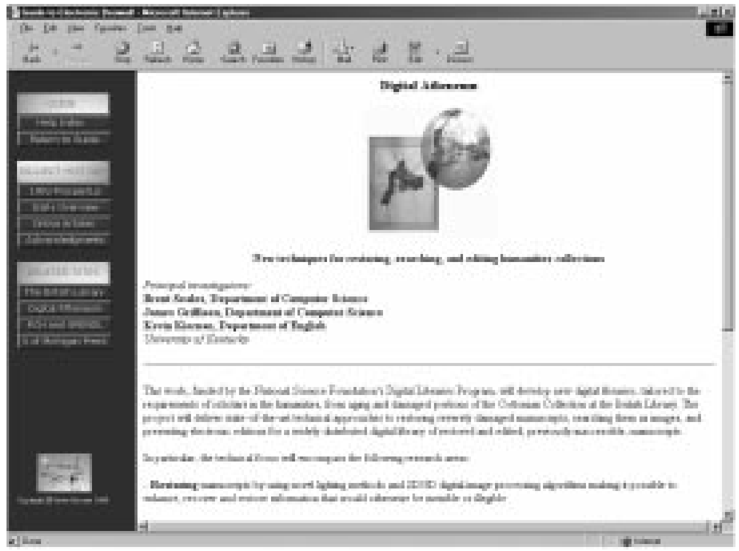
http://www.alexandria.ucsb.edu/adl.html

A project from DLI-1 with geo-spatial data and a useful 'workspace' and specialized searching



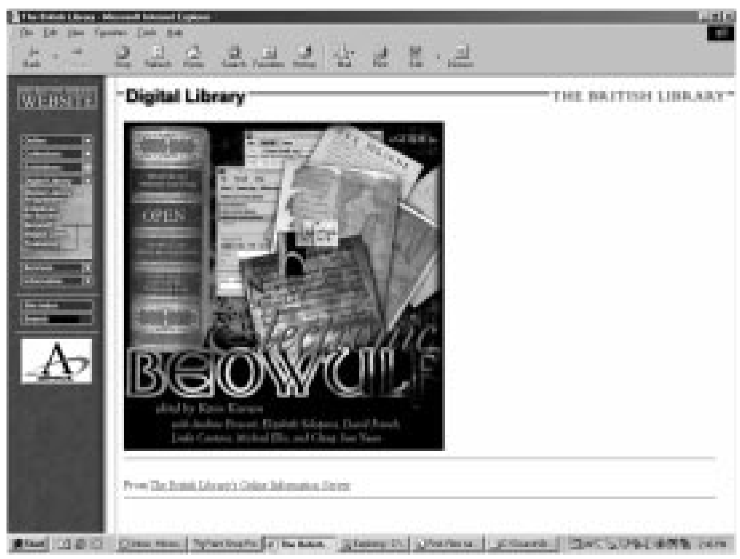
http://www.digitalatheneum.org/

A project digital library concerned with the preservation of the original material. Thus it is likely to concentrate on physical description (missing pieces, etc.) more than most and have a wealth of unusual images – not just the digitized ‘pages’.



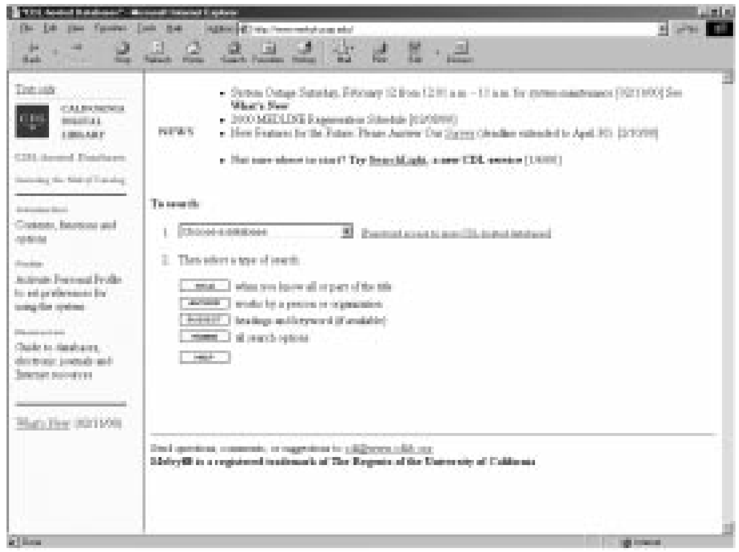
http://www.bl.uk/

A long term site which is actually not a digital library at all – it is additional information and help for the single document that is Beowulf – the CD-ROM.



http://www.melvyl.ucop.edu

A very typical digital library where that is defined as “a web accessible library”. It is the web OPAC to the University’s traditional catalog.



http://www.clir.org/diglib/dlfhomepage.htm

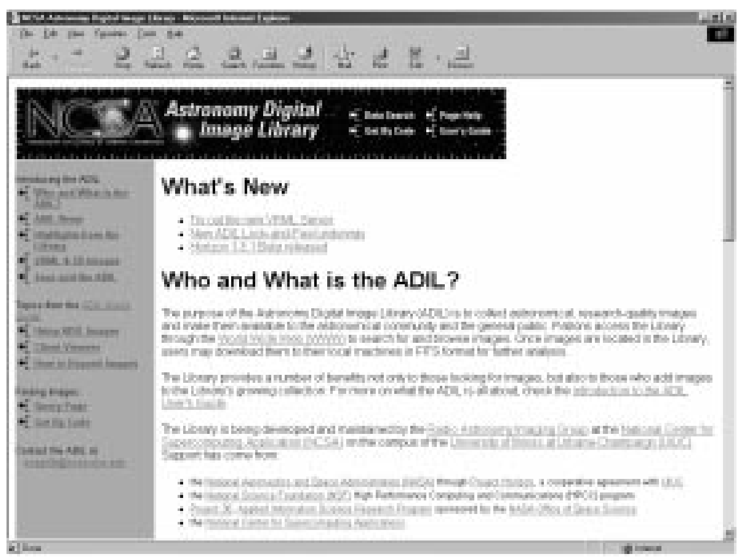
Not really digital library examples at all, but a few useful resources to use for information of a general nature about the advancement of digital libraries and research.

http://mhtml.ulis.ac.jp

A really unique digital library of multi-lingual renditions of Japanese folk tales. It is slowly growing and they are asking for volunteers to help translate.

http://imagelib.ncsa.uiuc.edu/imagelib.html

No digital library collection would be complete without pictures from NASA. This has them but, if you are prepared to wait you can also download 3-D simulations and VR walk-throughs of galaxies.



http://www.nla.gov.au/images1

A long lasting digital library. It is well organized by collection, even if some of the ‘collections’ are quite small. The bird paintings are beautiful.

http://www.digital.nypl.org/

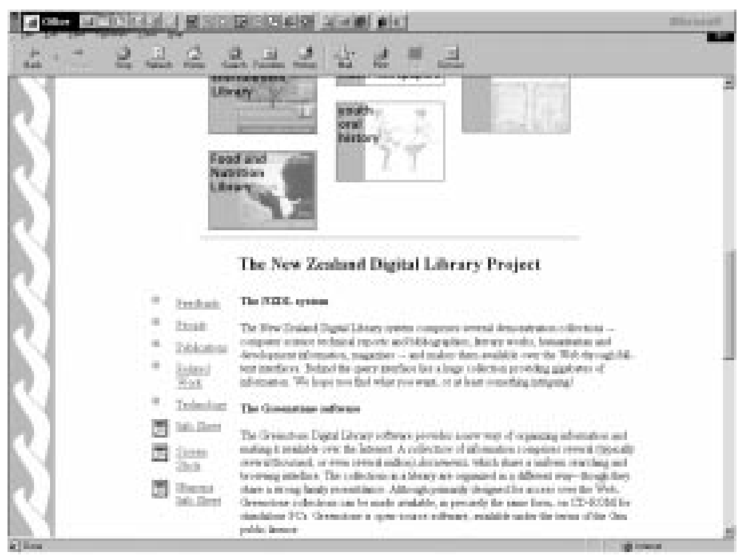
New York Public has a quite extensive set of images in its collection. They are also collection oriented and searching is through this route, more browsing than searching.

http://timeframes1.natlib.govt.nz/

Two from New Zealand. Timeframes showing historical documents in a variety of collection contexts.

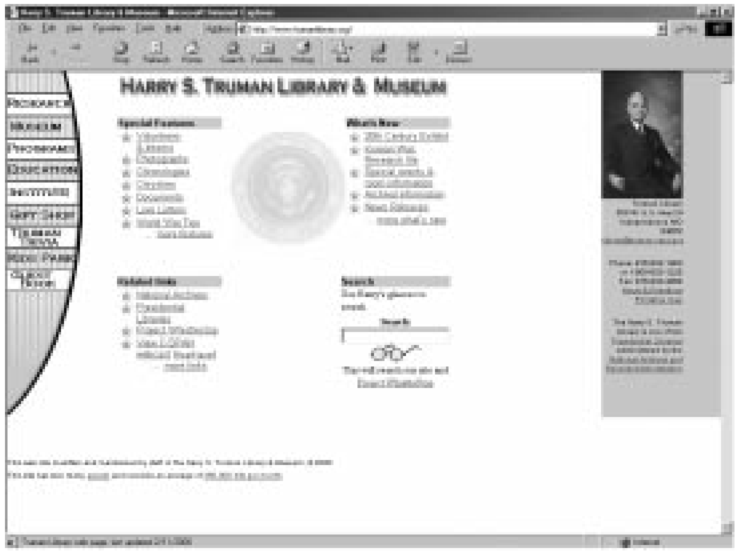
http://www.nzdl.org/fast-cgi-bin/library

The NZ digital library project is one of the most eclectic around and its collections are thematic and cover a range of topics and sources. It includes news service offerings as well as static material collections. It delivers full text documents.



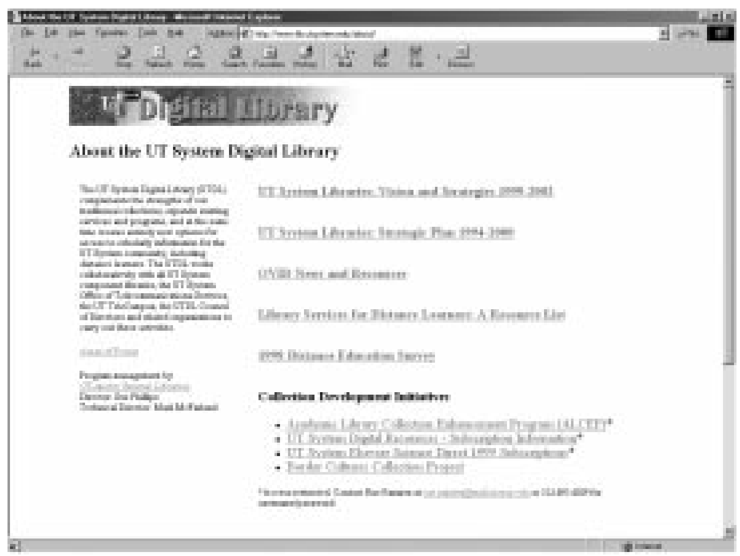
http://www.trumanlibrary.org/

A thematic digital library (within a thematic library) with material of diverse types. It includes audio and some video as well as text and image.



http://www.lib.utsystem.edu/about/

A very standard digital library (read 'web accessible library') with a dedicated audience in mind. It is designed for the university and is primarily an effective delivery mechanism for them.



http://scholar.lib.vt.edu/

Virginia Tech gets two examples as they have a good electronic publishing digital library which provides full documents directly oriented to student use.

http://scholar.lib.vt.edu/imagebase/

Virginia Tech also has a very nice clean image library with simple and advanced keyword searching (as are all image libraries) and very thorough descriptions of the images as objects in their own right.

Muse is not a digital library, but it is the sort of tool which may become very important for their exploitation. It is a multi-protocol meta-search engine which allows searching through web search engines and the library's main catalogue (Z39.50) engine simultaneously. It provides a method of dynamically combining digital libraries for user searching.

It was used to collect the examples used here.

Nice things just around the corner

These are topics that will become important for conventional and digital libraries in the future. Some will arrive very soon, some are longer term, and some are just things that are important and should be addressed.

Document management systems

The worlds of document description (libraries) and document management (filing systems, version control, routing and recording, warehousing and review) are slowly drawing closer. The digital library is very close to a document management system. The near future will see these systems draw even closer, and document management functions, such as co-operative creation, file tracking, and version control, will become adjunct functions to the descriptive capabilities of the library. The management functions will complement, and replace some of, the circulation modules of today's ILS.

Multi-media systems

More and more media types are being added to today's libraries and they need different handling from the print material. This is especially true if the material is in digital form. The handling and processing of these will necessitate a special module of an ILS, and the idea of a multi-media library as being anything special will disappear; all libraries will be multi-media.

The libraries will have access to remote resources to complement their own. Thus a library could rent space on a video-on-demand server to allow display of its video material, while still providing the catalogue searching functions and controlling all access itself.

Metadata

The concept of metadata has been around since the first catalogue. It is only now, with the advent of the Internet and the amount of material being published on it, that the problems are becoming urgent. Metadata, which is a list of the attributes used to describe an object, is moving in two opposite directions.

It is being simplified, as in the Dublin Core, so that a minimum standard exists that can be applied to as many objects as possible, and that stands some chance of being applied economically with reasonable consistency. This makes more material available and allows the prospect of automatic extraction of the descriptive information from either HTML “metatags”, XML tags, or Dublin Core elements.

It is being enhanced to provide more comprehensive descriptions. The advent of new material types (mostly digital) are requiring new attributes for both descriptive and technical reasons. Attempts to search across multiple databases hinge on the availability of accurate metadata describing the content of those databases. Further enhancement of this, to allow more resources to be included in searches at a greater level of abstraction, requires a second level of metadata. The descriptive pyramids will continue to grow as more and more powerful ways of combining the data are developed, and as users need to know more details of the similarities and differences of the underlying data, information, or knowledge.

Distributed databases, systems, libraries, services

The trend to distribution is well established and with the increasing number of libraries without walls, there is a strong need for it. Databases will be located (logically) closer to the creators of the information. The libraries will become processing centers drawing on a variety of resources to provide their answers.

The universal availability of libraries through the Internet means that users will chose a favorite, and use it wherever it is located as long as it provides the services and resources they need. Libraries may become distributed virtual entities which are the logical extension of today's consortia in providing a single access point to the aggregated resources of the member libraries and their partners.

At the most technical level, there are products emerging today, such as Sun's Intelligent Storage Network, that will enable databases and portions of databases to be clustered and partitioned as need be for the different services the library wishes to offer. Here we are considering the distribution at a level below the searching application so that, unlike today where a number of Z39.50 applications have to communicate to get a consolidated answer, the single application of the library can query physically and logically distributed databases as if they were its own single database.

This leads to more controlled operation of the application and better performance since the distribution is where it is needed, not just where it is possible. The libraries will become processing nodes dedicated to creating specialized information of a high quality. They will be providing specialized and general services to a particular market.

Better bibliographic models

The current bibliographic models are coming under strain from the advent of new media objects and the new ways they can be related or changed. These current models are designed for static and long life material with relatively simple and fixed features.

New material is becoming very time sensitive and is related in many more ways than before. It is also becoming important to enable relationships to be inferred, created, and recorded so that users are provided with a more rounded set of results to their queries.

The recent IFLA-sponsored work on a more theoretically satisfying bibliographic model, which culminated in the book, “Functional Requirements for the Bibliographic Record” (see the IFAL site *www.ifla.org* for details) provided a major advance. It should be capitalized on and systems should move towards the structures it recommends.

Active clients

Most current library applications are client server architectures with a Web browser interface added. This will change with the more widespread use of components and particularly of Java. The beauty of Java is its Virtual Machine (the JVM) which allows the same program to run on any machine. This means that a processing program can be written once and then made to operate on all the users' individual computers. This allows a controlled way for the systems designer (the vendor) and the systems librarian in the library to create a situation where processing is moved to the user's computer in a controlled manner.

This is the premise behind the network computer (NC or JavaStation). The application will be downloaded and run on it. Thus, the browser interface will disappear and Java functions will be used to give all the functionality and control of a normal PC interface, such as a Windows program, while operating over the Internet. Browsers will exist as the lowest common denominator means of communicating to sites or applications that have no active clients to provide the extra functionality and local user control.

Java will also become increasingly used on the server side of the total system to allow for different databases and for search and processing servers to be tied together by common processing software communicating through the Internet. In addition to the flexibility of this evolution, there will be the improvement in performance that will come from the three tiers of the total application interacting and generating results and displays where they are needed. After all, it is faster for almost any PC to generate a nice screen layout from a stream of text, than to have the layout generated at the server side and sent in formatted form. It also helps conserve that scarce commodity — network bandwidth.

Integrating IR and MM into the ILS

As stated above, the systems will become more modular and it will be possible for the library to choose the IR or MM components of their ILS. Different libraries have different search and material handling requirements, and that flexibility will become part of future systems.

The whole idea of Application Service Providers is one which would fit very well in the library market. It should be a direction to move in soon.

E-commerce

Even though libraries may not be commercial entities and charge users for the content they supply, they will have to operate in the world of electronic commerce. Users will be accustomed to on-line service provision from commercial sites and will expect it from their library. They will expect to be able to pay fines electronically, or even automatically, and to order services and receive goods over the Internet.

The library's suppliers will similarly become more electronic and the purchase of goods and services for everything from journal subscriptions to paper clips will become more network-oriented. The library's ILS will have to be capable of keeping up.

This electronic trade will lead to more commercial transactions being performed by two programs talking to each other, with no human intervention except in the case of problems. This could lead in one of two directions. The library and its suppliers could have their systems become more closely connected and provide a more efficient and tailored service. The alternative is that virtually every purchase could become an electronic auction in a search for the best service and lowest price.

Components and CORBA, etc.

ILSs will become more object-oriented as pieces of software. They are already some of the more complex of programs. Future development will become more complex and costly as users demand support for more material types, more functionality, and more methods of interaction and delivery.

The only way to undertake these developments will be to split them into components, undertake development, and upgrade one component at a time. However, the transition to a component-capable system is not an easy one and will take time and resources. Fortunately, this work will be aided by languages such as Java that allow a component to be re-used wherever it is needed.

Bandwidth

New technologies and research projects, such as Internet-2 and the Next Generation Internet (NGI), mean that bandwidth will be increasing. User side technology improvements, such as xDSL, x Digital Subscriber Line, and Gigabit, will mean that common telephone connections will become orders of magnitude faster.

Alternative delivery mechanisms such as cable and satellite will also offer bandwidth improvements. All of this means both bandwidth and Quality of Service (QoS) will improve, so that more information can be sent to users faster and more reliably. These improvements will be felt first at academic institutions, and then in the commercial and individual world. However, the pace of change is such that the time lag is likely to be months rather than years.

One good effect of this headlong pace of communications development is that countries that do not have an existing infrastructure can leapfrog and acquire the latest infrastructure technology, often for a cost of less than yesterday's technology.

Searching

Catalogue searching is a major function. In the last two decades of library automation, it has changed considerably. Currently, a catalogue should allow the users to either directly search for items by entering questions, or to browse pre-compiled lists of useful access points as a way to find what they want.

Direct searching generally involves a Boolean search query, often disguised behind graphical input screens, which is applied to either specially indexed parts of the bibliographic record or to the keywords extracted from the full text of a document. Non-textual material is handled by creating a text record (a surrogate) for it and then indexing that record. Some systems allow searching of non-text objects by their features, but this is currently a specialized operation.

The systems usually return a list of potential answers (hits) to the user for consideration and often will allow “more like this” searches to be started. Sometimes, the original searches are allowed to be refined or expanded to obtain a reasonable number of hits (“reasonable” is defined by each user).

The systems generally do not attempt to rank the results. When they do, as in Internet search engines, the results are so confusing that users generally have little confidence in them. Research is being conducted into more meaningful interaction between users and the search systems in many universities, but the research has not found its way into the mainstream ILS products.

The search advances will be incorporated into the ILS, possibly as optional modules and specialized searching for images, sound, video clips, etc., and thematic or conceptual searching will become available.

New forms of user interaction will be provided with some truly graphical interfaces to better visualize and manipulate the information. Users will get the ability to customize the interfaces to their requirements.

Meta search engines will become more important as the number of libraries accessible via the Internet grows. They will provide convenient access points to an individual library and to the wider world of other libraries, web sites, content providers, and commercial indexing services to provide a one-stop information access through the library.

An area still to be adequately addressed is the searching of the multi-media material that constitutes a digital library. Reducing searching to a textual surrogate record is less than satisfactory, but there are few alternatives at the moment. Certainly there is little support for direct image or audio searching within the existing ILS systems. This is an area with a fair amount of research work, but few available results.

Portals

With the expanding Internet, and particularly the increasing availability of high bandwidth connections, the age of portals is upon us. Portals are aggregations of services on one web site so that the user does not have to hunt in many different sites for information, games, or shopping. Portals are really department stores or shopping malls on the web.

Portals are already becoming specialized, serious commercial operations. One of the most defined niches is the educational portal where the portal service provides all the computing services a university or school will need via its web site. Each university using the service has individualized access to functions and features from student administration to the development and delivery of remote learning courses. This sort of service portal is not yet available in the information world, but it cannot be far away.

Libraries need to establish their information portals with a broad spectrum of information-providing services in order to retain their position as the one-stop shop for information in their community. If they don't do this, then the community portals (geocities, etc.) will provide local information, the business portals will take that role, the direct delivery shops and sites (amazon.com and netlibrary.com) will supply the reading material, and the library will be left with only meeting rooms and an archive. Portals may possibly represent the biggest threat to libraries in the medium and long term, but they also offer an opportunity for libraries to regain a position they haven't held in a long time.

Summary 8

This paper considers in depth the issues surrounding the creation of a digital library. The initial section (Chapter 1) raises a large number of questions which have to be addressed before the decision to proceed with the creation of a digital library is taken. The second section (Chapters 2 - 5) contains a discussion of the decisions, the management, the techniques, and the methods that need to be understood and used in the design, creation, implementation, and maintenance of a digital library. The last section (Chapters 6 - 7) contains lists of references and resources, and a glimpse at what others are doing and are planning, that will help make the vision of a digital library a reality.

The paper addresses important issues and directs the reader to consider them and decide on their unique solution. There are numerous resources and further reading for all these issues that can assist the reader in obtaining a well-rounded view of the issue. They also show what others have done and what the current thinking is.

Many sections enumerate and detail the techniques needed to build the digital library. Step-by-step procedures and calculations guide the novice reader through the stages of planning, designing, and building the digital library.

The resources section is, perhaps, the most important in the whole paper. It provides an invaluable reference to the tools and equipment that are available to help in all aspects of dealing with a digital library. In addition to associations and publications dealing directly and indirectly with the issues, it contains lists of vendors of the software and hardware that form the necessary foundation for creating and running a digital library.

The vendors are vital both for present offerings and for future potential. They are the partners who will make the digital library possible. Taking an overview of all the offerings makes it clear that there are companies strong in individual specialties, but there are very few who can offer a complete range of products and services from one source. These may not all be internal offerings, but a wide alliance of partnerships is a strength in itself.

Digital libraries are here to stay. However, their form will evolve rapidly as the external world evolves, offers opportunities, and makes demands. It is vital that the partners you choose for your digital library project will stay with you for the long haul. They must be capable of offering and guiding the changes your digital library will go through.

A digital library needs to be prepared the future more than most. Here good basic design with an eye on the immediate and longer term future is the foundation. The rest of the structure must be built using tools and techniques which provide solid reliable operation with the flexibility to change, adapt, and innovate in the future. Good basic design is language independent and depends on the expertise and innovative flexibility of the designers. Being able to design with the knowledge that the structures can be built is important, even vital. What is needed is a universal and secure environment for programmers so that what they produce does not interfere with other programs. This limits the chance for unauthorized access, commonly called “hacking”, and prevents programs from crashing each other. It provides an architecture with the promise of running on almost all computers and promotes a design which allows individual components to work together at the user’s desk and at the various servers in the possibly virtual digital library. The future will see the demise of the all-function-encompassing monolithic systems (often suites) in favor of aggregates of compatible interworking parts from which the purchaser will be able to customize a system with the exact functionality it needs. Building a digital library is a big undertaking, but it is a very exciting one that will ensure a library a place in the hearts and minds of the users of the 21st Century.

About the Author A

Dr. Peter Noerr has degrees in Physics and Computer Science and a Ph.D. in Information Science from The City University, London. In the 1970s he worked for The British Library for six years, four of them as Head of Systems Development. He then spent three years consulting for academic, national library, and IGO clients in all parts of the world. During this time he started his one library automation systems company (Information Management and Engineering Ltd. (IME)) in the UK.

This company produced "The Information Navigator" software (Tinlib) and sold it through distributors in 25 countries to over 2,750 customers in 38 countries. The company ranked in the top three in either special libraries or academic libraries in the annual Library Journal survey from 1994 onwards.

Just as important as the company's market success was the advanced design of the software. It utilized an entity-relationship database for accurate bibliographic modeling. It introduced a multi-user DOS based system in 1985, incorporating a client/server architecture. In 1987 the system migrated to UNIX and it incorporated Unicode support as early as 1990. The system operated in an isolated environment, very similar to a Java VM, allowing portability across multiple operating systems. The entire functionality of the ILS was controlled via profiles, and the system introduced browsing and inter-record navigation long before the web was available.

Dr. Noerr was the chief systems architect of this and the company's other products. He created systems designs for all levels of library from small special libraries to national infrastructure plans for government ministries.

In 1996 IME was sold and merged with Data Trek to form EOSi. Dr. Noerr stayed with the company through a transition period and left in August 1997. Dr. Noerr is currently employed by EduLib, an information systems, services, and consulting company, as Technical Director. He is engaged in consulting and system design work in the areas of digital libraries, multiple character set handling, information modeling, search system and interfaces, and systems architecture and design.

EduLib is currently producing an access control system (STOPit) and a multi-protocol meta search environment for the web (Muse). Dr. Noerr may be contacted through the company at *peter.noerr@edulib.com*.

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