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The accelerating age of electronic information and networks offers many challenges and opportunities to academic libraries. High-speed networks will allow libraries to capitalize on information access as a partial replacement for actual ownership of collections. This article attempts to provide a brief background and overview of the major issues that libraries must address to adopt these emerging technologies successfully.

The Future Impact of High-Performance Networks

Library Collections, Facilities, and Services

We are all aware that we live in the information age. Our economic productivity and competitiveness are largely dependent on our ability to produce and manage information. Our success at producing information is evidenced by such statistics as fifty-five thousand books and over one million scientific and technical articles produced in a single year. The production rate is still growing. Less well realized, but almost equally important in understanding the "information explosion," is the increasing variety of formats of information now available. Formats such as Interactive Compact Disk (CD-I), Interactive Digital Video (DV-I), and the more generic forms such as hypermedia and multimedia (which usually combine audio, video, and still images along with interactive computer programs) did not exist a few years ago.

Technology is both a partial cause of and a partial cure for the information explosion. Digital technology has enabled us to generate information at a faster and faster rate. Ninety percent of all information produced since 1979 has been produced in digital format. On the other hand, digital retrieval storage and retrieval systems offer us the only hope of managing this ever-increasing body of information. All libraries, both large and small, will have to adopt new information technologies to survive. They will

no more be able to resist this transition than the ancient libraries could resist the shift from hand-copied manuscripts to books produced on the printing press. The rate of this transition will vary from library to library based on resources, the need for the most current information, and the understanding of the paradigm shift in information technologies that is occurring.

The Insolvable Problems

Materials Acquisitions

Libraries as they exist today are a very capital-intensive means of transmitting information. The first step in this transmission process is the selection and acquisition of information such as books, journals, films, etc. Libraries select materials by trying to anticipate what the user will want before they come to the library. Libraries try to choose from the immense body of available information to which their users will require access most quickly. Materials are acquired and housed "just in case" they are needed. As the rate of information production grows, and the prices for published materials continue to escalate, libraries are able to purchase a smaller and smaller percentage of the information produced each year. Furthermore, the information content value of a library's collection requires a tenfold increase in collection size for the content value to double. For example, a collection of one hundred thousand volumes would need to grow to one million volumes if it is to double in information value to the users. This is due to the fact that bibliographic works on the same topic tend to have substantial overlaps in information content. The first book a library acquires on a new topic may contain 90 percent or more unique information for the library collection. However, the second book added on the same topic may only bring 20 percent unique information to the collection, and so forth.

Processing Concerns

Great strides have been made by the library community in sharing descriptive cataloging through systems such as OCLC and Research Library Information Network (RLIN), so that each library does not have to reinvent the wheel when cataloging common titles. However, each library must still process (e.g., property stamp, label for location, etc.) the materials it receives before they are placed on the shelf. Maintaining a processing capacity equal to materials receipts has often been difficult for libraries, because funding for materials is more readily obtained than funding for staffing to process materials. Even if libraries could keep up with acquiring the majority of the information produced each year, it is usually not realistic to assume the related staffing needs would be met.

Facilities

The most visible capital expense libraries face involves the ongoing need for space. A few standard figures quickly illustrate the magnitude of the problem. One hundred volumes require approximately one square foot of floor space, plus an additional one-quarter square foot for related space (e.g., receiving areas, aisles, rest rooms, etc.) for a total of one and one-quarter square feet. This does not include any seating space for the users. The typical cost of library construction ranges between $100 and $300 per square foot. If a library adds twenty thousand volumes per year, at an average construction cost of $200 per square foot, the library needs to spend over $200,000 every five years just to build space to house collections. Added to this is the facilities operating cost of housing collections, which is generally considered to be in excess of $8 per volume per year. Larger facilities also require more staff, more furnishings, etc. Few institutions will be able to continue building the larger and larger library buildings required to house comprehensive collections.

Collection management and user access become increasingly difficult as the sizes of collections grow. Even if a library could house all of the materials its users need, its size would become a major impediment, and keeping its collections in order would require an army of staff. A collection of two million volumes requires an area the size of a football field filled with shelving eight-feet high just to house the materials!

Preservation of Materials

Another major capital investment facing libraries is the preservation of the materials they already have. Even if libraries can acquire books, journals, and other materials, they are then faced with keeping materials from decaying on the shelf. The basic goals of most libraries—providing materials to users and preserving materials for future generations—are in conflict. Even if libraries had adequate climate control systems (I have yet to find one that does!), they would have to choose between finding temperature and humidity levels that are best for their clients or best for their materials. Preservation is expensive and it is obvious that libraries will not be able to preserve all of their existing collections. Libraries are now making the difficult choice of which relatively few items they should preserve.

For nonbook materials, the preservation issue for libraries is not only one of keeping the media intact but also keeping appropriate technology needed to use the media. New technologies displace old ones. Finding 78-RPM record players is difficult today. Equipment for some cartridge-type film loops is no longer being made. Getting repair parts for Beta videocassette players is becoming increasingly difficult. Even computer-based technology has a high rate of obsolescence. Finding an Apple II microcomputer to run the historically significant spreadsheet program *VisiCalc* is often a hard task at many universities.

The Promise of Technology

Digitalization

Perhaps the greatest impact on civilization since the creation of the printing press will come from our ability to digitize all information regardless of format. Having information in digital form makes possible standardized storage, transmission, and displays. Text, sound, and images—both static and dynamic—can all be stored on the same disk, transported over the same media, and used on the same workstation. These digital formats are highly malleable. The resolution of images or sounds can be varied to produce "thumbnail" visuals or sounds for review purposes before the high-resolution version is retrieved. Digitization also allows for the transformation of information from one form to another (e.g., print to sound) and for an ever-expanding range of retrieval options.

Our relatively long experience with text databases has, at times, limited our ideas about what future databases will be like. The common data format of today is text, often referred to as ASCII files. Creation of text files normally requires someone to enter data into the database by using a keyboard to record the information character by character. Even the new scanning technology used to create text files often requires an extensive amount of manual proofreading: converting pages to text files destroys the integrity of the printed page, and formatting, graphics, and type styles are all generally lost when pages are scanned.

Networks

Up until recently we had little choice but to move most data as text files because of the limitations of the available technology. The future for moving print electronically lies in moving text as images. A page treated as an image preserves all of the contextual information—graphics, layout, type style, etc. The new generation of personal computers and workstations can readily handle all but full-motion images, and full-motion capability is just around the corner. New high-speed telecommunications networks allow images to be sent very quickly. Common T1 networks transmit data at 1.5 megabits per second (Mbs). The newer T3 networks transmit data at 45 Mbs and now there are networks that can transmit data at 1,000 Mbs, or a gigabit per second. T1 networks are widely available, and T3 networks are becoming more commonly available through public broadband network providers such as the regional Bell operating companies and InterLata services.

The table on the next page gives the amount of time required to transmit a twenty-five page article with ten color images (960 megabits) over networks of different speeds:[1]

Network Transmission Speed for a 25-Page Article

Network	Speed	Time Required
Standard today	9600 bits per sec	28 hours
T1	1.5 Mbs	10.7 minutes
T3	45 Mbs	0.36 minutes
New high-speed	1 Gbs	0.02 minutes

As can be seen from the above table, the utilization of T3 and higher speed networks makes electronic-document delivery practical, and marks a new paradigm in the way information can be handled. Electronic-document delivery, along with printing on demand, can help decrease the collection of information that is printed "just in case"—the major content of libraries.[2]

High-speed networks also provide the capability of moving high-resolution images, sound, and full-motion video. As the ability to move this type of data becomes more commonplace, the use of multimedia incorporating a variety of formats is expected to increase. Today such use is often viewed as merely a fancy advertising technology. However, multimedia's potential in education and for expressing complex and abstract concepts is becoming widely acknowledged. Visualization, a multimedia of sorts, has proven to be quite valuable to scientists in understanding phenomena in ways not possible by simply looking at the numerical data.

Client-Server Computer Architecture

Another major technological promise is in the area of the way computers communicate with one another. Client-server architecture means that one computer can query other computers and display information from all to the user as though it came from a single system. It is not going to be necessary to mount student-address information, for example, on every system that needs it. Instead, the systems will go to the student-enrollment system to retrieve what information it needs at the time it needs it. This new architecture is leading to "integrating systems" rather than integrated ones.

With client-server architecture, the library's system will actually consist of multiple systems, each developed to do one or two things well. The systems will be interconnected by networks, and will adhere to the so-called Z39.50 NISO[3] standard known as the "information retrieval service definition and protocol specifications for library applications." Systems using this standard will allow the libraries to have a much greater role in developing the user interface for these systems than is currently the case. A library user might do a subject query that retrieves information from the library's on-line catalog, a separate system giving the titles on order,

another system that gives the government documents available from the local documents depository library, and yet another database, located thousands of miles away, of full-text articles the user can have sent to him or her as electronic images or via telefacsimile. All this information would be incorporated into a single display format for the user.

Libraries will be able to build virtual collections and reference works specifically tailored to their users. As an example, a library system could be built using client-server architecture that pulls together all of the major on-line catalogs of libraries with collections in textile engineering along with the appropriate on-line bibliographic retrieval services. As the ability to build comprehensive collections declines, the importance of building virtual collections using relative strengths of several libraries will grow.

Challenges to Realizing the Promise

Identification of Technologies

The major difficulty libraries, and their parent institutions, face today is that while many know where they need to be technologically speaking, all of the details on what and how are not totally clear. A basic example of this difficulty is how to wire a building. Many knowledgeable people believe future needs will require Fiber Distributed Data Interface (FDDI). However, the definition of an acceptable cable system to support FDDI ranges from voice-grade telephone wiring to high-quality (and expensive) fiber-optic cable. To be safe, libraries can install fiber-optic cable to every desktop. However, they may find in one or two years that the expense to do so was not warranted.

Budgetary Challenges

As the technological how and why become clearer, libraries will need to shift from a capital-intensive investment strategy to a model more oriented toward ongoing operating costs. Currently, the primary mode of operation for libraries is to invest in a series of one-time capital investments—a book is purchased once (hopefully) and is available year after year, even if the library receives no money to buy any more books; shelving is bought once and lasts forever, as are the old oak card catalog cabinets. While the management of digital information will require capital expenditures, in the future the emphasis will need to be on ongoing funding just to keep access to information the library had before. These ongoing costs involve equipment, telecommunications, and database access. Since the rate of obsolescence often requires equipment to be replaced in three to five years, the libraries can recoup this cost through on-line bibliographic retrieval services and document delivery services priced on a usage basis (e.g., based on length of computer time required to do the search or length of article sent).

Libraries must start budgeting part of their resources to gain access to, rather than ownership of, some resources. This is difficult because gaining access to resources must often be done at the expense of buying

materials to put on the shelf. While access to materials in electronic format via networks will likely become a viable substitute to ownership of materials, convincing various campus constituencies is not always easy. Among other things, both libraries and academic program-accrediting bodies will need to find measures other than volume counts to determine library quality. The degree of access a library provides to needed materials will be much more meaningful than the number of volumes on the shelves.

Using library materials budgets to purchase access to on-line bibliographic retrieval and document delivery services often poses other problems for libraries. First, it is not uncommon for library materials budgets to be in "capital lines." A book is considered permanent and therefore a capital item by many fiscal agencies. Access to bibliographic retrieval and document delivery services is not a capital item, but rather a purchased service. Moving funds from a capital line to a service line in the budget can be very difficult. Second, as mentioned above, these services are often priced on a usage basis, which means that they constitute a cost which is variable and sometimes difficult to control. The cost of a specific library volume on the other hand is a known, fixed amount. Some vendors are working with libraries to try and develop set-rate pricing for on-line bibliographic retrieval and document delivery services. These pricing schemes usually either allow for unlimited usage for high-volume traffic, or a specified number of uses at a set price. Before most libraries will be able to aggressively substitute use of on-line bibliographic retrieval and document delivery services in place of actual ownership of materials, the libraries must be able to purchase these services as part of the materials acquisitions plan (and budget) and at predetermined fixed costs.

What happens when electronic information vendors take their "books" with them when they go out of business?

A great deal of research and discussion is currently underway to determine how charges for access to materials in electronic format can be handled to ensure that authors and publishers receive appropriate compensation. It seems that the technology used to transport electronic information can also be readily adapted to keep track of royalties and other fees due to authors and publishers. The creation of wide area networks, such as the Internet and the proposed National Research and Education Network (NREN), are vitally important to libraries if they are to provide access to the growing array of electronic resources that are available. Often library access to networks is not a problem that academic libraries can solve on their own. Network access is usually an institutional problem, not a library problem.

The fear librarians have about moving towards a dependency on electronic information has two major economic components. The first is the concern about depending on outside sources to continue providing information at a reasonable and predictable cost. An unanticipated rise in cost in access to electronic information could have the same affect as permanently removing journals from the shelf. The second major concern is the long-term viability of information suppliers or of a particular

product. Most libraries have many books whose publishers have gone out of business long ago. What happens when electronic information vendors take their "books" with them when they go out of business, or if vendors decide a particular database is no longer economically viable? Most libraries are not ready to abandon their preservation role and adopt the "information Darwinism" that dependency on outside vendors implies.

Staffing Challenges

The new technologies offer a wide variety of means to access an ever-expanding universe of information. For many users, navigating a modest-sized traditional university library is a real challenge. Navigating the virtual library will require more and better-trained intermediaries. Librarians have generally been undergoing a constant process of retooling since the late 1960s. This rate of retooling will have to accelerate, requiring librarians to spend more time away from direct user service, and thus requiring more librarians to provide the same hours of service. In addition, many print sources the users have navigated on their own have become more powerful and less intuitive-to-use electronic sources requiring more librarian support. The indexes available on CD-ROMs are a case in point. Many libraries have reported it takes an average of twenty minutes *per user* of a librarian's time for patrons to be able to use these CD-ROM indexes.

Librarians will also need to play a primary role in the development and continual refinement of the user interfaces to all of these electronic sources. The librarian is charged with the responsibility of understanding how users seek information and making this process more successful. The librarian will be facing a constant challenge to provide access to increasingly complex systems without making the user interface more complex. While the technology will make transmitting information easier for libraries, this will be offset by the librarians having to take on much greater roles in helping users find what they are after and understanding what they have found.

Redefinition of Libraries

One of the problems that digital information has created is the increased fragmentation of information. The benefit of malleability of digital information can also be a drawback. This has caused real problems for libraries in defining to what information/technology they are responsible for providing access. Historically, libraries collected data and information that were compiled in some physical format. Without the physical attributes, it is difficult to determine what bits and bytes constitute a "work" worthy of being added to a collection. The task of managing the ocean of data that surrounds us is well beyond the scope of even the largest libraries. This means that libraries will have to define and articulate what information they are responsible for collecting and managing. Libraries have historically done this through the use of collection development plans, which were fairly static. The new digital information services will require these collection development plans to be recast in a much more

fluid form. Information sources and types that potentially replace others will continually need to be evaluated and, where appropriate, incorporated into the collection development plan.

Summary

As stated above, these changes and challenges confront virtually all libraries, including those associated with metropolitan universities. Urban universities have some potential advantages over their more isolated counterparts. Often the telecommunications infrastructure exists because of the needs of businesses in the area. Also, in many cases libraries in metropolitan areas have well-established cooperative agreements that can ease the transition to local client-server type models of cooperation. Lastly, vendor-supplied expertise in the areas of new technologies is more readily available in urban areas.

In the words of the Walt Kelly character Pogo, "We are faced with insurmountable opportunities." Insurmountable they may be, but they cannot, nor should not, be passed up.

Endnotes

1. Alan Blatecky, Presentation before the University of North Carolina University Library Advisory Council, July 19, 1991.
2. Paul Evan Peters, "Networked Information Resources and Services: Next Steps," *Cause/Effect* (Summer 1991).
3. National Information Standards Organization. Approved on January 15, 1988.