The Internet: will this highway serve the digital library?

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The future of the biomedical enterprise and the biomedical libraries that serve it is tied closely to digital information. The changing nature of this type of information will create new pressures on libraries, particularly in health care organizations. Libraries must learn to deal with these pressures. Currently, libraries depend on the Internet primarily for connections to resources and other libraries; thus enhancements to the Internet will impact the libraries of the present and future significantly. This paper provides an overview of the technical capabilities that will be available in the near to midterm, what libraries will be able to do with those capabilities, and how libraries can position themselves to take advantage of the impending changes.

The future of the biomedical enterprise is tied closely to digital information. Digital information is data in machine-readable format suitable for computer processing, network transmission, and electro-optical storage. It is different from the traditional, alphanumeric ASCII format, now the most common form of information on the Internet. Digital format is needed to transmit images and multimedia, which are becoming increasingly important in today's information environment. The digital nature of the
information is the basis for significant innovation beyond the constraints of either paper-based information or even electronic information limited to text and numbers.

Innovation made possible by the transition to digital information promises to offer significant improvements through the following:

- reduction of the space and time barriers to physical access, particularly in a geographically distributed environment;
- lowering of barriers to intellectual access—the ability to find what you want or even know that it exists—that may be erected by a rapidly expanding information base (e.g., information from computer-driven imaging or experimental devices);
- incorporation of richer forms of information resulting from the integration of multiple media, such as text, graphics, images, audio, and video; and
- facilitation of new ways for teams to work together in an information-intensive environment.

Although some of the innovations with digital media remain within the realm of research, an increasing number of new forms of information are becoming available. Adoption of such advances is not optional for a biomedical library or health care organization that wishes to be prepared for the twenty-first century. Both must begin to incorporate and integrate the new forms of information that already exist and to prepare for those that are coming soon. This transition will require operational changes in biomedical libraries and the other information-based activities of health care organizations, especially in terms of how activities are coordinated and access to information is integrated.

The Internet will play a pivotal role in information access for libraries in the coming years. Although the Internet has been in existence for a number of years, the federal government’s commitment to a National Information Infrastructure (NII) has increased the network’s visibility significantly. The media, opinion makers, techno-gurus, and government officials often use the metaphor of the information highway or superhighway. While imperfect, this metaphor—by invoking our experience with the interstate highway system—usefully illustrates the breadth, capacity, impact, and value of the NII. In this paper, the term “information highway” is used loosely to refer to the Internet, the enhanced Internet that is now appearing, and the greatly enhanced NII, which will appear by the end of the decade.

Digital information offers both opportunities and challenges for libraries. Together with desktop computing and ubiquitous networks, it will de-emphasize the definition of the library as a place where information is stored. Thus, the changing nature of digital information (and the underlying technologies) will pressure libraries to find new roles. Unless libraries respond effectively, their roles may be diminished and even their existence threatened. A strong library is needed for the future, but not guaranteed. To prepare the libraries for the future, new skills must be developed, new technologies mastered, and new organizational approaches to problem solving introduced. Libraries must become key places where users can find information about, and skill in accessing, the world of digital information. In other words, libraries will be important as the place where librarians and other information specialists can be found.

This paper provides an overview of the technical capabilities that will be available in the near to mid-term, what libraries will be able to do with those capabilities, and how libraries can position themselves to take advantage of the impending changes. Readers are assumed to have a basic understanding of the Internet and current networking technologies. Readers who need basic information on networking and the Internet can consult the resources listed at the end of this paper.

THE LIBRARY OF THE FUTURE

The critical mass of information necessary for effective performance in the biomedical disciplines continues to grow in size and complexity. The essential information base now includes not only unstructured information (e.g., text) but also structured information (e.g., databases such as the Genome Data Base) and images. Increasingly, more of this information is in digital format.

An additional feature of this changing information environment is that in much of the biomedical enterprise, particularly in the research community, the distinction between data production and publication is being blurred. For instance, in the Human Genome Project, several centers have generated large amounts of information that will be available through the information highway and may not be published (or peer reviewed) according to the standards that are common today. Yet, this information will be very valuable to others.

These changes have demanded that the information-seeking behavior of biomedical professionals become more complicated and varied and have broken the traditional link between the printed work and information transfer. This also means that the role of the library and librarians is evolving. New and richer types of information, including multimedia information, must be made accessible. Much of this information will be available only through computer-based systems.

If merged with online forms of traditional print information, the library will become the nexus of a new digital environment. Librarians should also take a proactive role in lending their knowledge-organiz-
ing and user-interaction skills to biomedical professionals who increasingly are acting like publishers. Failure to incorporate online information and help the new “publishers” may relegate the library to a marginal role, with dire long-term consequences.

At the same time, the biomedical enterprise is becoming more geographically dispersed, with faculty, staff, and students spread over a wider area. Although traditional modes of communication, fax, and e-mail mitigate some of the effects of this dispersion, much library-based information cannot be adapted easily to this distributed environment. Will students or residents at off-campus primary care sites have access to library-based information or to librarians? What is the cost in personnel, training, and universal access? What is the role of biomedical libraries in supporting primary care providers, many of whom are likely to practice at some distance from concentrations of biomedical information? Libraries must begin to address these problems now.

It is clear that libraries cannot solve the problems of a geographically dispersed client population in isolation. They must work in close concern with the networking and information technology units in their organizations. In virtually every organization, important decisions are being made now about networking and infrastructure that will set the tone for information transfer for the next decade. Libraries must ensure that their needs and imperatives are articulated and met.

What goals should a library establish to meet these future challenges? There are some basic steps that can be taken to address the information needs of the future.

Knowledge transfer. Library staffs need to have expertise in managing digital information. Knowledge transfer should work both ways—that is, from biomedical professionals to library professionals and vice versa. In addition, physical as well as intellectual access must be addressed. This is probably best (but not exclusively) addressed through a close working partnership with an associated information technology unit in the organization.

Digital publishing. Methodologies and technologies are needed to enable the online publishing of relevant digital information. It is expected that much of this information initially will be in the form of textual and numeric data. However, as other related technologies mature, multimedia forms of information (e.g., images) also will be important. The library must internalize as many of the needed skills as possible and find collaborators within information technology units to fill gaps. Much of the information generated will be of local origin (e.g., material to support research, education, or training). Libraries should become a resource for publishing this locally generated information in an easily accessible manner. Their role will be to provide information management expertise, organizational skills, and software tools to allow the producers of the information to publish it. Library and information professionals would be responsible for designing the overall structure of the online resources.

Improved access to digital information. A rate-limiting step to accessibility is the decision of commercial publishers to make information available in digital formats, but it is inevitable that this will happen. Libraries must be in a position to provide online access to as much information as possible. Beyond that, libraries must be prepared to use a combination of economic leverage with the publishers and self-publishing activities to increase online access to digital information.

THE INTERNET

The Internet is not simply a web of networks that connects millions of machines and users from all over the globe. For some time, it also has been an admitted technophilic community with a distinct character. Now, it is becoming an entirely new mass medium for communication. By connecting to the Internet, an information provider now potentially can reach a mass audience. Thus, the basic technological, economic, regulatory, and cultural underpinnings of what is known as the Internet will be changing in dramatic ways.

As with national newspapers, television, and radio, individuals can “surf” through (i.e., select or search for) information programming organized and prepared by someone else for public consumption. Unlike these traditional mass media, however, current Internet tools allow small groups and even individuals to enter the mass programming or publishing business. More to the point, these tools allow libraries to address a mass audience located at some distance from their physical location.

By reducing the costs of addressing a mass audience, the Internet makes it possible for increasingly diverse types of useful information to be made available. Moreover, anyone can publish. There is no quality review process or editing. This allows tremendous innovation and very poor quality programming to coexist. How will this paradox be balanced? Enhanced access to junk does not seem to be a worthy goal.

Also, unlike traditional media, Internet-based tools allow individuals to customize their own views of the outside world. Simple capabilities in some of the most popular information access programs for the Internet allow a user to develop a completely idio-
syncratic view of information sources—a view that includes personal value judgments. For example, "bookmarks" in Gopher or "hot lists" in Mosaic make it possible for a biochemist, dietitian, or physical therapist to develop a customized view of the information sources seen as most valuable and reliable. These mechanisms for personal filtering and organizing of information are powerful ways to ensure the quality of information.

This process of personal peer review does not have to be totally introspective, thanks to the notion of a personal "home page." (With Mosaic, a user can connect to the University of Michigan Medical Center’s Home Page at the URL http://www.med.umich.edu.) A home page is a customized information resource and generally includes an overview of both its structure and contents. A personal home page allows an individual to create his or her own identity in cyberspace. A significant portion of an individual’s home page often is linked to other home pages or connections to other servers. Might it be profitable for a library to work with local domain experts (e.g., renowned heart surgeons, genetics researchers) to enhance and publish their personal home pages, which could serve as a central access point for the wider community? After all, the most common way of answering a question is to ask someone who knows about the subject. By viewing the home page of an individual who is an expert in a particular domain, a user could link to other sources. This type of "social" peer review is very effective in a world full of too little time and too much information.

Library professionals need to prepare for the future by asking a very simple question: "With a growing suite of tools available to individuals, why will users cruising down the information highway stop at the biomedical library exit?" Is there an answer to this question? If not, what implication does this have for the future of the library organization—or profession?

The authors believe there are at least three reasons why users will want to access libraries from the information highway:

- To get help publishing their information,
- To get help locating information, and
- To get help in determining the quality of various information sources.

The multimedia experience is radically different from text-only options. At least for the immediate future, there is a tremendous need for information specialists to help originators of information produce truly useful multimedia products. For example, as researchers rely more on visual images (either complex data sets or three-dimensional structures) to represent their findings, they will need some mechanism to capture the experience and structure it so that their work can be communicated effectively. This is a function that should fall to librarians, because of their formal training in organizing information as well as their long experience dealing with the information needs of biomedical professionals.

How should the reference desk change in response to the breadth and complexity of the information resources on the Internet? One suggestion is that libraries should use knowledge robots (KnowBots). These independent programs, called intelligent agents, surf through the Internet to survey, filter, and evaluate information resources. While KnowBots are still a concept than a reality, there are solutions emerging from real life. In some settings, the traditional reference desk librarian could be replaced by a human Internet surfer. These are individuals who explore sources of information on the Internet—they might be called "PeopleBots." PeopleBots accept various types of information requests and either satisfy the requests or forward them to other PeopleBots who are better positioned to help. KnowBots are for the future, while PeopleBots are at work now. In many cases, they already work for the library. In the future, their skills can be encouraged by libraries.

Finally, current clients will want to access the digital library so the library can put a "stamp of approval" on the information published or accessed through the library. Such approval can come in the form of intelligent organization of the data or deliberate omission of sources of questionable origin. This function implies that librarians will begin to forge links with the domain experts who can become partners in filtering activities.

INFRASTRUCTURE, TRAINING, AND INTEGRATION

To meet the challenges of the digital library concept, librarians need to address specific elements: networking infrastructure, training of professionals, and the integration skills necessary to apply the strategies of the future.

Networking infrastructure

In the future, both intellectual and physical access to information will depend on the provision of an adequate network infrastructure. Without this infrastructure, the ability to deliver information to the user will be limited. Various types of network access could be offered, and several of these are in use today. Future networking technologies will increase ability to access or deliver information. It is important to understand that no single type of networking will be used. Depending on their location, organization size, resources, and needs, users may wish to have information delivered via a number of different methods, such as modems, the Internet, leased lines, and pri-
vate networks. Future technologies such as BISDN and ATM (i.e., high-technology, circuit-switched communications methods being developed by telephone companies and others) offer the promise of cost-effective, high-speed connectivity, which will be required for use of many forms of digital information. Images and multimedia will require networks with performance capabilities that are higher than those supporting textual information transfer today.

Clients will have a varying level of knowledge about the use of such technologies, so the library staff will have to have some knowledge of how network technologies are used and how to train the end user in methods of access. The library staff need not manage the networks, but they must be knowledgeable about using them. This is where a collaborative effort by information technologists and library professionals will be needed. The network infrastructure will be managed by a number of different entities, most of them outside of the library. Health provider organizations and their associated libraries will need to agree on the best way to support the necessary infrastructure.

A new strategy should be exploited by library management to make sure the library receives the necessary organizational and financial support to be an active participant in network planning and use. The changing face of health care has raised competitiveness to a much higher level of importance. Consider making this argument at a future budget meeting: Reform will “push down” to primary care providers more prestige, resources, and responsibilities. Along with these benefits will come increased risks. The only reliable and cost-effective way to reduce these risks is through knowledge and education. An active, “extroverted” library, fully attuned to a digital information environment, may well help providers choose a health care delivery organization with which to affiliate.

The issue of standards for delivering information over the network also will need to be addressed. At the protocol level, the current standard for accessing information is the Internet protocol TCP/IP. If a standard such as this is used, then most types of computer-based information can be accessed and delivered across the network infrastructure. Standards for multimedia information and images also will require close attention. There is no widely used standard now for the use or presentation of this type of information, but over the next few years one probably will emerge. Librarians and vendors should follow this standard-setting process closely.

Training professionals to use new skills

Managing digital information and providing intellectual access are roles that are just emerging for those in the field of library education. These are new skills that current information professionals, as well as those entering the field, will need to acquire. What are the best methods for training current professionals in the new technologies that will be necessary for the libraries of the twenty-first century? Are existing structures adequate to accomplish these ambitious goals? The authors believe there are very few formal mechanisms to train or retrain large numbers of library professionals in the new technologies they will need to be effective with digital information. New training programs will need to be developed, and existing and new training approaches merged.

The first question to be answered is, what type of individuals will be needed to manage the new information technologies and strategies? The simplistic answer is individuals who have been trained in the core elements of librarianship plus the necessary technical skills and concepts. While this combination of skills is easy to visualize, a training program would not be easy to implement. It might require too much time and too broad an array of subjects to be manageable.

It may be that the optimal training program is one designed around digital information and collaboration, focusing on how to apply these skills in the setting of a typical library organization. Librarians possess the skills and knowledge needed to manage information and have special insight into users’ perspectives and needs. Information technologists have considerable training in the intricacies of the relevant technologies. As opposed to trying to produce a “super librarian” who combines both library and information science with information and networking technology skills, a realistic training program might seek to produce a professional who can articulate a shared vision for the joint efforts and work effectively with both librarians and technologists to blend their different strengths. In addition, the new professional would be trained to deal with the organizational and cultural changes associated with the increased importance of digital information in the library setting. Problems associated with change are often sufficient to paralyze or derail efforts to use new technologies, whatever their value.

Training may come from several different structures. What follows is not an all-inclusive list of training methods, but rather a sampling of existing structures that could take on this responsibility.

Library schools. Established schools of library science should foster development of as many of the above-mentioned skills as possible. Many schools are examining these issues and expanding the knowledge base of trainees in this area. This is a difficult and frightening time for many library schools. The authors hope these challenges will not induce a
"siege" mentality but rather will be used as an opportunity for a fundamental rethinking of the future needs of library professionals.

Cross-training programs. Professionals in disciplines other than library science increasingly are becoming interested in information management and storage. These individuals already have skills in areas that will be needed by the library of the future. These professionals can be trained to use these different skills to complement existing librarians. This retraining of information management professionals and experts from other disciplines could be based in library schools or other programs.

Integrated Advanced Information Management Systems (IAIMS) program. Another structure that could facilitate cross-training is the IAIMS program sponsored by the National Library of Medicine. This program includes a number of institutions around the country that have committed to preparing for the information needs of the future. The IAIMS community has realized that new models of information management can be developed. However, the number of trained professionals is limited, and this may be the rate-limiting step in applying these new models. Thus, many IAIMS institutions have developed programs to train individuals from a variety of professions in the skills necessary to meet future challenges in information management. These programs may be applicable to biomedical libraries.

Integration skills
In addition to the network infrastructure and professional training, libraries must acquire the skills necessary to integrate the various forms of digital information. It is unlikely that all information needed by an individual or library can be obtained through a single, integrated external system. Structuring the information and integrating it into a retrievable format will require varying integration skills. This is a role that can be played by information technology collaborators.

Information such as images, multimedia, and text will have to be integrated into a form that can be delivered to users wherever they are located. Why is the structure important? It is important primarily from the retrieval standpoint. For example, in an academic health center, large numbers of images are created daily by researchers and clinicians. These individuals usually do not have the skills needed to organize their own set of images for classification and retrieval purposes. Such image sets will need to be managed through a collaborative effort to organize and classify digitized information so it is retrievable.

All the information to be managed by the library cannot be located in one database, because such a database would be too large and cumbersome. In fact, the various forms of information probably will be stored in many different locations. How will library staff go about maintaining and organizing this dispersed information structure? Database, networking, and storage management skills will be needed to make the integration workable. Information technology professionals will need to be part of this activity to make the information access appear seamless to the individual user. Library professionals will need to understand how the integration works and develop the training and user interfaces to provide intellectual access.

All of these different strategies, used in combination, are necessary for the library of the future to manage and maintain digital libraries. The structure of a health provider organization must reflect the interdependence of the library and other information-based activities. The information highway, by serving as the goal for digital information innovations, may well provide the focus that will help meet the needs of the biomedical community.

IMPROVING INTELLECTUAL ACCESS AND COLLABORATION
More information does not translate automatically into an improved information environment for biomedical professionals trying to solve problems. In fact, current computer-based systems are a two-edged sword. They offer better information, but they also greatly increase the volume of information—to the point that the usefulness of the resource does not improve and may actually decrease, due to the vast amount of information generated by the biomedical community.

As the size and complexity of the information store increases, it is important that steps be taken to maintain and improve intellectual access to the information. Intellectual access means the ability to find the right piece of information—when needed and wherever the location. But intellectual access alone, however important, is not enough.

An information environment must be established that fosters collaboration around the information it provides. Most biomedical professionals still get answers to many of their questions from the local expert "down the hall." Many of these interactions are centered around a piece of information—an X-ray, a diagram of a surgical approach, a patient record, or the page of a laboratory notebook. As integrated information environments expand ability to get remote physical and intellectual access to computer-based forms of information, the meaning of "down the hall"
will be extended. This is particularly so for students and residents, who will find more of their educational experience taking place off campus and, possibly, away from the local expert. E-mail and fax have provided some help, but new, richer forms of information soon will overwhelm their ability to support collaboration. The information highway will play an important role in redefining "down the hall" and thus is critical to the future of librarians.

Beyond the concept of "down the hall," the most productive work of biomedical professionals increasingly is being performed in the context of groups—research groups, team-taught courses, and clinical care teams. And, increasingly, these teams are geographically distributed. Whether a few miles to an ambulatory care site or across several time zones, this physical distance vastly complicates interaction around information, even if the information is easily available. To be relevant in the future, the library must extend its role to include making the information shareable in an easily accessible manner. As experts in information dissemination, librarians should find this role logical. These intellectual access activities fall into several categories.

**Organization of information.** New techniques are emerging for the organization and dissemination of information. Librarians need to begin to focus on mastering these techniques. For example, Gopher, Wide Area Information Server (WAIS), and World Wide Web (WWW) are important technologies for sharing information. Much of this sharing is now ad hoc and suboptimal. The involvement of library professionals in the design and organization of these resources can greatly increase the usefulness of the information.

**Interface design.** High-quality interfaces are unlikely to be developed by computer and information scientists if they work in isolation from librarians. (As individuals with roots in and close ties to the computer science and information systems communities, the authors can attest to this fact.) As "retailers" of access methods and interfaces, libraries are best suited to understand the users of information and guide the development of interfaces that are beneficial to those users.

**Tools for assessment.** Tools are needed for "instrumenting" interfaces—tools to collect data for rapid and continuing assessment. The continuing assessment of the systems is critical to the improvement of the information environment. Again, this is not likely to happen on the appropriate scale without the involvement of libraries and library professionals.

**Impact of integration.** Integrated environments carry the inherent risk of becoming very complex for the users. Efforts are underway to determine how to organize an information environment made up of disparate resources. This is a different problem from the challenge of organizing an information resource with closely related components, such as text-based documents. Because the goal of integration efforts is to build a diverse environment, care must be taken to incorporate into the process an effort to improve intellectual access. Library and information professionals must work closely with information technology professionals to ensure that each discipline cross-fertilizes the other, to the benefit of the users of information.

**SUMMARY**

It would be an exaggeration to predict that everything about libraries will change before the turn of the century—except the budget. But technology definitely will, and the information highway is only an example of the type of technological change that will affect libraries. Library organization and culture also will change. With technology changing so rapidly and health care reform driving parallel changes in the entire biomedical discipline, it is unrealistic to expect that anyone other than librarians can develop all the solutions to the resulting information management problems, because libraries are most familiar with the problem areas.

Experiment with technologies and resources and become more involved with clients. Seek out partnerships with information technology providers and domain experts. As technology produces broader and more diverse forms of information, libraries must adapt or become less functional. As a profession and as a culture, libraries must adapt to these changes. Few generations of the library profession have had a challenge of this scope.

It is the authors' hope that this paper will stimulate useful discussion and reflection on how libraries will use the new technologies, especially the information highway. The paper offers very few specific prescriptions for technologies. The appropriate technologies for libraries cannot be chosen from a distance or without substantial knowledge of the local technical environment, problems, and resource base. That is why local discussions about and explorations of the technology are so important.

The authors hope this paper will stimulate a sense of urgency among libraries about taking steps to begin to evolve. The authors believe (and hope) libraries will continue to thrive. This belief is based on the fact that librarians and the skills they possess will always be needed. However, except through forums such as this journal, the authors have little power to ensure this outcome.
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SUGGESTED RESOURCES

Print


- LANE ES, SUMMERHILL CA. An Internet primer for information professionals: a basic guide to Internet networking technology. Westport, CT: Meckler, 1992.

Online

There is also an online version of an Internet guide, which can be accessed via the Internet using WWW or Mosaic. A very extensive bibliography relating to the Internet may be found on this server. If you have an Internet connection but do not know how to use WWW or Mosaic, seek out your support person or local power user.


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