Networked Information: A Revolution in Progress

ABSTRACT

Progress in telecommunications and information technology has extended computer communication networks and increased network speed. With the resulting increase in networked information, questions arise as to who will control it, who will supply it, and who will have access to it. The role of the library in this electronic networked environment is changing from providing access to traditional paper-based holdings to directly acquiring material in electronic form and providing access to it. Questions arise about interlibrary cooperation, clientele, and competition for patronage. In addition, the development of the end-user workstation that will access a range of networked information resources may lead to new information markets (such as competitive intelligence) and to the potential of multimedia information access and personal scholarly publishing. The traditional role of librarians will also change. Librarians will become information specialists, skilled in the management, searching, evaluation, and organization of information. Finally, library schools must expand and refocus their roles in training these information specialists.

INTRODUCTION

The word "revolution" has been debased in recent usage. Once used to describe political upheaval and forcible rearrangement of a power structure, it is now a hackneyed advertising device: We have not only
the hyperbole of "revolutionary technology" but the obscenity of "revolutionary new personal hygiene products." We have become desensitized to the meaning of revolutions. In fact, there is a revolution in progress, in the old, true sense of the word: Power structures and roles are being rearranged, sometimes forcibly, though without bloodshed. Fortunes will be made and lost and power will shift; some institutions will fade and others will move to dominate.

In past revolutions, media and communications technologies have played a key role (Innes, 1972); although it seems more accurate to term the printing press, for example, an instrument of revolution rather than a revolutionary technology. The revolutions occurred long after the invention of the printing press as the presses were placed in the service of the revolutionaries.

Today's revolution is about information: about who will control it, who will supply it, and who will have access to it. Drawn into this conflict are publishers and information providers, libraries, universities, and all types of information consumers. Instruments of this revolution are drawn from the armory of information technology and computer communications networks, as well as from the blending of existing mass market consumer technologies with the computer and digital networks. These instruments are already well refined; now they will be harnessed.

Information most commonly of interest to libraries—related to scholarship and culture and typically of relatively long-term value or interest as opposed to the ephemeral, time-sensitive information that drives the daily operation of finance, business, and government—is one of the last areas to be drawn into the maelstrom of revolution. In the past two decades, the application of telecommunications and information technology has completely restructured the worlds of finance and commerce and, in a somewhat more subtle way, of government, international relations, and intelligence. Striking, suggestive parallels can be drawn between events that occurred in the spheres of finance and consumer market information and changes that are now happening in the realm of scholarly information and public knowledge.

This paper, which is based on a keynote speech given at the 28th Annual Clinic on Library Applications of Data Processing in April 1991, attempts to chart some aspects of the current revolution and the prospects for the "new order" that may result and emphasizes the fates of various types of libraries. Although a great deal of technology is surveyed superficially, the focus of the paper is not really technology but rather how technology may affect the information environment.
Networks and Connectivity

Everyone is aware that networks are growing and spreading, but few realize how far and how fast. The Internet, a constellation of several thousand interconnected networks, now links between a quarter million and a million computers for interactive traffic and reaches every continent except, perhaps, Antarctica. Curiously, no one knows exactly how many computers—or individuals—are connected through the Internetwork. Furthermore, the Internet serves as a sort of core for a much larger community of users who can communicate with each other through electronic mail. This broader community of electronic mail users, which includes users of machines on BITNET and USENET and users of commercial electronic mail services such as MCIMAIL or CompuServe, reaches well into the millions, but again no one knows exactly how many people are really involved; and recent estimates suggest that people in over seventy nations participate. This global collection of networks is what John Quarterman (1990) calls, following the science-fiction author William Gibson (1984), "the (global) matrix." Others call it worldnet.

The Internet, and the broader global matrix, reaches many of the expected places: universities, libraries, corporations, research laboratories, and government and military sites. It is also increasingly reaching some less likely places: public libraries, elementary and high schools, and even individual homes. In certain circles, it is no longer peculiar to find ethernet cable, a router, and a class C Internet Protocol network number for someone’s residence.

The massive growth of the networks was not exactly planned. The entire Internet, for example, can be understood as a research and development project that became so useful that it turned into an operational service and then grew out of control. Governance, funding, infrastructure planning, and technology development have all lagged far behind the explosive growth of connectivity; and network planners, engineers, and managers are struggling to keep up with the growth rate—dealing with problems that range from the potential exhaustion of the address space used for assigning network addresses, effective network management and problem diagnosis in very large collections of linked, autonomous networks, and security and authentication mechanisms, through the need to devise workable governance policies and funding arrangements for the Internet.

Powerful forces are at work both to extend connectivity and to increase network speeds. At the federal level in the United States, there is the movement for the National Research and Education Network
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(NREN), which is based on the executive branch’s proposal for a High-Performance Computing and Communications Initiative from the Office of Science and Technology Planning and the legislative bills championed by Senator Albert Gore (SB 272—signed into law Dec. 9, 1991). The NREN movement calls for massive investment in very fast networks (gigabits per second) in the 1990s. Some versions of the NREN vision also call for ubiquitous networks that will reach elementary and secondary schools and public libraries across the nation. Some state legislatures (for example, in Texas) are considering initiatives to connect the elementary and high schools on a statewide basis. In addition, strategic partnerships among state government, regional networks, industry, and both elementary and higher education are growing more extensive.

Of course, massive government and corporate computer and telecommunications networks have also been under development since the 1960s. The Internet, at least in the United States, has always been well connected to the government networks. The Advanced Research Projects Agency of the Department of Defense funded the original ARPANET network core and much of the basic research on internetworking. Part of ARPANET, split off and renamed MILNET, continues to support unclassified traffic among a large number of government and military sites. The National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and particularly the National Science Foundation (NSF) are heavily involved in the funding and operation of the current backbone networks for the Internet/NREN-to-be. Increasingly, large corporate networks are being connected to the Internet in the 1990s; today most of these belong to technology-oriented firms that exchange substantial communications with the university, research, and government institutions already on the network. But, in time, it seems likely that the enormous networks that have developed to support financial transactions, airline reservations, and other business enterprises will also be linked, at least in limited ways.

Wireless communication is suddenly becoming widely available to the general public. Car phones and portable personal telephones are everywhere and are more compact and cheaper than ever. There is a long tradition of radio-based networking arising both out of amateur ("ham") radio activities and military communications research. Both of these communities have long been part of the Internet (Lynch & Brownrigg, 1987). But now we are seeing major communications and information technology companies working on wireless network products for the commercial sector and the general public. Wireless local area networks are available, and proposals are before the Federal Communications Commission for the allocation of spectrum to support
public wireless data communications. The sudden maturation of wireless networks in the 1990s is likely to produce notebook computers continually linked to the network by radio at relatively low speeds when being carried about and "docked" with larger machines connected to high-speed wire or optical fiber networks when the user is at a fixed location such as home or office. Perhaps access to the networks will become available to the general public via radio at low speeds without charge.

Existing monopolies face continual pressure. The breakup of the Bell system in the United States has encouraged the development of low-cost, high-speed trunks for long-haul communication in the United States. Today, short-haul leased lines provided by local telephone companies are often more costly than interstate lines due to politically determined rate structures set by the state public utility commissions. In Europe, there is some loosening, through privatization initiatives, of the grip of the PTT monopolies that have restricted the development of computer networking. Internationally, monopolies such as Intelsat and the treaty arrangements with foreign telephone companies, which have kept the costs of international communications links high, are increasingly questioned and threatened with competition and deregulation.

Network speeds will continue to increase rapidly. Today, the NSFNET, the primary high-speed national backbone for the Internet, is completing a transition from T1 (1.544 megabits per second [Mb/s]) to T3 (45 Mb/s); billions of packets now transit this backbone monthly. Advanced Networks and Services (ANS), the corporation formed by IBM and MCI to supply services to the NSFNET (among other things), is projecting that they will have SONET-level services (probably around 600 Mb/s) available within the next year or two. Local area networks are moving from ethernet (10 Mb/s) and token ring (16 Mb/s) to FDDI (100 Mb/s) over optical fiber. The Defense Advance Research Projects Agency (DARPA) and the NSF are funding a series of gigabits-per-second network testbeds to develop the next generation of technology. The NREN programs call for national backbones running at speeds in the low gigabits per second later in the 1990s. These backbones, as well as new local and metropolitan area network technologies, will build on experience gained from the gigabit testbeds.

After a decade of bumbling, common carriers are seriously entering the networking arena in the United States. Historically, the common carriers have merely supplied bandwidth in the form of leased lines; other organizations built networks by attaching packet switches or routers to these lines. Now the common carriers are offering potentially useful packet-switched service in the form of Switched Multi-Megabyte Data Services (SMDS), which allows transmission in the T1-T3 speed
range. In addition, Integrated Services Digital Network (ISDN) technology offers two 64 kilobits-per-second (kb/s) channels to homes or offices over the existing copper cable plant. Although too little, too late for serious interorganizational or intraorganizational networking, ISDN technology could offer a considerable improvement in the ability to connect homes, small businesses, and other places to the nearest terminus of the high-speed national network. The adoption of ISDN depends on whether costs are reasonable. (And it appears they will be: The early offerings in some states are priced at about $20-$30/month for the service on use-insensitive terms within the local service area. In other states, tariff proposals have been rejected by state public utility commissions because the proposed rates were too high.)

Following ISDN is the proposed Broadband ISDN (BISDN) service, which in the early twenty-first century would offer multi-megabit data services on a commodity basis, if it actually becomes available. This technology seems to require optical fiber to the end-user premises (at the home or office); and in the United States, the development of this technology seems linked to public policy questions of whether existing cable television franchises or telephone companies will ultimately provide high-speed consumer network services. (There are several relevant public policy debates that are now receiving attention ranging from a bill in Congress for a massive program to install subscriber loop fiber optics through a revision of the rulings by Federal Judge Harold Green that would allow the RBOCs to enter information content marketplaces, thus creating a major new business justification for high-speed services.) Other countries, such as Japan, are investing heavily in the development of BISDN. The proponents of BISDN come from a rather different culture than many of the NREN’s current advocates in the United States. The orientation is towards very broad-based services arising from consumer electronics and entertainment roots.

Internationally, the situation is more problematic. In many countries, high-speed leased lines are still not available within reasonable time frames and at reasonable costs, if they are available at all. Instead, the common carriers continue to promote national packet-switched networks running at relatively low speeds (64 kb/s or less), and in some cases these are costly and unreliable. It is also worth noting (Paul Peters, personal communication, April 1991) that in much of Europe flat-rate telephone service for residences does not exist, which implies that connectivity to the network from home via modem is simply unaffordable. Thus, although networks are spreading across the globe, the ubiquity of connection outside North America is still significantly constrained. The European Economic Community (EEC), for example, is still discussing how to establish a usable 2 Mb/s international network backbone linking its member countries.
The explosion of connectivity has a number of implications worth mentioning, especially under current pricing schemes, which are not usage sensitive (for end-users) and which are distance independent. The network disconnects the user from the tyranny of geography and time zones and creates electronic client-provider relationships that are distance independent as well as international communities of interest that may seldom or never meet in person but that share common concerns and communicate constantly. Information travels quickly within these communities. Connectivity will affect the spread of information about scientific discovery or political activities and, as the networks become a place to transact commerce, will create a “hot” marketplace where price may be set on a per-transaction basis.

For example, there have been proposals to conduct a marketplace in airline seats over the networks (Kuttner, 1989), which would presume the ability of the airline computers to calculate nearness to flight time, aircraft loading, historical route traffic patterns, and other factors in bidding price and which would allow customer computers to request the best bid from among all the airlines. Purchasers could choose to gamble on low prices at the last minute (due to unsold seats) or hedge against rising costs through early purchase. Some purchases might be offered preferential treatment—a direct extension of current frequent flyer programs. Such a market scheme also permits secondary market makers to appear—for example, speculators attempting to corner all airline seats between New York and Los Angeles for the Thanksgiving weekend—and then reselling these seats. Similar per-transaction models might develop for the purchase of information: “hot” authors (for example, those being awarded Nobel prizes) and “hot” topics (such as those that receive sudden national media attention or papers announcing key breakthroughs) might suddenly have their prices hiked by a publisher’s computer. Of course, the meanings of old commodity-oriented terms, such as “cornering the market” and “secondary market makers,” have yet to be fully defined in a hot networked information marketplace.

Such real-time markets are often unstable and notoriously difficult to manage. They are already present, to some extent, in the financial sector, where computers operated by the large brokerage houses and investment firms conduct “program trading” (a form of computer-directed multiexchange, multicommodity arbitrage) in securities and other financial instruments. According to some, this type of program training has been responsible for at least one major stock market slump (Office of Technology Assessment, 1990).

The increasing internationalization of the networks also may produce some unsettling effects. We have moved from markets governed by national laws and fixed in place and time (such as stock exchanges)
to a 24-hour marketplace built from a concatenation of fixed markets across the time zones of the globe, and now these global, continuous markets are moving into purely electronic venues, divorced from any particular place or locus of regulatory control.

Import and export controls are rapidly breaking down as intangible electronic data and intellectual property move from nation to nation across the networks, and taxation of information crossing national boundaries seems impractical. Some countries, ominously, are attempting to regulate transborder data flow. For example, there are proposals that the flow of personal data be prohibited between countries that have enacted strong privacy laws and those that have not. Equally important, as the international networks develop, it becomes clear that not all countries share common cultures and legal understandings. Science-fiction writers such as Bruce Sterling (1988) have portrayed the development of offshore “data havens” in the third world where information that is regulated in first world countries can be stored and sold outside of government controls. Some nations do not seem to recognize intellectual property the same way in which most first world countries do, and perhaps the first data havens will be collections of pirated intellectual property rather than dossiers on people and organizations developed in contravention of privacy laws. This issue is of sufficient concern that it is currently under study by the United States Congress Office of Technology Assessment as an extrapolation of current problems with, for example, software piracy in Southeast Asia.

It is interesting to consider possible responses to the development of data havens as illustrations of the complexities of the new global networked environment. Other than through international diplomacy, the only way to prevent use of a data haven is to cut off access to the country that hosts these renegade databases and information services. Given the operations of the technology underpinning the Internet, however, it may be impossible to cut off access selectively to hosts in that network. And even isolating a country is very difficult. One can imagine the creation of pirate transborder microwave links to neighboring countries, shortwave packet radio links, illicit satellite uplinks, or any number of hard-to-control international connections. The battle to maintain or cut such links amounts to full-scale application of technologies developed for electronic warfare—jamming, direction finding, and low probability of intercept communications. Even the legal situation becomes murky. A user in a copyright-recognizing country displaying information from a database in a data haven may be breaking the laws of the copyright-recognizing country. But, if that user exports programs to the data haven to “mine” data stored there and only to return certain derived results, the legal status of the user's action is unclear (at least to the author).
Current controversies about cryptographic technology are an excellent illustration of the dilemmas that the global networks create. It is generally agreed that the computer communications networks are frightfully insecure and vulnerable; solving these problems requires widespread implementation of advanced cryptographic technologies such as public-key cryptosystems. Such technology (much of it simply software) is controlled in most countries by law; certainly it is restricted for export. History suggests that governments jealously guard the right to monitor communications—and most of all international communications; this practice reaches far back into the early days of the development of postal systems. Yet securing the networks requires that communications be secured with technology that may be sufficiently robust to secure it from everyone, including governments. And controlling the international proliferation of these technologies is no longer a simple matter of customs enforcement when programs can be sent from one nation to another across the networks.

Services (and Other Things) on the Networks

The purpose of the ARPANET, the now honorably retired initial network in the Internet, was to provide shared national access to expensive computers. It became clear that it also provided communication among people who were attached to the network (through electronic mail) and the ability to share software and data (through file transfer). In the early days, these applications made up the bulk of the user traffic on the Internet. The NSFNET, established in the mid-1980s, was originally intended to provide national access to high-end supercomputers that were located at a handful of NSF-funded supercomputer centers and, over time, to other high-end scientific equipment (such as specialized, massively parallel processors, telescopes, or superconducting supercolliders). Over the life of the Internet, various other specialized equipment has also been connected to the network, including elevators, soft drink vending machines, and toasters. But the service of access to specialized equipment is needed only by a small community of users. (Internet appliances, such as toasters, are still exotic and expensive, and they are not necessarily shared by large communities.)

For the majority of users today, the network provides connectivity for electronic mail, not access to information services. Yet information services are appearing, and users are starting to become aware of their existence and are beginning to try to locate and to use them. As users adapt to the idea of information services on the network and become familiar with the modest, primarily noncommercial, offerings currently available, expectations rise, and questions are asked about the information services that are not yet available through the network.
(The current situation has very important parallels with the introduction of the online catalog in libraries, which immediately led the user community to demand that the catalog be supplemented with databases providing access to the journal literature, source material, more extensive bibliographic records, and links to document delivery services.) Network-accessible information services, compared with supercomputers, are of interest to huge numbers of people. They are the battlefields of the revolution, and it is in this context that the role of libraries is being called into question.

Consider the information resources available to an Internet user. There are perhaps a hundred online library catalogs publicly available (St. George, 1992), although access to the all-important journal literature abstracting and indexing (A&I) databases mounted as part of some of these online library catalogs is blocked since institutions have licensed them from database providers. There are a large number of public access file transfer archives, containing everything from out-of-copyright books in digital form through innumerable computer programs. Although these archives are treasure troves, it is enormously difficult to find anything in them.

The archives problem illustrates several interesting developments that are likely to become commonplace. Most of the archive files available—many of which are small or of relatively transient interest, such as patches to a given release of a software product—are at best described by a very brief author abstract. These abstracts do not use any type of consistent descriptive scheme or vocabulary. The contents of many of the files are programs, which do not lend themselves to automated content indexing. Thus, despite some very clever schemes such as the Archie FTP (file transfer protocol) archive index at McGill University, programs trying to provide access to the archives do not have much with which to work. The root problem is that really effective access seems to require human intellectual effort to organize and to describe the various files available, yet in most cases this effort has not been made. In fact, for many files, the value of the file does not justify the investment of such human labor. Yet the totality of the files, as a collection, is quite valuable and would be made much more so by the availability of such access tools.

There is a wide range of public access campuswide information systems (CWISs) that universities and other organizations have made available that contain information such as weather data, seminar announcements, train schedules, and song lyrics. Government data repositories are emerging, and legislation currently under consideration may increase the amount of federal government information available to the public through the Internet. There are hundreds of listservers and network discussion groups, covering everything from public access
library systems to virtual reality research, molecular biology to computer communications protocols, and public policy to private pleasures (Lynch & Preston, 1990).

What is missing—but likely to appear in the next year or two—are the so-called information utilities (e.g., DIALOG, BRS, and LEXIS) and the providers of source material in electronic form (e.g., publishers). The services offered by these organizations, unlike the current public access services, will be fee based. In many cases, the transactions will be between end-users and commercial service providers. In other instances, the end-user's institution may provide subsidy as a broker/intermediary or by establishing a site license on behalf of its user community.

The forthcoming availability of these for-profit, fee-based services presents a dilemma to the libraries in the network environment. Over the past decade, there has been talk of "disintermediation" as users become increasingly capable of accessing information directly, thereby cutting the library out of the process. In the past, disintermediation has been passive—the library has been eliminated from the process because the user has been able to access information directly, not because the user has been blocked from obtaining access to information through the library. In the past, libraries did not have a monopoly on information access; they offered a relatively efficient, inexpensive means for the user to obtain access to information (Pfaffenberger, 1990). In this sense, the impact of disintermediation during the 1980s has probably been overstated. Many users continued to obtain information through intermediaries (either librarians or professional information brokers) because they offered good, cost-effective service and because they were better than the end-user at gathering relevant information swiftly and at reasonable cost.

In the evolving network environment, however, the equation changes. Even those libraries invested in electronic information—whether as A&I databases or electronic source material—are prohibited by contract or by copyright from making this information freely available to users throughout the network. The end-user must purchase information from the information utilities or directly from the publishers. At least, the user might persuade his or her primary service provider library to license access to the information. But if the user's primary library cannot afford to license access or if the publisher will not deal with the library, then the end-user is forced to deal directly with the information provider.

If these trends continue, libraries will be displaced from their current roles by the networks and the presence of information "owners" on the networks. Libraries will continue providing access to paper-based information but will be largely blocked from using the new electronic
environments for anything but the provision of access to inventories of their (increasingly less interesting) paper-based holdings. Barring major shifts in position by the information owners or major changes in the current structure of intellectual property law, the traditional role of the library will be more and more difficult.

Of course, there are opportunities for libraries to continue serving their primary clienteles in the electronic network environment. A library acquiring material in electronic form will be able to offer it to members of its institutional community. For example, a university library will be able to provide access to A&I databases or to licensed electronic source material to members of their community. But the current free sharing environment of library resources on a national level will be greatly constrained. Users will not be able to use the networks to access any library independent of geography for resources other than online catalogs. And even the institutional library serving the end-user will face direct competition from commercial services.

Particularly threatening is the possibility that the restrictions on information transfer in the evolving network environment will undermine the long and valuable tradition of interlibrary cooperation through such activities as coordinated acquisitions and interlibrary loan. The new electronic environments will continue to restrict transfer of information from one library to another, and the effect will be to cast individual libraries increasingly in isolation. They will end up competing with commercial services to support their primary clienteles rather than operating within the existing model of a national consortium of libraries attempting to provide access to information for each library’s patrons.

The question of user affiliation will become terrifically important. With ubiquitous networks undermining geography, a user might theoretically seek affiliation with any library on the network—or, in fact, any set of information providers. Entrepreneurial libraries may seek “users” on a national basis; information providers will seek to limit the scope of libraries’ user communities. This will be a new arena of competition among libraries and a new area for negotiation between libraries and information providers.

The issue of clientele will also take on a policy dimension, both nationally and internationally. As the electronic distribution and access infrastructure becomes established, the marginal cost of adding third world nations and public libraries to this infrastructure will be relatively small, particularly if these groups only want access to public information and older, out-of-copyright data. The question will be whether they should be given access on a marginal cost basis.

As the national networks develop, others will compete with libraries for the user’s patronage. Organizations such as professional societies (who are, technically, nonprofit, but who have become large businesses
and subsidize a wide spectrum of activities through their publication programs) will become extremely visible and influential as information providers. The American Chemical Society is already moving in this direction. The American Physics Society has recently issued a report from a study group exploring its role in electronic information distribution (Loken, 1990; “Task Force,” 1991) and envisions the development, within the next 20 years, of a massive central physics data repository containing published journal literature, bibliographic citations, and even experimental data. The word “library” does not appear in this vision, which foresees a direct service from the physics community to the physics community, eliminating the library as an intermediary (other than, perhaps, being the organization that sends in the checks to pay for access by academic physicists). Other professional societies, usually smaller and with less secure cash flow, have already “outsourced” their publications programs to commercial scholarly publishers and thus lost control of these publications.

In counterpoint to the existing commercial and pseudo-commercial publishers, a new group of information providers will emerge: the nonprofit information providers who place a high value on public dissemination of their messages. These will include consumer advocates, religious groups of all types, government agencies, and all manner of organizations for the public good or organizations simply determined to get their message across to the public. These groups, in fact, will be eager to subsidize access to their information, in much the same way as they subsidize access today through free leaflets and mass mailings.

The Rise of the End-User Workstation

End-users are gaining more and more computing power. Within the next five years, many scholars and students will develop long-term relationships with the workstations that they are already rapidly acquiring. Today, we are at the trailing edge of time-shared computing economics; some users continue to access networked information resources via terminal emulation to an organization information system. Their organizationally provided system, in turn, helps them access other network resources. Part of the reason for this is that it still is not as easy as it should be to access the spectrum of networked information resources, and software available for end-user workstations does not help as much as it should. Another part of the reason is simply that change occurs slowly.

Within five years, I believe this situation will change radically. A user will discuss information needs with software on his or her workstation. The workstation will access a range of networked information resources (both free and for-fee service), will handle
budgeting among these resources, will synthesize information from multiple sources, will learn about new resources as they become available on the networks, and will perform an active information refining function. There will be no need to involve a local, institutionally based (e.g., local library-provided) system to access commercial or free services on a national and international level. At best, files stored at the local library will be just one of many resources accessed by the workstation software, although perhaps the cost of using information there will be particularly attractive. The independence of the end-user will be the ultimate realization of disintermediation.

The technologies to support such workstation software are already in active development. These include workstation-based user agents (Buckland, 1990), Z39.50 as a common access mechanism for networked information resources (Lynch, 1990a, 1990b, 1991a, 1991b), and plans for machine-processable network information resource directories (Library of Congress, 1991), along with the necessary billing and authentication infrastructure services (Berger & Lynch, 1991).

Within the context of the rise of end-user workstations, three areas need to be addressed: competitive intelligence, multimedia, and user-driven scholarly communication. Competitive intelligence (for lack of a better phrase) is a major, largely unrecognized issue. Multimedia and end-user scholarly publishing are, in my opinion, overly promoted potential results of the workstation transition.

**Competitive Intelligence**

We have discussed “hot” marketplaces made possible by the networks. In a world where end-user workstations negotiate with networked information servers to access current information, some users need to know what information other users are seeking. Just as today we are beginning to see credit card companies mining their databases for salable information (for example, American Express might gain a considerable return on a finely targeted mailing list of people who spend more than $20,000 per year on airline tickets and who spend less than $1,000 per year on United Airlines), one can imagine DIALOG selling attributed searches in chemical databases by pharmaceutical corporations. There might be two rates: one where the searches are confidential, and one where the searches are available for purchase by the competitive intelligence aftermarket.

This world rapidly comes to resemble the old “spy-vs.-spy” and “spy-vs.-spy-vs.-spy” comics in MAD Magazine. One can imagine a pharmaceutical company commissioning the development of a computer program that deliberately searches large databases under the “resale permitted rates” and submits searches that, when analyzed by the competition, deliberately leads competitors down blind research alleys.
In a world of network-based information seeking, information and disinfection about information seeking are fungible commodities.

One can imagine as well the development of software that exploits information about who is searching what, and information that becomes more valuable as it becomes clear that more people are accessing it. Consider visions such as the Worldnet portrayed by David Brin (1990) in his recent novel Earth, in which users can configure personal information triggers: Show me news items in Category X that have been accessed by more than 1 percent of the network users in the past twelve hours. Such networks become complex, dynamic social and economic systems, incorporating elaborate feedback mechanisms and are subject to all manner of manipulation.

The full effects of point-of-sale (POS) tracking technology—the now ubiquitous bar code scanners in supermarkets, bookstores, record stores, and similar establishments—are just now becoming apparent. In the period during which this paper was written, two major milestones were reached. Supermarkets began to accept credit cards (at least in California) on a broad basis, permitting the collection of extraordinarily detailed data on the purchasing habits of anyone using a credit card at the supermarket. And Billboard, which tracks sales of recorded music, converted to POS data in the midst of considerable controversy over the fact that some very large record stores were not yet providing POS data to the firm that licenses this information from the stores, processes it, and resells it both to Billboard and to the major recording companies (for hundreds of thousands of dollars per company per year). The amount of very timely, very detailed data now available to track both market movements and individual purchasing habits for consumer goods will have an enormous effect on marketing and advertising as companies learn to exploit it, and a number of information brokers and refiners will profit handsomely as they help to gather and exploit these data. As the acquisition or use of information becomes more transactional, similar trends and players are likely to emerge. Circulation data may be a valuable and salable commodity for libraries (hopefully with appropriate privacy safeguards); sales data for acquisition on demand systems may become equally valuable (and will less likely contain the privacy safeguards we might like). If you use a credit card, "they" already know, or can know, for the cost of some computing cycles, a great deal about the books and recorded music you choose to acquire.

Bob Lucky’s (1989) picture of executive workstations trading office gossip about who’s getting raises, who’s getting fired, and who’s sleeping with whom on behalf of their owners may seem not only farfetched, but funny (at least the way Lucky tells it); but all it really requires is a program imbued with a bit more personality and ambition. Most of the data are already there.
Multimedia

The development potential of multimedia information as workstations proliferate has received much attention. This may in fact be chimerical: Multimedia require the author to be an orchestrator, movie director, scriptwriter, graphic artist, etc. Most multimedia today are built upon the recycling of existing musical scores, films, and images, generally in total violation of copyright laws. It seems likely that the costs of multimedia content development/acquisition will restrict development of new, "legal" multimedia to a handful of very broad-based entertainments (some with educational importance, much like today's public television programs). The average scientific communicator may be unable to develop readily legal multimedia products for distribution over the network, having neither the time, the skills, nor the licenses for components to be integrated into a multimedia work.

As an educational medium, multimedia will probably have greatest impact at the elementary to high school levels where large numbers of students study the same material, which changes very little from year to year. Here the unit cost of elaborate multimedia "textbooks" is reasonable. These costs will likely even be acceptable for introductory college courses, but it is hard to believe that it will be cost effective for advanced graduate texts and research monographs. In these areas (excepting the occasional "jewel"—a scholar's lifework, perhaps subsidized by a large grant), only modest use of sophisticated multimedia seems likely to occur in most disciplines, at least without a major revolution in authoring tools and the creation of large public domain sound, image, and video databases that can be used as source components. For routine scientific communication, text, still images, computer programs, data files, and perhaps modest amounts of audio (recorded voice) will define the scope of multimedia. The files generated by users of the NeXT multimedia mail system probably give a good sense of the level of sophistication we can expect.

A second aspect of multimedia is the problem of access to existing multimedia collections, such as film and television archives, and to new multimedia content that will be developed. Here, the prospects are equally grim. Consider a resource such as the University of California Los Angeles film and television archives. A scholar today could spend a lifetime mining a tiny part of the riches of such a collection. We do not know how to index movies or television programs for effective access, and technology will probably not provide a solution soon. Even in the more limited domain of paintings or photographs, despite the vast expenditure of resources by organizations such as the Getty Art History Information Program and the contributions of some very fine thinkers on the subject, we have only a superficial understanding of
how to describe (index or catalog) a great painting, and most of the thinking to date has not been tested in a real-world environment of public access to large databases. Thus, it seems likely that effective intellectual access to multimedia resources will remain a major missing link long after these resources become accessible (in that one can view or transfer them, if one knows what one is seeking) across the network.

**Personal Scholarly Publishing**

Some who envision the future of networked information foresee the potential of each scholar to be a publisher. A user could store files of important research results on a workstation and advertise the availability of these files on the network, thus bypassing the existing apparatus of scholarly publishing. Scholarly information would thus be freely available. Libraries might develop new roles helping scholars to become publishers and providing catalogs of available information.

There is a basic fallacy in these visions, however, that must be addressed bluntly. For the purposes of tenure and promotion (a primary motive for scholars to publish), acceptance of a paper by a major scholarly journal is essential. Even if promotion or tenure is not at stake, professional reputation often is based on publication in the “right” journals. Transfer of copyright to the publisher—a professional society or a commercial publisher—is a basic condition of publication. There is a vicious circle here. Until personal publication on the network is viewed as having equal value as “legitimate” scholarly publication, only a few visionaries will practice it. Copyright will continue to be the major tool for restricting access to information by the commercial or quasi-commercial (professional society) publishing community, and libraries increasingly will be left out of the cycle.

Furthermore, those who do self-publish will risk obscurity for another reason: Nobody will be able to find their work. In a growing torrent of publication, increasingly elaborate A&I databases will become a primary resource for locating important literature (along with traditional methods, such as citations in other works and word of mouth). Currently, A&I databases play an important role in continuing to legitimize and affirm the status of the primary scholarly journals. It is philosophically unlikely and economically perhaps infeasible for these A&I services to cover an infinity of self-published literature, unless one postulates extensive changes in the way these services do business. For a fee, the author might submit a document to one of these services for review, and if the service favorably reviews it, then the citation to the work on the author’s workstation would be published in the database. But, in such a world, the A&I service itself begins to function very
like a journal with page charges. And it is only a small step, then, to having the A&I database demand rights to act as a distributor of the accepted documents.

In summary, I view the rise of the end-user workstation as the development of a very sophisticated access device to networked information resources and a potential disintermediator for libraries. As more and more access becomes electronic, new information markets (such as competitive intelligence) will develop, much as the extensive conversion of financial markets to electronic transactions (for example, the adoption of credit cards by consumers) has created (and continues to create) a myriad of new information markets since the 1960s. I do not think the workstation is a major tool for shifting the locus of control or ownership of information—although I would like to be proven wrong. Although sophisticated multimedia will be available on the networks and viewed on workstations, it will be less common and more costly than many people expect. And unsophisticated media are likely to be oversold in terms of their impact.

The Development of the Information Refiner

Almost everyone depends on information for some aspect of their personal or professional life—for example, for scholarship, business strategy, investments, or health—and, in all fields of endeavor, the information user is about to be swept away by a swelling flood of information. There are many causes: the growth in human knowledge and publication, the increasing use of electronic media, the increasing internationalization of many aspects of commerce and scholarship, the development of round-the-clock financial markets, the proliferation of sensor systems, and the development of computer-based tools that can exploit real-time or near-real-time information and take action upon it.

Services that can filter, sort, organize, and prioritize this information flood will develop in all fields in this decade. They will not, typically, create information; rather they will distill information into knowledge by collecting it from multiple sources, correlating it, and evaluating it. It seems likely that, by the turn of the century, many information seekers will deal with these new secondary services rather than with primary information suppliers. Implementations of such services will range from purely automated systems—for example, a program that scans newswires and uses a combination of keyword matching and superficial linguistic analysis to extract news items that fit a user's interest profile—to purely human-based systems perhaps as simple as weekly recommended readings sold by major authorities in research fields or abstracting and summarizing services in narrowly focused subject areas. (In the 1970s and 1980s, there was a huge growth in costly,
specialized newsletters tracking developments in various fields of finance and technology; in the 1990s, these newsletters will evolve into network-based real-time services.)

In scholarly publishing, the issue will be not so much whether one can get an article published but whether a scholar can convince the various information refiners to present it to the community as worth reading. In some ways, this resembles the current situation where the scholarly journals function as "gatekeepers," but the new information refiners are likely to be quite different in character from the peer reviewers of today's scholarly journals, in ways that we do not yet fully understand. If nothing else, they are liable to be far more selective in their ratings of information and far less concerned with academic and professional courtesies.

ACCESS TO INFORMATION: THE RICH AND THE POOR

Sol Yurick (1985) authored an extremely important, but little-known meditation on the social, political, and cabalistic implications of the new electronic world, Behold Metatron: The Recording Angel, which should be required reading for anyone concerned with the new electronic technologies. He argues that if information becomes the new coin of the realm, then not all information will be available to everyone. In fact, information will be more tightly held and more dearly sold. We are not entering an age of universal wealth. There will still be the rich and the poor. To be sure, there will be more information than ever, with a wider range of prices than ever. Some information will be cheap and readily available—but it may not have much value. This point is often overlooked in discussions about the possible roles of libraries in the future world of electronic computer networks. Consider the three major sectors of libraries in the new universe of pervasive electronic information.

Academic (Research) Libraries

The challenge for these institutions will be to provide excellent service to their primary clientele in an environment of competition from information brokers, commercial publishers, and professional societies. They will succeed to the extent that they can subsidize access to information for which the user would otherwise have to pay and to the extent that they can add value by organizing, selecting, and refining the commercial offerings (a point discussed in the next section).

The great research libraries will face other dilemmas. Due to restrictions on licensed electronic information, they will be less able
to act as the libraries of last resort standing behind public libraries, special libraries, and smaller academic libraries. For older (out-of-copyright) information, because networks will facilitate faster information transfer, smaller libraries will discard collections choosing instead, in the face of growing budgetary pressures, to rely on a few major research libraries to fill requests, thus transferring the cost burden to these few large libraries. (And these large repository libraries will increasingly recharge their real costs for servicing interlibrary loan requests.) This trend is already apparent as libraries respond to serials costs increases by canceling subscriptions and relying on interlibrary loan, but in the future, this approach will become less effective as publishers constrain transfer from one library to another through licenses to electronic information.

Furthermore, the nature of the great research library is twofold, and increasingly the two aspects are in opposition. The great research library should offer superlative service to its clientele—that is, access to information and help in locating and obtaining information. But also, the great research library houses a great collection—including things that nobody wants now but that may be critical to future scholars' understanding of the world of today. The very notion of collection is under numerous pressures in a world that is moving to electronic information. There is the sheer proliferation of material (e.g., print, electronic discussion lists, radio programs, television programs, movies, computer games, and recorded music). And there is the fact that as information rightsholders move from public law (copyright) and sale to license (contract law) for electronic information, the library does not actually own anything—it merely has a license to a set of electronic material for a fixed period of time after which it must pay more license fees.

The material of scholarship is not always economically viable. A publisher housing material on a network server for acquisition on demand may find, after a certain period of time, that the usage rate on this material is so low that it is not cost effective to keep it accessible on the network. As the cost of computing and storage drops, the crossover point will shift, but if the material is not used, eventually it will not be cost effective to keep it available for sale. The publisher is then liable to take the information electronically "out of print." In a license environment, no library will necessarily "own" a copy of this material to preserve its availability for future scholars. Mechanisms are needed to ensure that copies of such materials are maintained for future access—if not by publishers subject to the economic constraints of profitmaking corporations, then by libraries subsidized for the public good. And simply devising a code of "good behavior" for publishers on the network, which suggests that they submit materials they are taking "out-of-print"
to some library-financed repository, may not be sufficient to preserve the continuity of the scholarly record.

Special Libraries

Some special libraries will behave much like narrowly focused academic research libraries; the rest will become irrelevant. In fact, it will be increasingly hard to distinguish the successful special library of the future from an academic research library in terms of services offered to the user community, except that special libraries will support a more limited set of disciplines than a university library and perhaps support them in more depth.

Special libraries may find that they have another new advantage over the larger general research libraries. Some information vendors or refiners may choose not to sell to public or large academic libraries (or to sell only at impossibly high prices) because the value of their information is in its scarcity, and they are unwilling to dilute the value over the large user communities of larger libraries. But they may be willing to market to special libraries (for example, those supporting corporate research and development efforts) because they know that the information will remain closely held. Again, the beginnings of this trend are already visible: Corporate libraries regularly acquire expensive research reports and newsletters; these are not commonly found in academic libraries. It is unclear whether this is because of the high cost of the material or because the information suppliers do not want to sell to the academic and public library sectors. Certainly, the information vendors are not marketing to these groups and are not making their materials easy to acquire—for example, they are not working much with the jobbers that service most major libraries.

Public Libraries

The future for this sector of the library community is the most perilous. Many smaller public libraries will be reduced to lending current novels and will be unable to fill other information needs for their user communities. They will have neither the funding nor the expertise to operate as intermediaries to electronic information, either as access subsidizers or refiners. In some ultimate sense, of course, public libraries are not endangered: Although scholarly information may migrate relatively quickly to electronic form, popular novels and self-help books will persist in paper form indefinitely, and thus the economics of shared acquisitions and lending for this material will continue to be viable indefinitely. The issue is the size of the constituency that the public libraries will be able to serve.
The general public will become increasingly information poor. Aside from those users who can affiliate with some academic or special library with the funding to underwrite their access to information, the general public will have to fund their own access to information or lose access altogether.

Ken Dowlin (1990) of the San Francisco Public Library uses the slogan "Ignorance kills" to emphasize the importance of public libraries as providers of information, particularly to those otherwise disenfranchised. He speaks of access to information about health, finances, community services, and educational opportunities. But, realistically, what quality of information in these areas will libraries be able to license and provide?

One often thinks of public libraries as primarily serving the adult populace, but they also fill other key roles, such as supporting primary and secondary school students and local businesses. It is in these areas that access to electronic information will be most essential to the health of commerce and education in the community, and the public library will face massive problems. Research libraries will be less able to be the provider of last resort for the public libraries due to the license restrictions already discussed. In addition, seekers of information will face a discontinuity that is already growing visible, leaving the public libraries to stand or fall on their own, increasingly meager, resources.

The currently available sources of health and medical information illustrate this discontinuity. It seems likely that some relatively low-cost "general public" databases will be developed for the mass market, perhaps at the level of current popular press articles on medical and health matters; some prototypes are already available, targeted for public library markets. But an information seeker wishing to delve even a little deeper is immediately confronted by a huge chasm: The next step is a very costly, complex, sophisticated database such as MEDLINE®, which, if the user has access to information only through a public library, is unlikely to be available unless that user purchases access personally. And, even if such access is purchased, there are the dual problems of obtaining the source material located through such a database as interlibrary loan becomes increasingly constrained by electronic information licensing and of simply understanding the citation information availability through a "specialist"-oriented database like MEDLINE. The same problem appears in many other fields. There is no longer a smooth transition from information intended for the layperson to that aimed at the specialist. And electronic information will be more complex than today's paper-based materials.

The library that flourishes in the 1990s will have to walk a tightrope across competing demands (each of which can absorb a near-infinite amount of money) to
1. continue to acquire "traditional" paper-based information;
2. acquire or provide (subsidize) access to electronic versions of the existing paper-based reference works, journal subscriptions, and similar materials;
3. acquire or provide (subsidize) access to A&I databases that provide access to the journal literature—materials held by the library as well as those available through interlibrary loan or document supply services, and existing both in paper and electronic forms;
4. acquire or provide (subsidize) access to new electronic-only forms of information: e.g., listserves, netnews, multimedia publications, numeric databases, weather information, factual databases; and
5. acquire, develop, or provide (subsidize) access to the information refinery services—evaluative, correlative, and filtering services—to control the flood of information generated by the first four demands.

A successful library in the 1990s must address all of these areas. The balance achieved will depend on the library's mission, as viewed by its management, and on the demands of its constituency. The library management must recognize that consensus is unlikely to emerge from the user community demands. User communities may fragment instead into competing factions with opposing agendas. And the most discontent of the factions, particularly if they are not advocates of expanding paper-based archives, will be fair game to competitors to the institutional library that will populate the networks.

CONCLUSION: NEW ROLES FOR LIBRARIES IN A WORLD OF NETWORKED INFORMATION

The traditional library mission has four major components:
1. to select and acquire information,
2. to house and preserve information,
3. to organize information, and
4. to provide access to information.

Compare this list of traditional functions to the pressures on the library of the 1990s enumerated above. The demand for acquisition—now generalized to encompass both traditional purchase and provision of access (via purchase-on-demand agreements or fast interlibrary loan) predominates. The archival functions are overlooked. In a sense, the archival role is sacrificed to the marginal pricing advantages of provision of access for the great research libraries. As acquisition becomes more user driven, the library's role in selecting a long-term collection is reduced. Further, more and more of the traditional library role in
information organization—at least as it is understood today—is carried by copy cataloging and the purchase of A&I databases.

But there are new roles for libraries that combine elements of the four traditional missions. Libraries can play a vital role through evaluation and selection: They can choose information refiners, or they can, themselves, be information refiners.

Making the transition will require that libraries become much more comfortable in evaluating and determining the value of information. Historically, libraries' acquisitions decisions have basically been made based on information evaluation, but beyond acquisitions, they have assigned equal value to all information. There are many prototypes in progress that define librarians in new roles as information organizers, refiners, and evaluators, offering services ranging from low-cost, low-technology, but highly effective, review services, such as Current Cites at the University of California, Berkeley, which provides brief alerts of new and important publications in library and information science fields, through the costly, complex, sophisticated Knowledge Management process pioneered by Nina Matheson and Richard Lucier at Johns Hopkins University (Lucier, 1987, 1990). Unfortunately, for every project that involves libraries, there seem to be several that do not.

The central issue for libraries is how they can add sufficient value to guarantee their continued role in a world transfigured by information technology, ubiquitous computer networks, and massive disintermediation. Simply purchasing a role by subsidizing information access will not be enough in the long term, unless it saves a great deal of money for the institution. For institutional managers, increasingly concerned with short-term popularity, current fashions like "empowerment"—in this case, being used to justify the transfer of funds directly to the end-users and allowing them to purchase information from any supplier on the network—will have great appeal (and will attract great support from the end-user community), even though much of the library's archival function will be sacrificed in the process. Why preserve continuity of the scholarly record when the alternatives are tangibly reduced costs and empowered, happy end-users? It is possible to draw some comparisons to the restructuring of corporate America that has occurred in the past two decades? The focus on short-term profitability has, in some sense, led to an efficient corporate world, but one that promises serious weaknesses in long-term competitiveness and the development of the industrial and research base in the United States.

There are several areas in which libraries can add intellectual value. Information evaluation and filtering have already been discussed as has the creation of new information (often through partnerships with researchers) that the library can sell, broker, or otherwise control, thus
placing the library in the role of primary information provider rather than simply as an information intermediary. Two other major roles are obvious. The library can organize and integrate the complex and fragmented information access environment. The beginnings of this role are apparent in the efforts of various librarians to help their communities navigate the Internet and employ the various information resources. Finally, libraries can continue to earn a role—perhaps an expanded one—as information intermediaries. It is true that more information is end-user-accessible and that the access software is becoming easier to use. At the same time, the total amount of information available is growing very rapidly, and some of it is complex and difficult to search and evaluate. Some libraries may forge effective partnerships with researchers as specialists in gathering information to support the research enterprise. If the libraries as institutions fail to do so, entrepreneurial librarians will move out of the existing library organizations in ever greater numbers to become part of research activities directly. This new breed of information specialists will combine deep area expertise with skills in information management, searching, evaluation, and organization.

Revolutions are times when the unthinkable becomes possible. One need only consider the changes that have occurred in the financial and commercial worlds since the introduction of networks and information technology to see the extent of the unthinkable changes that can, in fact, occur seemingly overnight. (To see a marvelous example of such changes, consider the trajectory of the House of Morgan from 1930 to 1989 [Chernow, 1990] from the most conservative of investment bankers to one of the most aggressive participants in the hostile takeover frenzy of the late 1980s.) Recent political events have also reacquainted us with revolutions. Who, a mere two years ago, would have predicted not only the liberation of Eastern Europe but also the breakup of the Soviet Union? The unthinkable can, in fact, happen, sometimes more swiftly than most of us want to believe. Existing institutions must rejustify their roles and value to their constituencies in the face of new alternatives for those constituencies. This is precisely the challenge that the network information revolution is creating for the institution of the library.

A POSTSCRIPT: TRAINING FUTURE INFORMATION PROFESSIONALS

The keynote speech that was the basis of this paper was made at a conference sponsored by one of the leading schools of library and information science. Many of those present at the conference were educators and students. Thus, in closing, it seems appropriate to focus
briefly on the future role of the library schools in the new world of networked information.

Although the role of libraries may be in doubt, I believe that there will be an enlarged demand for information specialists. (I do not think the term "librarian" is appropriate any more, although what are now called "library" schools may well serve as training grounds for many of these professionals.) In this sense, library schools may look forward to a promising future, if they rise to the challenge. Emerging fields such as medical informatics and large-scale scientific data management offer opportunities for library schools to expand and refocus their roles (perhaps through joint programs with other departments) in training the specialists that will be needed in the future. Following behind these immature, but now well-established disciplines, are new fields of study that as yet have no defined names but that deal with information, networks, and advanced computing technology. It is interesting that at many institutions, existing departments of computer science have not focused strongly on these new areas.

At the same time, a massive overhaul of library school curricula will be needed if these institutions are to produce graduates who can contribute to and thrive within the changed world described in this paper. Furthermore, this curriculum will have to be taught not only prospectively to people entering the field but retroactively to large numbers of established library and information professionals. This curriculum must include a comprehensive coverage of the various technologies fueling the revolution—advanced user interfaces, mass media, computer networks, and database technology. It must include study of the exploration and uses of information resources, which needs to be coupled with study of information organization and use, but from a perspective founded more on basic theory than on the mechanics of today's practices. (An excellent recent book illustrating the shift in emphasis I believe is needed is Michael Buckland's [1991] Information and Information Systems.) Finally, many students will also need to gain thorough knowledge of one or more applications disciplines—medicine, meteorology, finance.

This is not to say that the current, rather vocationally oriented courses need to be abolished, any more than the networked information revolution will lead to the abolition of all libraries as we know them. But the world will become more segmented, and the demand for traditional librarians will follow the diminished role and importance of libraries that remain staunchly traditional. Library schools, as institutions, need to decide whether they will look to the past or to the future. And, if the schools look to the future, they and their graduates will play a central role whether or not libraries as institutions manage to rise to the challenges of the networked information revolution. The
winners of the network information revolution, be they libraries or new institutions that develop to supplant them, will require a new breed of information specialists. The library schools are the obvious training ground for these professionals.

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