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## Networked Delivery of Full-Text Electronic Journals: Diverse Options, Shared Limitations

### INTRODUCTION

The term "electronic library" does not yet have a widely accepted meaning in the academic world. Online catalogs, online searching, CD-ROM (Compact Disk-Read Only Memory) stations, and electronic mail, all of which have become familiar (though not quite ubiquitous) in the academic world, herald the arrival of the electronic library to some. To others, the concept of the scholarly electronic library implies a decentralized information distribution system that provides faculty and students with access to the materials and services they require, free from the space and time constraints of the physical library. This has yet to be achieved anywhere in academia.

Scholarly journals play a central role in research and education, so the degree to which they have been freed from the bounds of the print medium is an important measure of progress toward the realization of the "full-service" electronic library. In fact, numerous services claim to deliver full-text electronic journals today, including the following:

- commercial online services such as DIALOG, BRS, and STN;
- CD-ROM collections such as ADONIS and UMI's Business Periodicals OnDisc and individual titles from scholarly societies and other publishers;
- electronic-mail-based journals such as *Psycoloquy* and *Bryn Mawr Classical Review*;
- locally mounted files, obtained on tape or other media and made accessible with full-text search systems, such as BRS/Search, Verity's Topic, Fulcrum's Ful/Text, and others;
- unique services and experimental projects such as the OCLC/AAAS *Online Journal of Current Clinical Trials*, the CORE (Chemistry Online Retrieval Experiment) project at Cornell, Red Sage at University of California at San Francisco, Project Mercury at Carnegie-Mellon, and Elsevier's TULIP project.

A variety of software tools (e.g., Gopher, Wide Area Information Servers [WAIS], World Wide Web [WWW], and File Transfer Protocol [FTP]) permit archives of network-based electronic journals to be browsed, searched, and

copied—all from the comfort of one's own home, lab, or office. Each service and access mechanism has something different to offer in terms of cost, accessibility, timeliness, accuracy, faithfulness to the original (if there is a print equivalent), functionality, ease of use, comprehensiveness, performance, and other characteristics.

Yet despite the seeming diversity of options, the great interest that the topic has generated, and the enthusiastic response to many of the services, when one scratches the surface, all is not well with today's electronic journals. Electronic journals available today do not compete favorably on many points when compared to their print counterparts. Problems with readability, portability, user comfort, browsability, flexibility of format and content, navigability, access mechanisms, etc., are commonplace and make clear that the electronic journal is far from being a mature form.

Although point-by-point comparisons between electronic and print journals may seem inappropriate, the rationale for making them is understandable. The long history of scholars' reliance on print journals for current awareness, sharing results, evaluating the quality and legitimacy of new research, establishing credibility, and providing a permanent scholarly record places a heavy burden on any new medium that attempts to supersede them. Alternative communication and publishing mechanisms that fail to provide equal or superior functionality in these and other critical areas will not readily be accepted by the scholarly community.

Much work remains to be done before electronic journals can reproduce many of the best features of print journals. Given the demands that electronic capture and dissemination of journal content make on computing systems, and the fact that affordable equipment, appropriate software tools, and a sufficient networking infrastructure have only appeared recently, it is not surprising that print, which has had several centuries to be polished and refined, still holds an advantage in some areas.

A great deal has already been written about possible new models for the distribution of scholarly publications in electronic form and the financial impact they may have on libraries, publishers, authors, and end-users. Popularizers of network electronic journals have emphasized the push side of the push-pull dynamic in scholarly communication (Harnad, 1992). That is, they have touted the value of nearly instantaneous and wide-scale distribution along with the possibility of immediate feedback, without giving serious consideration to how the format and content of such publications will affect their reception. More exploration is needed of the implications of the technical underpinnings of electronic journal systems for libraries, librarians, and end-users.

This paper will explore some of the difficulties and limitations facing the current generation of electronic journal initiatives, as well as some potential solutions. Many of the examples will be drawn from endeavors underway at Cornell University's Mann Library, where an electronic library has been "under construction" for over a decade, and where a variety of electronic journal efforts are being conducted.

#### THE RESPONSIBILITIES OF THE LIBRARY IN A VIRTUAL WORLD

Having myriad choices for obtaining the same kind of information can be seen as an embarrassment of riches or a confusing jumble. Collection

development librarians are used to making hard choices about what resources to purchase with limited acquisitions funds. But they have not previously faced the complexities imposed by the nature of primary information resources in electronic form. In fact, there has not been much opportunity for libraries to influence the format or presentation of materials in the past. Academic librarians have become accustomed to identifying what materials to buy, organizing them and providing access to them, aiding in their use, and preserving them in usable condition. The question, "Does ink on paper serve the needs of our clients?" has not generally been asked, because there hasn't been an alternative.

On the other hand, machine-readable data are almost infinitely flexible, but there are precious few standards for display, searching, or interchange. More options are thus coupled with far greater responsibility. Although electronic catalogs and indexes of library holdings and scholarly publications are commonplace now, the manner in which primary publications in electronic form support the pursuit of scholarship remains largely untested. We must now ask whether this material really serves the needs of users, and if not, what should we do about it?

Some data on how well electronic systems serve the needs of scholarship were gathered in a large-scale study of the uses of the journal literature by faculty members in the chemistry, sociology, and English departments at Cornell University and the University of Pennsylvania (Olsen, 1993). The study revealed numerous perceived weaknesses in the design of electronic information systems, both in terms of the manner in which they support intellectual activities and their ergonomics. A few of the conclusions of this study include the following:

- In some disciplines, the absence of graphics and/or special characters and symbols dramatically reduces the utility of a resource.
- Users are uncomfortable reading computer screens for any length of time.
- Navigational tools of existing electronic information systems are weak. Scrolling in particular was criticized as a poor substitute for page turning. Poor mechanisms for browsing were seen as inhibitors to serendipitous discovery and creative thinking.
- Electronic searching capabilities were generally praised as a major advantage over print. However, much of the random or less-directed activity that scholars described as typical of their interaction with journals is not well supported in the electronic environment.
- The portability of print is a major advantage over electronic information systems.

In the next section, I will examine some of the underlying causes of the aforementioned complaints, and I will discuss some of the work being conducted at Mann Library to overcome the obstacles to providing network access to electronic journals.

## DESIGN PROBLEMS OF ELECTRONIC INFORMATION SYSTEMS

### Missing Graphics and Special Symbols

The fact that many electronic journals consist of nothing but ASCII text reflects two problems. The first is the predominance of VT100 terminal emulation as a network telecommunications standard. Character-based terminals

used to be the only way of communicating with a remote computer. Yet today, with powerful desktop personal computers, graphical user interfaces, and high-speed local and wide area networks (LANs and WANs), VT100 emulation still dominates the telecommunications landscape. In today's heterogeneous computing environment, this is less a technological than a standards issue.

The second problem is at least partially a derivative of the first. VT100 emulation enforces use of unadorned ASCII text, which does not permit, for example, the transmission of graphics. Thus, use of ASCII makes meaningful communication in many fields of scholarship nearly impossible. It is no accident that most of the early network-distributed electronic journals are in fields that can manage pretty well with ASCII. Yet even in disciplines where graphics and non-ASCII characters are essential for publication (e.g., most science and engineering fields, music, and art history), there is a paucity of machine-readable text and graphics, and much of what is available is simple ASCII text. This situation prevails despite the fact that most publishers converted to electronic composition systems quite a few years ago, and such systems require the creation of machine-readable text prior to publication.

Unusual amongst publishers, the American Chemical Society (ACS) began to retain the input files for its phototypesetting system in 1975 and began exploring uses for them other than the production of print journals. These files contain all the information necessary to produce the textual portion of ACS journals on paper, including references to the many special symbols used in chemistry. For many years, these full-text files (largely stripped down to plain ASCII) have been available for searching over STN (Science and Technology Network) as part of the CJO (Chemical Journals Online) datafiles. With these same files as the foundation, ACS is now participating in the creation of a full-fledged networked electronic journal system—including the complete special chemistry character set and all original graphics—as a collaborator in the CORE (Chemistry Online Retrieval Experiment) project.

The CORE project, a collaboration involving Cornell's Mann Library, Bellcore, OCLC, and ACS and its Chemical Abstracts Service division, is using SGML (for a discussion of SGML applications for personal computers, see Flynn [1993] and Karney [1993]) to tag the full text of 20 ACS journals going back to 1975. SGML is substituted for the original ACS proprietary markup by a translation program. SGML permits and/or facilitates (a) customized restructuring of the text on a display or hard-copy device; (b) fine level fielded searching of text from all elements of the original document; (c) references to nontext objects such as graphs, equations, and bitmapped figures; (d) references to characters outside of the ASCII set; and (e) some hypertext features.

SGML is a powerful tool, but it alone does not solve the VT100 problem. An alternative to VT100 emulation, which is becoming more widely used with improvements in hardware, software, and networks, is the X Window System (hereafter just "X"). X has the potential to address several of the criticisms of electronic journals mentioned by scholars, but especially those concerning the absence of important content features. X is being used for development of all user interfaces in the CORE project.

Like many disciplines, chemistry relies heavily on nontextual material in its publications. ACS did not have any of the graphics from its journals available

in machine-readable form, so these had to be captured by scanning from paper and microfilm. The files resulting from scanning are bitmapped page images.

A bitmapped image of a page from a print journal can offer much that is missing from an ASCII representation. All the elements that are impossible to represent with an ASCII display are present—all the illustrative matter, all the unusual characters and symbols, all the text attributes and structure that give the printed page much of its readability.

Unfortunately, bitmaps have several major drawbacks. One has to do with the nature of bitmapped page images. Since bitmaps are just streams of data representing dots, it is not possible to do much more than display them unless further processing is undertaken. The text represented cannot be searched, and there is no positional association between the dots and the content they represent. Thus, features such as highlighting and hypertext links, which can easily be accomplished with electronic text, are difficult to achieve.

Another drawback is storage size. Experience has shown that bitmaps scanned at less than 300 dots per inch (dpi) capture insufficient detail. A typical 300-dpi scan of an  $8.5 \times 11$  inch page in monochrome (i.e., each dot is either black or white, no color and no shades of gray) from one of the ACS journals takes up about a megabyte before compression. (The use of monochrome bitmaps was considered acceptable in the CORE project since ACS journals contain little color or halftone material, but would be more difficult to justify in fields where journals have heavy photographic content.) Compression (using the CCITT Group 4 fax standard) can reduce this to about 100 kilobytes per page. This is at least 10 times the size of even a heavily marked up page of ASCII representing the same text (minus the images, of course).

The large size of bitmap files has influenced the kind of hardware used to store them. Most projects and products utilizing large collections of bitmaps employ optical storage media, such as CD-ROM and WORM (Write Once Read Many), since they provide the most economical large-capacity storage solutions available today. But consider that even with 600 megabytes of available storage, a single CD-ROM can only hold about 6,000 pages of compressed monochrome images. The ACS alone produces about 100,000 new journal pages each year. The cost advantage of optical media is quickly lost if one drive is provided for each disk, so mechanical jukeboxes, in which a robot arm manages the insertion and removal of a large number of disks in and out of a small number of drives, are used.

Optical drives result in access times and data transfer rates on the order of 10-20 times slower than magnetic drives. Jukeboxes can have anywhere from a few to hundreds of shelves, but usually only two or three drives. Thus in a heavily used system, there is considerable competition for the few drives, and substantial retrieval delays can result. Add to this the time required to decompress the image before display, and the period between request and ultimate display can be quite lengthy.

The CORE project is taking steps to deal with some of these problems. The most obvious remedy is to take advantage of faster technology as it becomes available. Servers with faster CPUs cut down on decompression time. CORE is also utilizing an optimized Group IV fax decompression algorithm in order to lessen the time required for image decompression. New networking

technologies such as FDDI (Fiber Distributed Data Interface) and ATM (Asynchronous Transfer Mode) cut down on data transmission times. Mann Library took advantage of the installation of a fiber optic backbone at Cornell and connected the CORE servers to it shortly after they became available.

We are also making the bitmapped page images available in two resolutions. In addition to the original 300-dpi images, we are offering a scaled down image at 100 dpi that has been enhanced for readability. The lower resolution images can be transmitted more rapidly across the network (they are about one-fifth the size of the high-resolution files), and we are able to store the most recent couple of years on magnetic drives for rapid retrieval.

A more unusual approach is to combine the best of the ASCII world and the bitmapped world. CORE is experimenting with two interfaces (Scepter from OCLC and SuperBook from Bellcore) that combine SGML machine-readable text with bitmaps of just the graphical portion of each page. The resulting file (including indexes) is small enough to store the complete contents of nearly three quarters of a million pages on fast magnetic drives.

However, speed of retrieval is only one aspect of total system performance. By exploring multiple techniques for presenting the same data, we have an opportunity to compare and contrast various functional parameters as well as important user preferences.

Others are working on overcoming some of the other limitations of bitmaps. The RightPages application from Bell Laboratories has focused on how to extract more information from bitmaps (Story, O'Gorman, Fox, Schaper, & Jagadish, 1992). They have developed algorithms for cleaning up bitmap images (to improve the accuracy and reliability of other post-processing activities), for identifying important structural components of certain critical journal pages (e.g., the table of contents) and for improved display of scaled down bitmaps. RightPages is a component of a new experimental electronic journal collaboration called Red Sage, involving Springer-Verlag, AT&T Bell Labs, and the University of California at San Francisco (Jacobs, Lucier, & Badger, 1992).

### Reading from Computer Displays

Lack of comfort reading from computer displays stems largely from limitations in computer display technology. The resolution of displays sold even with high-priced engineering workstations rarely exceeds 100 dpi, much less than what can be achieved on the printed page. Other problems derive from low refresh rates (which causes subtle flicker) and glare.

Within the CORE project, we are trying to make due with the limitations of current technology. Only a small portion of a 300-dpi bitmap of an 8.5 × 11 inch page can be viewed at any one time on a 19-inch display with 75-dpi resolution (common specifications for a workstation monitor). By scaling the image down, it is possible to fit much more of the page on smaller displays, which provides improved browsability on displays costing substantially less than those normally found on engineering workstations.

Use of machine-readable text circumvents some of the problems of readability of scanned text. The fonts used are designed for use on 75- or 100-dpi displays,

and text displayed with these fonts does not suffer from the size or clarity problems that can plague bitmaps.

### **Navigational Tools of Existing Electronic Journal Systems**

Because existing tools are weak, we have tried to include features in the CORE interfaces that provide reasonable support for browsing. In addition to browsing by page, article, and issue, we also expect to supply a mechanism to browse the graphics. This may prove to be of more value to some chemists than others, since the graphics vary in significance between chemical subdisciplines.

The CORE interfaces utilize some hypertext features. One interface permits a new search to be initiated by clicking on any term in the text. Another makes it possible to move directly from a citation in the bibliography of one article to the cited article (assuming it's also in the database). We have not found a substitute for scrolling, but we are exploring a number of different navigational techniques in the hope of learning what works best for different types of users.

### **Searching Capabilities**

The first widely available Boolean search systems were designed around bibliographic databases. Such systems have been refined over several decades into what are thought of today as state-of-the-art search capabilities represented by DIALOG, BRS, Silver Platter, and many others. As full-text material became available, new features such as more flexible proximity searching were added.

What has not changed, and what remains as a holdover from the days of "bibliographic-only" searching, is the notion that the user approaches the system because he/she has a specific information need and expects to be lead to specific citations that address that need. The ability to support less-directed information needs (i.e., anything from browsing for current awareness to idle curiosity) is not nearly as well supported in these environments.

One might expect that the CORE interfaces, having been designed from the beginning as vehicles for the primary literature, would incorporate a profoundly different approach to the information underlying them. Yet the text-searching capabilities provided in CORE are mostly quite conventional. Facilities for browsing are more accessible and more complete than what is typically found in bibliographic search systems, but it is unlikely that they provide for as wide a range of undirected interaction as do print journals. More work needs to be done to understand the subtleties of these interactions and how they may be transferred to and enhanced in an electronic environment.

### **Lack of Portability**

True portability of electronic journals in a manner approaching that of print journals will have to await improvements in storage technology, display technology, wireless LANs, and batteries. Nevertheless, bringing electronic journals that more closely resemble their print equivalent in content and function

to the labs and offices of those who rely on them most heavily is an important step toward breaking the physical and temporal bounds of the library building.

### EQUITABLE ACCESS CONCERNS

CORE is a research project that may help shape the direction that future initiatives in electronic journal publishing take. But how realistic is it as a model for what is possible in most academic libraries today and in the near future? After all, CORE is, in some respects, a "best of all possible worlds" project. The data we are working with are very likely unique in terms of their depth and breadth within a discipline. The collaborative nature of the project has made resources available that are not typically found in libraries.

On the other hand, if libraries wait to get involved until better quality data are ubiquitous and most users have high-end workstations and high-speed network connections, it will be too late to have much of a say in resolving the critical issues that the transition from paper to electronic media present. The dilemma that arises is how to uphold a commitment to the provision of free, equitable access to information resources without becoming a slave to lowest common denominator standards in hardware, software, data, telecommunications, and networks.

I would suggest that this question arises, at least in part, because of the self-delusion that librarians have indulged in since the introduction of remotely accessible electronic resources. Providing electronic resources via "lowest common denominator" standards does not guarantee equitable access any more than having an entirely print-based collection did (e.g., we have not made our print collections readily accessible to visually impaired or wheelchair-bound patrons). Even today, not everyone has a computer or network connection in his/her home or office, so universal remote access is a myth. We attempt to make up for this by providing public access computers, but some users are inevitably better off than others.

I believe that we need to experiment with systems that are closer to the state of the art than are those we use to deliver our mainstream resources. In many cases, by the time that experimentation is complete, the bulk of users will have caught up with the level of technology used during the experiment. Such experimentation may, in fact, be the only practical way to keep up with the seemingly unending rise in the computing price/performance curve.

In the meantime, we must draw the line somewhere in deciding what facilities to utilize in providing remote access services. A single standard for all institutions will not do, but regular surveys could go a long way toward providing a rational basis for deciding when the local user community is ready to take advantage of new technologies. I am not prepared to recommend at which level of technology saturation a new service based on that technology should be offered. But if the library expects to continue having a major role in information management, it must either adopt new technologies or be displaced by other service providers who will.

There are ways to do this without shutting out users with less-sophisticated systems. For instance, SGML-tagged text could be stripped of its markup and



sent as plain ASCII, or even formatted especially for use with character-based terminal emulators, while still allowing users of more sophisticated display devices to take full advantage of it (Weibel, 1993). In addition, we should maintain a commitment to providing high-quality access from within the library building, and elsewhere on campus, as may be appropriate.

#### MAKING THE BEST OF ASCII DATA IN A VT100 ENVIRONMENT

As limited as ASCII data in a VT100 environment seem, they are much more representative of what is "out there" than the richly marked-up data of the CORE project. In fact, most of the electronic journals being passed around the network are ASCII only (Strangelove, 1993). At present, all of Mann Library's production networked electronic resources (as opposed to research projects) are in this form. We are currently working on two projects exploring ways to enhance the utility of available ASCII files.

On a much smaller scale than the CORE project, Mann Library is experimenting with the markup of several networked-based ASCII journals, including *New Horizons in Adult Education* and *Psycoloquy*. The goal of this project has been to try to automate to whatever degree possible the processing of these titles into BRS load format. This will allow us to make them available to patrons for search and display using BRS/Search, a multiuser, full-text, search-and-retrieval package that we currently use to provide networked access to four bibliographic files.

One of the more interesting observations from this work to date is that ASCII may not be such an intractable form after all. With a well-structured, consistently formatted ASCII journal, it is possible to make a one-time effort to write a reformatting program and completely automate the process of formatting future issues. Journals that lack consistency require considerably more manual processing labor. It is not clear whether the absence of consistent structure is an expression of editorial creativity or, rather, of unconcern. It would certainly be worth the effort of the library community to raise this issue with editors, since in many cases a small additional effort toward consistent layout could result in substantial benefits for libraries and their patrons.

Mann Library has gotten additional experience with ASCII electronic journals through its participation in the Cornell University Library Task Force on Electronic Journals. The task force has mounted the full text of several network-based electronic journals under WAIS, Gopher, and CUINFO (Cornell's campus-wide information system). The purpose of this pilot project is to examine a variety of library-wide concerns related to network-based electronic resources. Some of these are patron access, staff training, investment in technology infrastructure, archiving, and copyright. Other institutions have already investigated these issues on their campuses and reported their findings (Dougherty et al., 1991; Manoff, Dorschner, Geller, Morgan, & Snowden, 1992).

Mann Library is responsible for the Gopher portion of the task force installation. Some of the steps we have taken in order to maximize the utility of the installation include the following:

1. making as much use as possible of meaningful file names in the menu hierarchy (primarily through the heavy use of ".cap" files);
2. installing a version of WAIS behind the Gopher server that permits the use of Boolean operators, partial string matches, and literal phrases in searching;
3. creating multiple indexes (at the issue and volume level) to permit searches restricted by time;
4. installing the UNIX Gopher client on the same machine as the server so that users without direct Internet access and/or those without a locally mounted Gopher client may still use the system; and
5. installing an intelligent pager that provides easier navigation, better searching within files, and customizable help (for users running the client described in point 4).

We are also planning to install an improved help system and to experiment with the creation of indexes to support fielded searching, a feature not normally found under Gopher.

The point is that working with ASCII need not be thought of as second rate, if we are willing to explore enhancements that increase the utility of such data. Though we may be working with ASCII data for many years to come, we can do more than just bemoan its limitations.

In the meantime, successors to ASCII are already waiting in the wings. There is an 8-bit (256-character) standard called Latin1, which comfortably accommodates all the European languages. There are also two more ambitious coding systems in the works—Unicode and ISO 10646—which are 16-bit and 32-bit codes, respectively. Each would be able to represent the characters of all the known alphabets of the world, as well as numerous punctuation marks and symbols, but at a cost of fatter text files and more network traffic (Sheldon, 1991).

## CONCLUSION

The question of how to cope with the coming transition of primary scholarly publications from print to electronic-based media is undoubtedly one of the most significant issues facing academic libraries today. Some libraries that are studying the question have concluded that materials in electronic form should be dealt with according to the same time-honored traditions that have guided our approach to print-based materials for so many years. That is, we should be guided by existing policies for selection, acquisitions, cataloging, etc.

This approach may be fine, but it is rarely taken far enough. For example, many libraries still have poor or nonexistent network connections. Many libraries have little or no experience with multiuser computing systems. Allowing others, be they academic computing centers, publishers, or cable companies, to provide the computing expertise (as well as the computers and networking infrastructure) means abandoning control of the management of electronic resources. Strategic alliances with outside organizations may be desirable but not at the cost of complete abrogation of responsibility.

In order for libraries to have a voice and a role in the transition from print to digital media, we must have knowledge and experience. There is still time

to gain both, but that time is rapidly running out. Now is an excellent time to start experimenting. Electronic journals are in their infancy. Publishers and technology firms are interested in joint ventures with libraries. Such collaborations give libraries an important opportunity to make their partners aware of the difficulties they face and of the issues that are most critical to them and their patrons. As licensing begins to replace subscription as the predominant mechanism for marketing scholarly information, libraries need as strong a voice as possible to keep licensing agreements that are contrary to the library's mission, and the best interests of its patrons, from becoming the industry standard.

Libraries that do not feel prepared to enter as equal partners into projects with major publishers or computing companies, or who are not financially positioned to do so, may still benefit from joint projects with other libraries. There is still much work to be done regarding issues such as cooperative collection and dissemination of electronic resources, as well as cooperative processing and archiving. There is freely available full-text data available on the nets as well as free software for providing network access.

Multiuser computer systems are not free, nor are the trained staff needed to operate them. However, the cost of the former has dropped dramatically in the past few years, and the cost of the latter, though still high, will very likely be less, in the long run, than the cost of always having to depend on outside expertise.

Libraries cannot afford to look at the limitations in the current generation of electronic journals as "somebody else's problem." The process of overcoming those limitations may well embody the future of scholarly communication and, quite possibly, the future of academic librarianship.

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