Dimensions of Electronic Journals

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Some three hundred and thirty years ago, the first two scholarly journals came into being: the *Journal des sçavans,* in January 1665 in France, and the *Philosophical Transactions* of the Royal Society, in March 1665 in England. Now, as we prepare to enter the next millennium, the two have grown to some fifty thousand, and paper journals are becoming perceived as increasingly ineffective means of scholarly communication, and as expensive and outmoded sources of information overload. The growth of knowledge that commenced in the seventeenth century enlightenment has become a major problem, the understanding and control of which, through information sciences and technologies, is now an important knowledge objective in its own right.

However, the transition from paper to electronic journals is not a simple process of technological substitution. Book-sized microcomputers with high-resolution screens and optical disk readers are already available which could support electronic journals that emulated paper journals. However, the use of computers and networks in scholarly discourse has already taken advantage of many new capabilities that go beyond such emulation, and the direct substitution of electronic for paper journals is no longer attractive. The new features include rapid and widespread dissemination through the Internet, content-directed retrieval from a large body of material, multimedia presentation of sound, color pictures, videos, and simulations, and access to data sets and programs. Electronic journals do not emulate paper journals, and are best understood as a major revolution in the media for scholarly discourse.

While much of what is happening in the transition from paper to electronic journals is welcome in terms of enhanced capabilities, it also raises concerns about possible negative side effects, such as breakdowns in the quality assurance associated with journals' editorial and refereeing processes, the universality of access to knowledge, and the

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preservation of knowledge through long-term archives. The processes of discourse through paper journals have become embedded in scholarly culture through three hundred years of experience, and there are risks in making a major and rapid transition to a new technology. Since journal publication is a distributed responsibility of the entire scholarly community, it is neither possible nor desirable to control the transition. Individuals and disciplinary communities will use the new resources as they see fit, and all one can do in a book such as this is attempt to provide analysis and advice that may be useful to those responsible for some aspect of electronic journal publication.

The primary objective of this chapter is to provide an overview of the main characteristics of electronic journals in relation to issues of scholarly discourse, particularly those of quality assurance. It provides a check list of significant dimensions along which electronic journals may vary in ways relevant to readers, authors, and publishers. It is not intended to be prescriptive. There is scope for completely different patterns of scholarly publication than those we have developed in the past. These will develop through creative experiments and community evaluation of the utility of the results. Other chapters in this volume provide details of existing experiments, and recommendations based on them.

Technological Aspects of Electronic Journals

The enabling technologies for electronic journals have been the personal workstation, the Internet, the modem, and the laser printer. It is the decreasing cost of, and the resultant ubiquity of access to, these resources that has provided an environment in which electronic publications can reach the majority of the scholarly community. Widespread access has come about through requirements for word processing and electronic mail rather than for journal publication, and it is important to remember that the availability of these technologies for scholarly discourse is a minor side effect of their other applications. The developers of electronic journals have to take advantage of technology trends over which they have little influence.

Early Experiments with Electronic Journals

The transition to a technology able to support electronic journals has been very rapid and is a phenomenon of the 1990s. Technologists such as as Wells (1938), Bernal (1939), and Bush (1945) noted the need for new technologies to replace paper journals in the 1940s and 1950s.

Lancaster (1978) documented the basis of increasing library costs in great detail, and saw "paperless information systems" as providing a solution to the problem. In the late 1970s, an experiment took place with National Science Foundation (NSF) funding, in which a psychological journal on mental workload was developed and operated on the EIES (Electronic Information Exchange System) computer-based conferencing system (Hiltz 1984). The rationale and expectations for the new technology were expressed in the final report on that experiment:

> The traditional journal system has among its strengths a defined subject-matter, a developed body of subscribers, an experienced editorial staff, a group of referees chosen for competence in the subject matter, and a form that is convenient in numerous ways, including, for example, portability. Authors submit articles to the editors; the editors choose referees to review the material; the referees submit their judgements to the editor; and the editor makes a decision whether to accept or reject material. If the decision is to accept the article, it is edited and put into the production pipeline, eventually being included in a volume that is printed, bound, and mailed to the subscribers. On the other hand, the drawbacks of the traditional journal include such problems as the fact that each volume contains material that many subscribers are not interested in; that delays between acceptance of an article and its publication are often long, as much as a year to two years; that library storage is expensive and space consuming; that finding specific material can be difficult and time-consuming; and that the limitations on the size of a volume drive editors and authors toward excessive brevity and limits the publication of raw data. (Sheridan, Senders, Moray, Stoklosa, Guillaume, and Makepeace 1981, 8)

The report remarks that "the results fell short of initial aspirations," and "many of the participants, not themselves experienced with computers, found EIES inconvenient or difficult to use" (1). However, dissatisfaction with the technology is not surprising at a time before the advent of UUCP and Usenet, when access to the system was at 110 or 300 baud, largely through teleprinters, and with no possibility of transmitting anything other than textual material in a discipline that traditionally makes heavy use of graphs and figures.

Such technical limitations still applied at the time of the larger British Library BLEND (Birmingham and Loughborough Electronic Network Development) experiment in the UK from 1981 through 1983 (Oakshott 1985), but the political restrictions were equally significant. BLEND was undertaken in major part because the telecommunications

authority in that country, the British Post Office (BPO), had vetoed participation in the NSF experiment because the digital communication involved would infringe its monopoly. In agreeing to BLEND, however, the BPO imposed restrictions on participation that restricted readership of the electronic journal to a small part of the relevant scientific community. Such restrictions on access would not have allowed an electronic journal to have a meaningful role in scientific communication at that time even if the technology had been adequate.

What has happened in the 1990s is that personal computing systems have fallen in cost to become as ubiquitous as the telephone system, and the monopolistic control of telecommunications has been relaxed through deregulation in the majority of Western societies. In addition, the capabilities of the low-cost technology to support high-quality, multimedia publications has greatly increased.

Problems of Data Interchange Formats for Journal Material

The primary residual weakness in the technology for electronic journals is the lack of standardization of the typographic, image, and page layout information that constitute the electronic representation of journal material. Computer typesetting systems use proprietary coding schemes, as do word processing and page layout programs, although Microsoft's Rich Text Format (RTF) (Walden 1987) has become a *de facto* partial interchange standard as a result of commercial needs to offer users ways of migrating from one program to another.

In the academic world TeX (Knuth 1986) has become widely used by mathematicians and computer scientists since its adoption by the American Mathematical Society, and is treated as a standard in related publications. The device independent intermediate output format of TeX, DVI format, has become widely used for archives of papers in computing and mathematics, since it is reasonably compact and readily converted to output on laser printers. The lower level image format of PostScript (Adobe Systems Incorporated, 1986), which is the "machine language" of many laser printers, is also used as a common archiving format, since it is non-proprietary and can be exported from many word processing and page layout programs.

The difficulty with going to as low-level a format as PostScript is that it is not compact, not universally usable as an output standard, and not indexable or editable as a document. The current difficulty with any higher-level standards is that they are substantially less universal, and the more proprietary ones are also not indexable or editable except in the related application software. There are two so-

lutions to this problem on the horizon. One is that the growing need for document interchange between word processor users has encouraged the development of a substantial secondary industry offering data conversion programs. Many such programs are now available at low cost for personal computers, and it is becoming reasonably safe to assume that one will be able to convert a document developed on one mainstream document processing system to be accessible on another mainstream system. In particular, Adobe's Distiller program (Seybold 1993) converts PostScript to a format that may be indexed, cut, and pasted, as if it were a word processor document.

The second solution to the lack of formatting standards is the development of graphic and typographic structuring languages that are designed for document interchange. The Standard Generalized Markup Language (SGML) (Goldfarb 1990) is the major contender. It is a way of embedding a knowledge structure in a document that specifies the roles, within a predefined structure of potential roles, of each component of the text, for example, title, author, first-level heading, and so on. SGML is a very flexible standard, essentially providing a meta-language for defining markup conventions through formal Document Type Definitions (DTDs), and this enables it to be applied to the representation of complex document structures such as those for mathematics, music, chemical formulae, and hypertextual links. SGML does not address issues of image interchange formats, but it supports the markup of images as being files defined in other ISO, or industry, standards. The protocol used in World Wide Web documents is HTML (hypertext markup language), a particular format within the SGML rules.

The major advantage of SGML from a conventional publishing perspective is that different "house styles" can be applied to the same SGML document. An associated disadvantage to an author is that he or she loses the control of layout that comes from supplying "camera-ready" copy. However, authors in this situation can also use an SGML publishing system on their personal computers to apply their own "house styles" to the SGML text. Brailsford and Beach (1989) provide an interesting discussion of these issues in the context of their planning for the journal *Electronic Publishing,* which commenced in 1988 to itself become an electronic publication at a later date, and Alexander and Water (1990) provide a critical commentary on SGML from a publisher's point of view.

The Internet MIME protocol for multipurpose Internet mail extensions (Borenstein and Freed 1993) is not based on any of these standards but rather provides a meta-standard within which plain text, RTF, PostScript, SGML, and other document formats can be used

as required. MIME enables a wide range of text, typographic text, fully made up documents, pictures, video, and sounds, to be transmitted over Internet through a well-defined protocol. Convertors and filters are being developed for MIME, so that material sent in any format can be viewed in systems, or on equipment, that does not fully support that format.

The management of document interchange formats is a major problem for developers of electronic journals. Approaches range from using ASCII text only, by prescribing TeX or PostScript, to allowing a very wide range of formats. It is unlikely that there will ever be a single universal standard, and support for a few common formats is the most common compromise.

Sociological Aspects of Electronic Journals

Advances in technology enable the publication of electronic journals, but a technological perspective alone does not address some major issues, because it does not encompass the social needs motivating the use of the technology. Journals are the major medium for discourse in the scholarly community and, as such, are intrinsically part of the social processes in that community. This section reviews the role of social processes in knowledge production, and emphasizes the significance of journals in ascribing priorities to intellectual innovations as part of a social reward system encouraging knowledge production.

Because the material in journals has become detached from the activities, mental processes, and an existence of its originators, it may be seen as a record of those activities and an external expression of those processes, available for the critical assessment of others independent of the originator. This gives rise to the "objective knowledge" perspective on scholarly materials, as products of human activity that are ultimately, in some sense, independent of it and autonomous in their own right (Popper 1972).

Hence, one role of the journal is to act as a repository of knowledge and to make this widely available. This role involves the nature of knowledge, particularly as it is perceived by the client community who are not so much concerned with critical development of scholarship but with use of "knowledge" as something that is reliable in application and whose sources can be trusted. The philosophical definition of knowledge as "justified, true belief" provides a generative principle for the quality control that is applied to scholarly publication. The objective is *truth*, but this arises from the expression of the *beliefs* of authors, through arguments which *justify* those beliefs. The refereeing processes of cur-

rent journals have been developed to apply standards of "truth" and "justification" to the material submitted, so that certain minimal levels can be relied on as applying to all material in those journals.

Justifications in the literature are generally not independent of one another, but cross-reference other justifications to form a network of interdependent material. At a coarse level, much of this structure is apparent through the citations between publications, and citation analysis provides a useful overview of the structures of scientific disciplines and their interrelations (Garfield 1979; Bayer, Smart, and McLaughlin 1990). The formal structure of scholarship as objective knowledge may also be modeled as a network of linked theories (Balzer, Moulines, and Sneed 1987), whose dynamics of change may be modeled in terms of the underlying structural dependencies (Stegmuller 1976) which are again reflected in the citation patterns in the literature.

This "objective knowledge" perspective on journals emphasizes the significance of the product, its quality, and the technical linkages between items. There are complementary perspectives that see knowledge production and dissemination as a human social process, and emphasize the producers, their quality, and social linkages between them (Cole 1992). Like all human discourse, the communications of scholars through journals serves many functions and carries many messages other than those overtly communicated. The review process that ensures that material is of adequate quality has the side effect that the successful publication of material in a journal reflects well upon the authors—their statuses are enhanced by that of the journal in which their work is represented. In disciplines where scholarly research is dependent on access to limited resources, whose allocation is itself dependent on estimates of the status of the researchers, the journal publication process becomes part of the economic dynamics of the research program itself. The link between perceived capabilities and access to research resources significant in enhancing those capabilities is a positive feedback loop that gives rise to what has been termed the "Matthew effect" in science (Merton 1968), that "unto every one who hath shall be given."

The intricate involvement of journals in the processes and value systems of scholarship, and particularly the direct impact of journal publication on the allocation of resources to individual scholars, imply that the development of new technologies for scholarly communication is not solely a technical matter. They have to be designed to play an effective role within the social infrastructure of scholarship, and any changes and extensions to the nature of the publication process have to be examined in relation to both that social structure and the underlying dynamics of knowledge itself.

Dimensions of Electronic Journals

We are seeing new patterns of scholarly discourse emerge through use of the Internet, and these are exciting for their innovation but also problematic, because many aspects of scholarly publication, such as quality assurance, archiving, and universality of access, are not being addressed in ways that correspond to models established for paper publication (Gaines 1993). This section provides a framework for analyzing these issues within the new context of electronic publication.

One way of coming to terms with alternative approaches, and their relative merits and roles in scholarship, is to classify them along major dimensions of variation.

D1. Private—Public

Whether material is available to only restricted participants or generally available. E-mail is essentially private and most news groups are public, but many forms of semi-restricted access along this dimension are possible. For public news groups, an interesting subdimension is whether users are registered so that one can tell who has expressed interest, and a subdimension of such registration is whether one can tell which users are active recipients. That is, there are possibilities for instrumenting communities and measuring knowledge flows in ways that are much more difficult to achieve with paper-based media.

D2. Discursive—Archival

Whether the service essentially supports discourse or the storage of materials, or both. E-mail and news are both generally discursive, whereas data repositories are archival. However, again many variations are possible along this dimension, since some news groups are also archived, and archives with sequencing, for example through accession dates, can be used to support the type of "discourse" that is typical in journals where one article specifically comments on a previous one. An important subdimension here is the period of time over which material remains accessible. News is generally accessible for short periods, typically two weeks, unless archived, and archives generally maintain material for some years, but there is often no guarantee of this, and rarely a definite policy for the updating of versions of the "same" material.

D3. Moderated—Unmoderated

Whether material has to pass some checking process before being disseminated or is accepted without question. E-mail is unmoderated, as are many news groups, but checking is also common to support groups that wish to communicate information satisfying certain quality controls such as relevancy. There are many significant subdimensions here concerned with how, by whom, and on what basis the checking is done.

D4. Requested—Sent Automatically

Whether material is sent only on request or transmitted automatically to an individual or group of users. E-mail is sent automatically but news, even though it is sent automatically to sites, is accessed only at the request of users. Archives generally only respond to requests, but mailing list servers send material through e-mail to everyone registered with them. An important subdimension here is the visibility of material not sent automatically. News groups have a high visibility through specialist access programs designed to support browsing, but remote archives may be totally invisible to someone who does not know of their existence. Some archives provide automatic notification of updates and good browsing facilities, while others provide minimal directories to compressed files with nonmnemonic names.

D5. Standard Format—Nonstandard Format

Whether the material is available in one of a number of well-defined and interchangeable formats. As already discussed, it is unreasonable to require a single standard format, but it is possible to operate with a range of formats that can be converted into a locally usable form.

D6. Accessible Content—Inaccessible Content

Whether the full content of the material is available for search, indexing, or reuse, or whether only an image description is available.

D7. Multimedia—Textual

Whether the documentation representation supports fully typographic text, diagrams, pictures, sounds, video, and so on, or only text.

D8. Transient—Permanent

Whether the material is available only for a limited period or indefinitely. Permanent availability is important to the "freezing" of a particular statement of knowledge to make it a well-defined subject of critical commentary.

D9. Mutable—Immutable

Whether the material is fixed, so that the apparent publication is not subject to change, or can be edited without this being apparent except through content. This is, again, important to scholars having access to, and citing, precisely the same statements. Immutability does not imply that later versions of a document cannot be issued, only that these are treated as later descendants, not replacements.

D10. Authenticated—Unauthenticated

Whether the material can be checked to be an authentic, unedited copy of the version issued. This ensures that immutability can be propagated to replicas of documents.

D11. Registered—Unregistered

Whether the material has been registered with some independent authority to establish date of publication. To be useful, this registration has to be of an authenticatable and hence immutable document.

D12. Indexed—Not Indexed

Whether the material is indexed in well known, publicly accessible archives. This is important in supporting awareness of relevant material. The utility of the index may vary, depending on the amount of contextual and classificatory material entered, and on the quality of associated services, but some degree of minimal indexing is essential to the functions of a journal.

D13. Annotatable—Unitary

Whether the material is structured in a way supporting precisely defined internal citation. Page and line numbers have never been very satisfactory, but at least they were functional for paper documents. We

need to establish new conventions for electronic publications that can be supported by software. Uniform standards cannot be assumed, and the conventions will need to be fairly pragmatic for each form in which publications might be issued. This is very important to support peer commentary, conceptual and argument form annotation, and hypertext linkages.

D14. Attributed—Anonymous

Whether the author of material is identified. This is primarily relevant to refereeing, where referees are usually anonymous. There are a few publications that do not supply the identities of authors to referees, but this is not usually effective, since they are often obvious and also the publication should be refereed from the perspective of a reader who will have the full information and can interpret statements in terms of knowledge of the author or authors.

In terms of these dimensions and the discussion in this article, publications in an effective electronic journal should be public, archival, moderated, available to be sent automatically, in a standard format, with content fully accessible, supporting multimedia, permanent, immutable, authenticated, registered, indexed, annotatable, and attributed. None of the current applications of Internet satisfy all these requirements, and no past or currently established electronic journals satisfy them either. However, none of them are now technically difficult to satisfy.

An Agenda for Electronic Journals

This section stands alone as a statement of objectives for the development of electronic journals, based on the discussion of the preceding sections, but summarizing it in terms of action points rather than derivations.

A1. To enhance scholarship by systematically improving the creation, dissemination, and utilization of knowledge.

The difficult concept here is "systematic improvement," which may seem impossible, given the anarchy of knowledge creation processes, and undesirable, given that much of that anarchy may be essential to innovation. However, it is the very fact that we recognize these issues that makes it reasonable to attempt to support knowledge processes

systematically, including the freedom to innovate without constraints. We can use the capabilities of information technology to allow the media supporting scholarship to evolve from being passive repositories to becoming the life worlds of our nomadic knowledge products, and this means supporting the continuing evolution, and co-evolution with ourselves, of the knowledge worlds that we create.

A2. To improve the productivity of individuals and groups generating and using knowledge.

We should not assume that improvements in the processes of recording and disseminating knowledge will automatically result in improvements in scholarship. It is important to establish the requirement for advances in the technology in terms of support for the knowledge production processes of individual scholars and communities of scholarship. In particular, these processes should be studied in depth, and the impact of new technology on them should be monitored with a view to continuous improvement and enhancement of services.

A3. To reduce the adverse impact of the growth of knowledge by improving access to knowledge sources.

The major problem, currently, is not the lack of opportunities to publish but the information overload created by the growth of knowledge and the freedom to publish. It is the capabilities to organize, index, search, and use knowledge in electronic form that are most important in the design of electronic journals. For example, it would be absurd to design electronic publications in which the user did not have complete freedom to analyze and restructure the published material. Facsimile-style replication of paper publications might speed access to the material, but it would be a short-term expedient that did nothing to alleviate the fundamental problem of information overload.

A4. To increase the speed of knowledge dissemination.

The processing lag between a publication's being available in draft form and being published in journal form is several years in many disciplines, particularly for the most highly regarded journals. Scholars attempt to overcome this by informal dissemination of manuscripts, and this process should be supported through electronic archives.

A5. To increase awareness of relevant material.

All forms of dissemination, and particularly the informal availability of material prior to formal publication, are ineffective unless potential users are aware of the existence and availability of the material. The indexing of archives should be supported through the evolution of increasingly effective information retrieval systems taking advantage of access to the full text of the material.

A6. To maintain openness of access to material.

Concern has been expressed about the development of electronic cliques in which senior scholars maintain a discourse that is not open to others, either because they are unaware of it or because they are not allowed to join. There will always, presumably, be discussions that are appropriately private or confidential for good reasons. However, it is important to support and encourage the open access to knowledge which is already part of the culture of scholarship and of our society's attitude to knowledge. Electronic communications have the advantage of supporting the critical discussions commonly associated with workshops, without the physical restrictions on attendance that limit participation in conventional meetings. Experience with current mailing list servers shows how much can be learned from access to the ongoing discussions of major scholars about critical issues, and it is important that this type of peer commentary be supported and encouraged in the operation of electronic journals.

A7. To improve access to existing knowledge.

A critical mass of material available in electronic form will be most rapidly achieved through incorporation of conventionally published material as soon as possible. In particular, pre-circulation and parallel publication of material to be published in paper journals should be encouraged by establishing public archives in which scholars may deposit their publications, including already published material.

A8. To increase cross-disciplinary access to knowledge.

Much of the compartmentalization of scholarship can be attributed to the need to manage the growth of knowledge and avoid information overload. New developments should not take current disciplinary boundaries for granted, but should question their roles and placement.

In particular, there will be scope, once large amounts of material are available electronically, for new approaches to the structuring of knowledge, and these should not be impeded.

A9. To support the development of overt conceptual structures for knowledge.

Past media have encouraged the linear presentation of material and the implicit embedding of argument structures within the text. Electronic media give scope for major innovations in presentation, such as labelled hypertextual links, and the shadowing of informal arguments by formal and operational ones, using techniques of artificial intelligence. It is probable that few of the experiments to date in hypertext and computer-based knowledge representation will prove to be effective in the long term, and that the major innovations are yet to come, involving approaches that have not yet been developed. Innovation and flexibility in the use of electronic media should be encouraged and explicitly supported, not impeded.

A10. To use modern information technology to support the achievement of these objectives.

This is perhaps a rather obvious presupposition to the preceding objectives, but it is proper to place it late in the sequence as the servant to the other objectives, not their master. We will always have much activity that is "technology-driven," where those who see the elegance and potential of new technologies attempt to deliver it in useful form. However, it is important to balance the technology thrust with thoughtful planning that is "market-led," where those who see the essential needs of scholarship attempt to mobilize appropriate technology.

A11. To support existing innovations in scholarly communication.

Ease of access to existing network services has allowed many scholarly communities to develop new modes of operation on an informal basis. This makes available valuable empirical data that is important to the development of effective electronic journals. In particular, a perspective that sees the electronic journal as a formalization of this network discourse, in the same way that paper journals formalized postal and verbal discourse, is a useful counterbalance to one that sees electronic journals as the emulation of existing paper journals.

A12. To minimize the disruptive aspects of the introduction of new technology.

Much of the "human factor" of the introduction of electronic journals is subsumed in this statement. Designs that are based on existing usage of word processors on personal computers and existing access to networks are far more likely to succeed than those that require major changes in existing technologies or work practice.

A13. To maintain flexibility, allowing enhancements in technology and changing requirements to be incorporated with the minimum of disruption.

Electronic systems can be designed for change with automatic conversion between standards and continuous enhancement of capabilities, without disruption of services. Often, however, they are not, and flexibility should be stated as an explicit requirement.

A14. To encourage cooperation between those operating existing media and services and those developing new approaches.

Electronic journals not only have close relationships to existing journals, their editors, refereeing systems, authors, readers, and publishers, but also to a wide range of associated activities, such as abstracting, indexing, and information retrieval services, and to many aspects of library services and librarianship. It would be of greatest service to scholarship to mobilize the knowledge and resources available through these existing institutions to develop electronic journals as expeditiously and effectively as possible. It is possible that some of those potentially involved may see the new medium as a threat, and not be prepared to cooperate, but it would be counterproductive to presume lack of cooperation in advance. There is most to be gained in the short term by sharing information, resources, and opportunities, and attempting to enhance scholarship through open collaboration on a professional basis.

A15. To prevent any abuses of monopolistic control or copyright legislation that restrict developments in scholarly discourse.

The community of scholarship at large should be made aware of the new possibilities for the dissemination of knowledge and mobilized to

protect them from abusive practice if necessary. Ultimately, scholars are the major producers and consumers of knowledge and in a position to regulate the market place to the best advantage of the community at large.

Action Plans

The action points in this section are intended as examples to focus attention on a number of simple initiatives open to the scholarly community that could develop electronic publication services by mobilizing existing resources at a minimum cost and with a high chance of success.

P1. An Electronic Journal Consortium

Establish an electronic journal consortium as a loose confederation of interested parties communicating through Internet with a view to sharing ideas and technology, encouraging necessary developments, and supporting experiments with electronic journals.

This is a typical Internet activity, and has the usual advantages of mobilizing a diverse community without requiring a central power base, and completely transcending national and disciplinary boundaries. This consortium can have fruitful collaboration with those concerned with document standards, multimedia communication, groupware, and so on. It will serve to facilitate change and the evolution of *de facto* standards through experience. The actual operation of particular journals will be through editors, anonymous reviewers, commentators, and so on, as it is now, and it is important that these disciplinary communities have access to reliable, fully functional technology which they can use without responsibility for development and maintenance. It is probable that a printed form of most electronic journals will be required for the foreseeable future, and that support of printed output of a parallel paper publication should be treated as a major initial requirement.

A reference model for an electronic journal emulating paper journals and significantly enhancing their features might be:

1. A community concerned with a sub-discipline founds an electronic journal by defining the publication objectives, establishing a review board of relevant experts, and negotiating a paper-based publication arrangement with a book or journal publisher. It is assumed that the community already operates a list server and a Gopher.

2. Potential contributors routinely put their working articles in their local archives, making the knowledge rapidly available through FTP and Gopher. The appropriate format currently is PostScript, since this supports full typography, diagrams, and pictures, can be generated by virtually all word processors on all platforms, and can be read and printed using public domain programs on all common platforms. It is also annotatable, searchable, and reusable using Adobe's Acrobat technology (Seybold 1993).

3. When a contributor wishes an article to be reviewed for the journal, he or she informs the editor by e-mail of the location of that article.

4. The editor assigns reviewers, and also makes it known to the community at large through the list server that the paper is subject to review, so that anyone may comment on it.

5. When the editor has sufficient commissioned and other reviews, he or she sends them to the author with an editorial decision. It may also be seen as appropriate to make these reviews publicly available in the journal archives.

6. If the editorial decision is to publish without change, then the article is moved into the journal archives. (It might seem reasonable to just put a pointer to the article in the journal directory of the community Gopher, but copying the paper to the archives is intended to create an immutable "published" version.) If revisions are required, the author makes them, and the process loops back to 3.

7. Annually, or by volume, a paper volume of the electronic journal is published. This may become unnecessary in the long term, but currently such parallel publication is essential to make the published material universally available.

P2. Publication Archives

Establish public publication archives in which scholars can place electronic versions of works published in peer-reviewed paper journals.

These archives should support authentication, so that the copies obtained from them can be distributed with the means to check that they have not been edited. Generic archives for all disciplines and publications are suggested, so that they can be put in place rapidly, without dependence on action in particular disciplines. Restriction to published works is suggested, so that the archives do not become overloaded with material, or have to establish their own moderation procedures. This suggestion relies on scholars' having the right to make whatever use of their material they see fit, and is an extension of the existing practice of distributing reprints. It seems unlikely that

protect them from abusive practice if necessary. Ultimately, scholars are the major producers and consumers of knowledge and in a position to regulate the market place to the best advantage of the community at large.

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even publishers who do not explicitly return this right will object to the archives. Most scholars would assume that they have this right anyway, and would not continue to publish in journals whose publishers attempted to claim otherwise. Note that the works would not be placed in the public domain, and that the scholars and publishers would retain their copyrights. The use of material without due acknowledgement is very easy to detect in electronic publishing, and offenses ranging from professional discourtesy to outright plagiarism would be much more visible than they are now.

P3. Public Indexes to Personal Archives

Establish public indexes of personal or institutional archives of material that has not been peer-reviewed.

This is intended to support the current practice of placing submitted manuscripts, draft documents, reports, and data in public archives under local control, but to make the contents more accessible to the community. It balances the restriction of the publication archives above to articles published in peer-reviewed journals, by supporting any amount of publication based on the resources of the author or his or her institution. Permanence, immutability, and authentication should be encouraged in these archives, but these can also be achieved by setting up sub-archives that transfer selected material from the personal archives, probably operated by some disciplinary sub-community.

These three action plans are complementary and together, including also current network activities, they would give an adequate basis for a major acceleration of the progress towards electronic publication. They form a basis for the development of extended services based on content searches, hypertext linkage of peer commentary, knowledge structures for disciplines, and so on. However, before these new developments occur we need a critical mass of material available on the net and a significant community of scholars drawing upon it on a routine basis. That has to be our first practical objective, and it is the one addressed most directly by these three action plans.

Conclusions

Publication in paper journals is still the major system supporting human knowledge processes. If computer-based systems are to have any significant long-term impact on human knowledge processes, the functions of the paper journal have to be subsumed and enhanced. To do so effectively requires deep understanding of the social processes

underlying scholarly activities and publication, their support through the existing publication and library systems, and how that support can be emulated and enhanced through computer and communication technology.

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