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SOCIAL DYNAMICS OF SCHOLARLY PUBLICATION

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Abstract: The problems of information overload from the growth of scholarly literature, and the need to use information technology to manage them, were identified by major writers and scientists over fifty years ago. Yet the main form of scholarly communication, the journal, is still circulated in paper form as it has been for over three hundred years. Experimental trials of digital journals with the technologies of the 1970s and 1980s have not been successful, but new experiments are commencing with the improved technologies of the 1990s. Internet is being increasingly used for scholarly communication in ways that by-pass and supplement conventional journals. Any introduction of new technologies for the communication of scientific and technical knowledge has to take into account existing communication through journals. It also has to take into account the social processes involved in the production and dissemination of knowledge, particularly the reward and status mechanisms involved. This paper gives an overview of social processes in scholarship within which new technologies will be situated, and presents an agenda for the development of digital journals.

INTRODUCTION

When we examine the growth of science and technology in general and that of information technology in particular, we see two exponential processes in competition with one another. As knowledge has grown, one of its byproducts has been the technology to manage the impact of the growth of that knowledge, but for a very long period it seems that the growth of raw knowledge has surpassed the growth of the knowledge of how to manage it.

The problems of matching these growth curves have long been recognized. For example, in 1937, just prior to the advent of computer technology, Wells was promoting the concept of a "world brain" based on a "permanent world encyclopaedia" as a social good through giving universal access to all of human knowledge, and he remarks:

> "our contemporary encyclopaedias are still in the coach-and-horses phase of development, rather than in the phase of the automobile and the aeroplane. Encyclopaedic enterprise has not kept pace with material progress. These observers realize that the modern facilities of transport, radio, photographic reproduction and so forth are rendering practicable a much more fully succinct and accessible assembly of facts and ideas." (Wells, 1938)

Wells' world brain concepts and objectives have continued for over fifty years to be an active theme in the information systems community (Goodman, 1987).

In 1939, Bernal echoed the same issues from the viewpoint of the scientist:

> "In the old ideal of science, communications were the only link between scientists. Now the very quantity of scientific information has made its diffusion an enormous problem, with which the existing machinery has utterly failed to cope. The present mode of scientific publication is predominantly through the 33,000 odd scientific journals. It is, as we have already shown, incredibly cumbersome and wasteful and is in danger of breaking down on account of expense." (Bernal, 1939)

Some six years later Bush was re-echoing these sentiments in his famous article in *Atlantic Monthly* which is often cited as the first expression of the need for hypertext:

> "Science has provided the swiftest communication between individuals; it has provided a record of ideas and enabled man to manipulate and to make extracts from that record so that knowledge evolves and endures throughout the life of a race rather than that of an individual. There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. Professionally, our methods of transmitting and reviewing the results of research are generations old and by now are totally inadequate for their purpose." (Bush, 1945)

We are acutely aware of scientific and technological progress in the last fifty years, and marvel at the continuing exponential trend lines in information technology that result in surprising new capabilities year by year, but surely these statements give the lie to such feelings. If H.G.Wells, John Bernal and Vannevar Bush presented these statements at a session of the American Society for Information Society today, would not they appear timely, significant and utterly to the point? The volume of scientific publication has soared since these remarks were made but the means of disseminating the information in those journals has remained unchanged, that of physically transmitting print on paper. There have been major advances in the technology of printing during this period, notably the development of low cost photolithographic printing, phototypesetting and computer typesetting, but the end product remains basically the same as it was in 1665 when the Royal Society's *Philosophical Transactions* were first published.

EXPERIMENTS WITH DIGITAL JOURNALS

It is salutary to remind ourselves that the arguments for digital journals have been apparent for a long time, that experiments commenced over a decade ago, and that surveys

in the late 1980s indicate that none had succeeded in establishing a viable publication (Freedman, 1987). Some digital publications apparently providing a useful service during this period, such as *Clinical Notes On-Line*, have now been discontinued (Dixon, 1988).

In 1978 Lancaster documented the basis of increasing library costs in great detail, and saw "paperless information systems" as providing a solution to the problem (Lancaster, 1978). Following an economic analysis (Senders, 1977), action was taken at that time to investigate the possibility of operating a digital journal, and an experiment took place with NSF funding in which a psychological journal on mental workload was developed and operated on the EIES computer-based conferencing system (Hiltz, 1984). The final report (Sheridan, Senders, Moray, Stoklosa, Guillaume and Makepeace, 1981) 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." This inspired John Senders infamous aphorism, "I have seen the future and it doesn't work" (Senders, 1981). 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.

Experimental publication of digital journals continues, and there have been positive reports on some activities in the 1990s such as the *Public-Access Computer Systems Review* on BITNET (Bailey, 1991), although it will be many years before there it is possible to evaluate the staying power of these later developments. The most important of recent developments has been the announcement by the AAAS that it will publish a new journal, *The Online Journal of Current Clinical Trials*, commencing in the Spring of 1992 as an online, peer-reviewed journal (Palca, 1991). There are also innovative uses of the network to support scholarship that replace or complement some of the functions of journals.

KNOWLEDGE DISSEMINATION

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, first from studies in the philosophy and sociology of science, and then more generally in terms of the function of feedback processes in efficient management of a society of cognitive agents. It 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 existence of its originators, it may be seen as a record of those activities and external expression of those processes, completely available for the critical assessment of others independent of the originator. This gives rise to the 'objective knowledge' perspective on scholarly material, 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 definitions 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 that this arises from the expression of the *beliefs* of authors through arguments which *justify* those beliefs. The refereeing processes of current 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 science as objective knowledge may also be modeled as a network of linked theories (Sneed, 1977; Balzer, Moulines and Sneed, 1986), whose dynamics of change may be modeled in terms of the underlying structural dependencies (Stegmüller, 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. Like all human discourse, the communications of scholars through journals serves many functions and carries many messages other than those of what is apparently overtly communicated. The review process that ensures 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."

This analysis of the role of journals within the social processes of scholarship, and the interaction between the social processes and the production of knowledge, may be developed in detail through use of the literature on the development of knowledge. Feyerabend focuses on the sheer anarchy of the origins of knowledge, that there are *no*

universal methods underlying scholarship and science (Feyerabend, 1975). Gellner emphasizes that our notions of 'justified' and 'true' derive from processes for the *legitimation of belief*, rather than *vice versa* (Gellner, 1974). This lack of absolutes in both the activities and value systems of scholarship may be seen as necessitating the establishment of the working *paradigms* which provide criteria for rationality in particular disciplines over particular periods, and whose change Kuhn has identified with what are perceived as *scientific revolutions* (Kuhn, 1962). The definition of these paradigms is rarely overt, and they become identified with the social norms of cultures corresponding to sub-disciplines of scholarship that Crane has termed *invisible colleges* (Crane, 1972). The editorial and refereeing processes of journals associated with these invisible colleges support these cultures at the differing levels Hall has identified (Hall, 1959): at the *informal* level by providing examples that may be mimicked; at the *formal* level by accepting or rejecting material for publication; and at the *technical* level by publishing meta-level descriptions of the aims, objectives and methodologies of the sub-discipline.

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. This is a major requirement going beyond making knowledge overt to making the metaknowledge concerned with how it comes into being overt. The following subsection gives a brief account of some of the processes involved and the role of publications in these processes.

SOCIAL PROCESSES IN THE FORMATION AND DISSEMINATION OF EXPERTISE

In examining the social structure of science it is useful to commence from a perspective that sees it as functional, as part of a process through which our species allocates human resources appropriately for it survival (Gaines, 1989). We may view the species as consisting of a relatively undifferentiated set of cognitive agents, each of which has potential to perform useful functions, and where too much duplication would be wasteful yet detailed planning in the use of agents is not feasible because of the uncertainties of the environment. In these circumstances the positive feedback processes of the Matthew effect are functional in supporting the development of highly differentiated individual expertise in an initially uniform population through a distributed mechanism involving no central planning (Gaines, 1988). That is, the allocation of resources enabling further learning to agents with existing evidence of competence is a systemic basis for developing a diversity of capabilities in a society.

The structure and dynamics of this process of focusing the development of specialized knowledge within individuals can be analyzed in terms of a model which Hawkins has abstracted from industrial experience in developing mineral exploration expert systems and proposed as a model of human expertise relevant to expert systems (Hawkins, 1983). The model is summarized in the central diagram of five linked circles in Figure 1: the expert elicits data about the problem from the client; develops a minimal model that accounts for the data provided; generates advice based on the model and feeds this back to the client; the client may accept the advice, or query it and, possibly, the model; the queries lead to further data elicitation, and repeat of the modeling/advice/query cycle. Thus, in this model, the client plays an active role in further developing the model by providing more data until he or she is satisfied with the model and consequent advice. Expert advice giving and taking is part of a cycle of negotiation around a process of model formation.

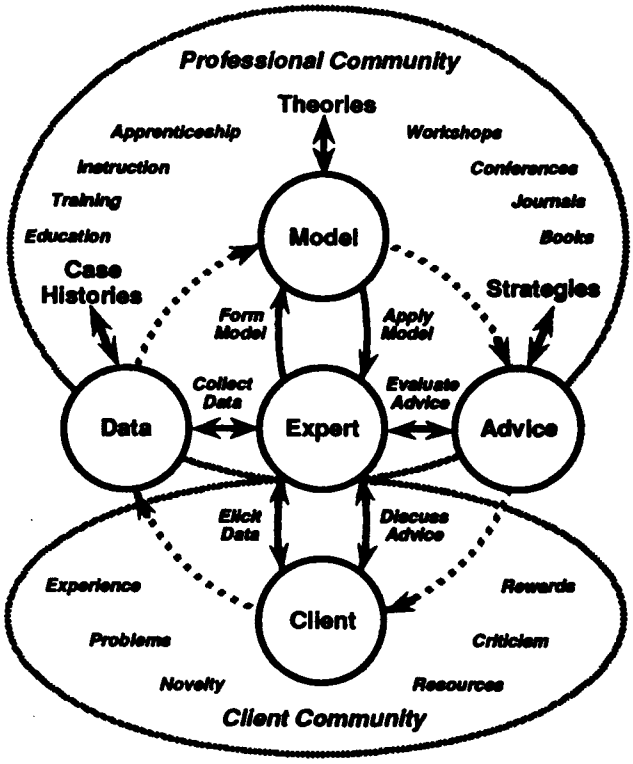

Figure 1 The formation and dissemination of expertise

The positive feedback processes already discussed may be analyzed in terms of this model by noting that the process of negotiation is also a basis for learning by the expert and client, and particularly so on the part of the expert who has exposure to many client situations and clients. As shown in the lower part of Figure 1, the client community provides access to practical experience through a variety of problems, particularly novel ones that go beyond existing expertise, and it also manages the growth of expertise through systems of reward, criticism and access to resources. The role of publications can also be analyzed by noting that learning from experience is a slow and error-prone process, and socially significant areas of expertise become associated with professional communities that attempt to expedite learning and reduce errors through the sharing of experience.

The upper part of Figure 1 shows these other processes, such as apprenticeship, instruction, training, education, workshops, conferences, journals and books. Professional communities usually also play a major role in refining and directing the client community's reward, criticism and resource allocation systems.

In terms of overall system dynamics we may see the positive feedback processes of the Matthew effect as acting to concentrate knowledge in particular individuals and to allocate the individuals themselves as resources to different areas of knowledge generation. However, individuals have finite lifes after which direct access to their knowledge is lost, and also they cannot generate all the knowledge that they require through direct experience, so a second system is necessary that encourages the sharing of individual knowledge. This involves rewards for the social dissemination of knowledge that complement those encouraging its individual concentration. The most significant award seems to be that of allocation of priority in an act of scholarship, typically a scientific discovery, but generally any innovation perceived of value by the community (Merton, 1957). From an objective knowledge perspective it is irrelevant except as a fact of history as to who first developed an innovative idea. The society of scholars and human society at large, however, pays homage to that individual to whom an innovation is attributed, and this creates social pressures both to innovate and to provide clear evidence of having done so in a way that is widely recognized.

Figure 1 also provides a microcosm in which to identify the type of information that requires capture and dissemination through journals. The "data", "model" and "advice" shown generalize to be all forms of relevant data and experience, all forms of theory, and all bases for applications and technology. One problem with existing paper-based media is that they are primarily targeted on the dissemination of theory and applications, and that the relevant data is often only available on a very erratic basis. This leads to problems of overstatement and fraud in reporting data analysis, and to problems of replication in comparing data. Information technology is already being used to alleviate these problems by establishing data banks and encouraging publicly available archiving of data. One can expect digital journals to accelerate these trends by providing links from published analyses to both the raw data and the data analysis techniques used. Indeed with the advent of low cost CD-ROM publication, there is little excuse for researchers not to give full access to a wealth of material relevant to their summarized results, including photographs and videos of laboratories and procedures, field studies, and so on (Claerbout and Dellinger, 1991).

DIMENSIONS OF DIGITAL JOURNALS

There are many different ways of attempting to improve scholarly communication using information technology. One way of coming to terms with alternative approaches, 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. Email is essentially private and most news groups are public, but many forms of semi-restricted access along this dimension are possible. For public newsgroups 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 tell which users are active recipients. That is, there are possibilities for instrumenting communities and measuring knowledge flows in ways which 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. Email 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 paper 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. Email 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. Email 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 email to everyone registered with them. An important subdimension here is the visibility of material not sent automatically. News has 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 non-mnemonic 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. Multi-Media—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 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 whether it 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 dependent 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 digital 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. There can be circumstances in which pseudonyms are appropriate also, for example, because an author does not wish knowledge of his or her identity to be used in interpreting a statement, or wishes to establish a separate identity. However, there have already been serious social problems generated by the establishment of false identities on CompuServe (Gelder, 1991), and it seems likely that present conventions of attribution and accountability on Internet should be continued.

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

AN AGENDA FOR DIGITAL JOURNALS

This section stands alone as a statement of objectives for the development of digital 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 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 digital form that are most important in the design of digital journals. For example, it would be absurd to design digital 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 does nothing to alleviate the fundamental problem of information overload.

A4. To increase the speed of knowledge dissemination.

The processing lag between a publication 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 digital 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 which 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 which 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. Digital 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 learnt 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 digital journals.

A7. To improve access to existing knowledge.

A critical mass of material available in digital 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 digitally 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. Digital 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 in hypertext and computer-based knowledge representation to date will prove to be effective in the long term, and that the major innovations are yet to come involving approaches that not yet been developed. Innovation and flexibility in the use of digital 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 attempting 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 had 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 digital journals. In particular a perspective that sees the digital 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 digital journals as the emulation of existing paper journals.

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

Much of the 'human factors' of the introduction of digital 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.

Digital 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.

Digital 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 digital 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 digital publication services by mobilizing existing resources at a minimum cost and with a high chance of success.

P1. A Digital Journal Consortium

Establish a digital 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 digital journals.

This is a typical Internet activity and has the usual advantages of mobilizing a diverse community without requiring a central power base, and of completely transcending national and disciplinary boundaries. This consortium can have fruitful collaboration with those concerned with document standards, multi-media 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 the first communities attracted to digital publication will be those with specific requirements better served by digital, rather than paper, publication, and it is important that such requirements are identified and addressed. It is also probable that a printed form of most digital 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.

P2. Publication Archives

Establish public publication archives in which scholars can place digital 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 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 would retain their copyright. The use of material without due acknowledgement is very easy to detect in digital 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 index archives 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 papers 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 digital 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 is that addressed most directly by these three action plans.

CONCLUSIONS

It is highly appropriate to have a workshop on communicating scientific and technical knowledge at the major annual meeting of the American Association for Artificial Intelligence. As we focus on computer support of knowledge-based systems, it is important to note that the paper journal 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 first to be subsumed and then enhanced. Much of what has already been achieved in artificial intelligence research provides the basis for major enhancements. In particular, research in knowledge acquisition and knowledge representation offers many attractive possibilities for new modes of discourse, argumentation, and the representation and communication of scientific and technical knowledge. The major impediment to significant advances in the application of knowledge support technologies arising out of such research is the difficulty of integration with the obsolescent functionality of the paper journal. The development of digital journals is a prerequisite to the development of knowledge support systems in which human and artificial intelligence can be effectively combined.

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