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Reforming scholarly publishing and knowledge communication: From the advent of the scholarly journal to the challenges of Open Access

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Abstract. This paper provides an overview of the continuing evolution of scholarly publishing, leveraged in the last decades by the tremendous potential of Internet technology. It introduces "self-archiving", the broad term often applied to the electronic publishing of author-supplied documents on the World Wide Web without commercial publisher mediation, and examines its impact on scholarly communication along with the Open Access Movement. The intensity of self-archiving and its pivotal role in scholarly communication is put into perspective through reference to some self-archiving initiatives set in motion in several countries. Finally, the paper concludes by outlining the challenges for information managers in developing the full potential of Open Access.

1. Evolution of scientific communication: Its adaptation to the challenges of the Internet

The origins of formal scholarly publishing date back to the 17th century when the *Journal des Sçavans* and the *Philosophical Transactions of the Royal Society of London* appeared in print as scientific journals in 1665 [34, pp. 5–8; 41, p. 361; 50]. As Swan and Brown [52, p. 4] point out:

> ever since the first scholarly journals were started in mid 1600s, academic authors have strived to publish and disseminate the results of their work for two main reasons – to advance intellectual progress in their subject and to establish rights over any intellectual advances they themselves have brought about.

Throughout the 18th and 19th centuries journals became more specialized, "reflecting the fragmentation of knowledge" [14]. The scholarly journal soon assumed the additional functions of registering "ownership", establishing "priority" over a particular scientific discovery, and of "packing" current

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communication into an indexed and readily accessible archive – a "public registry of scientific innovation" [18]. Publication of articles in journals became the prime indicator of professional standing for researchers and the organizations that employed them [50, p. 75]. The peer-reviewed journal fulfilled other requirements such as author recognition, quality control, historical record of and the archive for the progress of science [5, p. 404; 14; 49].

The appearance of a large number of scientific documents produced by the Allies during World War II triggered the need for new ways of organizing, storing and accessing this enormous body of information. Vannevar Bush envisioned a microform-based system, called Memex (for "memory expander") to store and retrieve information using a series of navigational links [8]. Memex is considered as the precursor to the modern hypertext systems of the Web [32, p. 43].

The expansion of research since World War II brought an exponential growth in the number of publications over the years due to the increased R&D activity [53, pp. 18–21]. Several government agencies in different countries have since then been trying to find solutions to a number of problems within the scientific and technical communication process. The problems addressed include the "information explosion", increasing publishing costs, delays in publishing and distribution inefficiencies – what has become known as the "serials crisis" [32, p. 43–44; 53, pp. 21–22]. Electronic publishing, digital processing of information and digital storage of large sets of data are among the many innovations made possible by the application of Information and Communication Technologies (ICT). The electronic journal, electronic abstracting and indexing services and the emergence of electronic databases of bibliographic information linked to the printed products are all good examples of such innovations [32, p. 43].

In the 1980s, new research projects, aiming to prove the feasibility of the electronic journal, were financially supported by commercial publishers and non-profit organizations such as Elsevier and the British Library Research and Development Department (BLRDD). Among them are ADONIS, Red Sage, BLEND, ELVYN and TULIP [53, p. 24]. At the time, libraries were also struggling with spiraling prices and pressures of physical space and there were hopes that the emergence of electronic journals might be the answer to the problem [54]. The development of the World Wide Web in the 1990s has had a significant impact on scholarly communication and aroused the interest of some imaginative researchers who in a vociferous and radical way sought to convince the academic community that the printed journal would disappear within a few decades ([19,37] as quoted in [53, p. 24]). Several models of self-publishing (sometimes called self-archiving) have been proposed, using the new enabling technologies as a means of returning the responsibility and ownership of scholarship to its creators [38]. One of the key assumptions behind developing "innovative publishing models for scientific communication is that, when scholars and scientists publish in peer-reviewed journals, they are not interested in monetary reward (royalties) but in having their work read, used, built-upon and cited" [24]. Researchers and academics are only too aware that job opportunities, tenure, promotion and merit pay are all dependent on the attention their papers receive; consequently, authors of journal articles seek impact instead of royalties [11,57].

As a result, the established scholarly journal system has been experiencing significant challenges to its continuing pre-eminence, due to several factors including slow dissemination of R&D results among peers, unacceptable delays in publication, and exorbitant price hikes in journal subscription rates that often exceeded rates of inflation and affordable library budgets [2,20–22,51,53,56]. The so-called "serials pricing crisis", which is seriously jeopardizing the economic viability of the printed system of scholarly communication, stems from several contributing factors such as increasing sizes of scientific journals in number of pages, and decreasing personal subscriptions [4].

This environment has encouraged the emergence of novel publishing models based on the Internet technologies for formal and informal communication among scientists. Functionalities of new publishing channels far exceeded those existing in print world. As well as promoting rapid access to information existing in scientific documents, in many cases without a fee, they also facilitate access to numerous multimedia materials available through the Web, like biological sequences, time series, videos, etc. Electronic journals (accessed primarily in electronic form), hybrid journals (electronic versions of paper journals), authors' self posting, subject-wide e-print repositories and the Guild Publishing Model were among the novel models tested [6; 7; 17; 28, p. 891; 30; 27; 39].

New electronic publishing models based on self-archiving have the potential to revolutionize scholarly communication, rendering it more efficient and effective. Self-archiving is a broad term to mean simply mounting of a document of author-supplied research in a publicly accessible web site without publishers' mediation [12, p. 11; 44].

2. E-prints

2.1. Overview

As discussed above, the advent of the Internet enabled researchers to recognize that the ICTs gave them efficient ways to share results, to combat the rise in journal costs fast outpacing a library's ability to afford them (serials crisis), to overcome the barriers raised by the full transfer of Intellectual Property Rights from author to publisher and to improve on the hitherto slow turnaround of traditional publishing. While several of their initiatives began as *ad hoc* vehicles for dissemination of preliminary results, a number of them have evolved into a more formal means for the efficient sharing of research results among peers in the field [10].

Pinfield [44] defines "e-prints" as electronic versions of research papers or similar research output. They may be "pre-prints" of unrefereed papers or "post-prints" of refereed ones. They may also include journal articles, chapters from scholarly books, conference papers, or any form of research output such as technical reports.

An e-print archive or repository is simply an online repository of publicly accessible research materials. The term "repository" is preferred by most archivists as curatorship and preservation are not the main functions of such archives [47]. Some e-prints may be peer-reviewed before being posted on the servers while others are posted without peer review to get feedback before formal submission to scholarly journals [16, p. 250]. Papers in some fields (e.g., physics, mathematics, and biomedicine) are submitted simultaneously to e-print repositories and traditional journals with a peer review process, although some journals consider e-prints as prior publication and thus refuse to publish them [6, p. 188; 30, p. 2].

The first e-print server was the Los Alamos Physics Archive created by Paul Ginsparg in 1991 [17,33]. Currently known as *arXiv.org* and located at Cornell University since July 2001, it provides access to pre-prints of papers in high-energy physics and related disciplines, mathematics, non-linear sciences and computational linguistics. Over the years, arXiv.org has become the primary means of scholarly communication and the largest repository of unrefereed research papers in the world. It is a fully automated electronic archive with mirrors in more than 15 countries. A number of separate e-print repositories have since been set up for separate subject communities. CogPrints (http://cogprints.soton.ac.uk/) in cognitive sciences and RePEc (http://repec.org) in the field of economics are among them [13,31]. The

Department of Energy (DoE) of US E-Print Network also provides a gateway to over 16,000 Websites and databases worldwide containing e-prints of research papers in basic and applied sciences (http://www.osti.gov/eprints) [29]. Elsevier set up three preprint repositories in chemistry, mathematics and computer sciences. Yet Elsevier's preprint service did not elicit enough interest to justify its further development and, consequently, stopped accepting new submissions on the 24th of May, 2004. As an alternative, many supporters of self-archiving/e-print archiving have advanced another strategy: *institutional repositories*. These are open-access archives set up and managed by research organizations to house articles published by authors of the institutions involved.

2.2. Benefits provided by the publication in e-prints repositories

For scholars and academics, there are several benefits to be gained from archiving their scientific work in e-print repositories. E-print repositories lower the barriers created by the conventional publication system [45, p. 4], thereby increasing the visibility of papers and making them freely available for others to consult and cite [1,25,48]. Studies began to demonstrate that open access also increases impact. Hitchcock [26] has an on-going bibliography of studies on the "The effect of open access and downloads ('hits') on citation impact: a bibliography of studies", which provide evidence that work that is freely available is more cited. E-print repositories also provide rapid dissemination of information to a wider audience and improve archiving of scientific data [16, p. 252; 58].

The e-prints offer substantially more features (e.g., annotation facilities and data integration) than their print equivalents. From the institutional point of view, an institutional repository will reform scholarly communication as it potentially serves as a tangible indicator of an institution's quality. Visibility, prestige, and public value all enhance the profile and help provide wider dissemination of R&D output. This, in turn, attracts high quality researchers and more research funds, and increases the number of citations that papers produced by the institutional staff get. Institutional repositories also provide valuable support for higher education institutions to carry out their mission in research and teaching [46, p. 303].

Furthermore, the e-prints repositories bring added benefits for scientists in the poorly resourced organizations or countries. By accessing e-prints repositories available anywhere in the world, they are provided with access to the global knowledge base. Equally important are the opportunities created by the e-prints repositories which offer the possibility, for scientists in less resourced countries or organizations, to distribute local research in a highly visible way and without the difficulties and bias associated with publishing in traditional journals, which tend to favour the publication of papers from well known authors or from known organizations in more developed countries [9].

3. Movement towards Open Access scientific literature

3.1. Open Archives Initiative

It became clear in the late 1990s that the usefulness of separate e-print repositories would be enhanced by the development of the interoperability between them. The movement called the Open Archives Initiative (http://www.openarchives.org/), which emerged from the Santa Fe Convention held in 1999, addresses this issue. The OAI aims to create cross-searchable databases of research papers and make them freely available on the web by developing and promoting interoperability standards that will facilitate the efficient dissemination of content and make individual e-print repositories interoperable.

At the centre of this work is the OAI Metadata Harvesting Protocol (http://www.openarchives.org/OAI/openarchivesprotocol.htm). This protocol creates the potential for interoperability between e-prints repositories by enabling metadata from a number of archives to be harvested and collected together in a searchable database. The metadata harvested is in the Dublin Core (DC) format and normally includes information such as author name, keywords in the title, subject terms, abstract, and date [48]. The contents of open archives servers around the world can be searched simultaneously by OAI-compliant search engine crawlers such as OAIster (http://www.oiaster.org) and Scholar Google (http://scholar.google.com).

Developed at the University of Southampton, the eprints.org (http://www.eprints.org/) was the first free software that enables any institution to install OAI-compliant archives. The e-prints software runs on Unix-based, open source GNU platforms and is used to set up centralised or distributed, discipline-based or institution-based archives of scholarly publications [9]. There are other OAI software applications such as Dpace, CDSWare and Fedora. The publication *A Guide to Institutional Software v3* (http://www.soros.org/openaccess/software) is a good source of information to learn more about OAI-compliant software packages.

The OAI-compliant e-prints servers provide value-added facilities. They can compile statistics and provide key metrics such as cross-searching and citation analysis of self-archived papers. Among them are Citebase (http://citebase.eprints.org/cgi-bin/search) and the Open Citation Project (http://opcit.eprints.org). Funded by the Joint NSF-JISC International Digital Libraries Programme (http://www.dli2.nsf.gov/internationalprojects/intlprojects.html), the Open Citation Project aims to provide integration and navigation through citation linking and give authors citation and impact analysis of their work (http://eprints.nottingham.ac.uk/information.html).

3.2. Budapest Open Access Initiative

To accelerate progress in the international efforts to make scientific and scholarly research results freely available on the Internet, a meeting was convened by the Open Society Institute (OSI) in Budapest on December 1–2, 2001. Participants represented many viewpoints, academic disciplines and nations. They brought first-hand experience of many of the ongoing initiatives that make up the open access movement and discussed how best the separate initiatives could be coordinated to achieve better progress. They examined the most effective and affordable strategies for serving the interests of researchers and explored how OSI and other foundations could use their resources most productively to aid the transition to open access and to make open access publishing economically self-sustaining.

The rationale was a need for a potential solution to the scientific communication crisis and to ensure that the results of publicly funded research remains publicly available, thereby avoiding the need to purchase them from commercial sources, with the expenditure of even more public money. As a result, the Budapest Open Access Initiative (BOAI) was announced (http://www.soros.org/openaccess/). The BOAI identified two main strategies: self-archiving and open access journals. The former strategy refers to the right of scholars to "self-archive" their refereed journal articles in free e-print archives while the latter encourages publishing open access journals that do not charge users for access. As of March 2005 some 3650 individuals and 304 organisations signed the BOAI statement (http://www.soros.org/openaccess/view.cfm).

There is a strong international movement that seeks to make research papers available by this method. *The SPARC Open Access Newletter* (http://www.earlham.edu/~peters/fos/index.htm), published by Peter Suber, is a highly useful resource for keeping up to date with developments in all areas related to electronic scholarly publishing (see his *Timeline for Open Access Movement* http://www.earlham.

edu/~peters/fos/timeline.htm for the most comprehensive account of major developments in this area). The frequently updated *Scholarly Electronic Publishing Bibliography*, *1996–2005* (http://info.lib.uh.edu/sepb/sepb.html), published by Charles Bailey, includes two sections with relevant articles on "New Publishing Models" and "Repositories, e-Prints and OAI".

3.3. Open Access journals

Scholarly articles can be made freely available to potential readers in two main ways: (1) by "self-archiving" papers in OAI-compliant electronic *repositories*, searchable from remote locations without restrictions on access (discussed above); or 2) by publishing in Open Access (OA) journals [52, pp. 8–11]. OA journals make their quality-controlled content freely available to allcomers, using a funding model that does not charge readers or their institutions for access. The costs of editorial expenses, peer-review, and setting up and running servers are borne by authors or their institutions submitting papers or by some funding agencies. For example, the *D-Lib Magazine* (http://www.dlib.org) is funded by grants from DARPA (Defense Advanced Research Project Agency) and NSF. The OA model is also implemented by several commercial publishers. In this model, authors or their institutions pay a fee to have their article published and the publisher then makes the article freely available electronically, after publication. For example, the BioMed Central (http://www.biomedcentral.com) used this model to launch its open access publishing service in 2000 [3; 52, pp. 8–9].

The *Directory of Open Access Journals* (*DOAJ*), produced by the Lund University Library (http://www.doaj.org), was created to increase the visibility and ease of use of OA journals, thereby promoting their increased usage and impact. As of April 2005, the directory included 1532 peer-reviewed, scientific OA journals, spanning all disciplines from agriculture to philosophy.

3.4. Open Access movement is gaining momentum

Progress is steady and gaining momentum towards OA. Establishing OA requires active commitment of each party involved. The year 2003 was the first year when regular items appeared in specialised literature, addressing both open-access repositories and journals [45, p. 12]. The year 2003 also saw the launching of an increasing number of policy statements supporting open access. These included not only research funders but also international organizations such as UN and OECD. Among them are:

- *Bethesda Statement on Open Access Publishing*, June 20, 2003 (http://www.earlham.edu/~peters) (from US research funders);
- *Wellcome Trust Position Statement on Open Access*, 1 October 2003 (http://www.wellcome.ac.uk/doc_WTD002766.html) (from UK research funders);
- *OECD Declaration on Access to Research Data from Public Funding*, 30 January 2004 (http://www.oecd.org/document/0,2340,en_2649_34487_25998799_1_1_1_1,00.html);
- *UN World Summit on the Information Society Declaration of Principles and Plan of Action*, December 12, 2003 (http://www.itu.int) Documents 1 and 2.

In parallel, *The Berlin Declaration on Open Access*, launched on 23rd October 2003 (http://www.zim.mpg.de/openaccess-berlin/berlindeclaration.html), defines OA as "immediate, permanent, free online access to the full text of all refereed research journals articles" (2.5 million articles a year, published in 24,000 refereed journals, across all disciplines, languages and nations). It has so far been signed by 55 institutions world-wide [23]. The Berlin 3 meeting took place recently in Southampton (March 2005) and gave added prominence to the Open Access issue.

International and national research projects are addressing potential impediments to the success of e-print archives – copyright, peer-review and quality control, long term preservation, and cultural issues. Among such programmes are the following:

- *FAIR (Focus on Access to Institutional Resources)* programme, funded by the UK Higher Education Council's Joint Information Systems Committee (JISC) (2002–2005) to investigate e-print repositories, e-theses services and intellectual property rights (http://www.jisc.ac.uk/index.cfm?name=programme_fair);
- *California Digital Library eScholarship Repository* (http://escholarship.cdlib.org/);
- *DARE (Digital Academic Resources)* programme (http://www.darenet.nl/en/toon), which involves collaboration of some 20 Dutch universities and research organizations including the National Library of the Netherlands.

4. Conclusion: Roles of information management profession within the Open Access movement

Information managers at large have a very important future role to perform within their organizations, regarding the future of self-archiving, particularly in relation to peer-reviewed journals. These include:

- Take the initiative to build OA repositories for their institutions; this embraces addressing the communication cultures within different disciplines, develop management frameworks that take into account of the technical possibilities, and take responsibility for the quality of the metadata (enhancing/validating the provided by authors);
- Ensure archival stability;
- Promote discussions among academia and administrators, at the highest level, regarding the advantages of OA deposition;
- Demonstrate to scholars the benefits of wider exposure via OA;
- Introduce and make available innovative performance indicators, such as counting downloads and citations at the article level;
- Coordinate programmes to advise and support scholars on copyright issues and how best to negotiate the right to self-archive; and
- Support potential authors in their electronic publishing activities.

In conclusion, information professionals have to be aware of the (r)evolution which is taking place in scholarly communication and influence it as much as possible, for the benefit of their own organizations and the global scientific and scholarly communities. Information professionals have to become skilled in the use of new applications and should be looking to take advantage of the new opportunities created by the ready availability of these OA resources.

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