Towards co-operative and distributed infrastructures for digital preservation

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"Achieving the aims and aspirations of e-Science is ... not just a matter of breakthroughs in hardware or software engineering, or system design improvements to provide tools that will be readily useable by individual researchers and their organizations - as challenging as those engineering tasks may be" - David (2004).

"Preserving our digital heritage is more than just a technical process of perpetuating digital signals over long periods of time. It is also a social and cultural process, in the sense of selecting what materials should be preserved, and in what form; it is an economic process, in the sense of defining what rights and privileges are needed to support maintenance of a permanent scholarly and cultural record. It is a question of responsibilities and incentives, and of articulating and organizing new forms of curatorial practice. And perhaps most importantly, it is an ongoing, long-term commitment, often shared, and cooperatively met, by many stakeholders" - Lavoie & Dempsey (2004).

"Both informal collaborations (associations and alliances) and formal partnerships among contractors and subcontractors will also surely arise, in which responsibilities for archiving are allocated among various other interests in digital information. Moreover, shared interests in, for example, intellectual discipline, in type of information, in function, such as storage or cataloging, and even interests in the output of information within national boundaries will all form a varied and rich basis for the kinds of formal and informal interactions that lead to the design of particular archival organizations" - Garrett & Waters (1996)

1. Introduction

The long-term preservation of digital heritage is gradually being recognised as one of the grand challenges of this present age, also one that will require considerable ongoing attention for generations to come. The past twenty years has seen a gradual shift in the amount of attention given to this problem, a pattern that has accelerated since 1996, when the Task Force on Archiving of Digital Information published its final report entitled *Preserving digital information* (Garrett & Waters, 1996). This influential report helped to catalyse and focus a number of institutional and national responses to the digital preservation problem. The gradual spread of awareness about the challenge of digital preservation has led to the development of a range of different activities, all attempting to address one or more aspects of the problem.[1] Some of these activities have come under the aegis of national initiatives like the Digital Curation Centre (DCC)

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[1] Perhaps the most comprehensive source of information about these is the Preserving Access to Digital Information (PADI) website developed and managed by the National Library of Australia, but now with the additional support of the Council on Library and Information Resources, the Digital Preservation Coalition, the nestor Kompetenznetzwerk Langzeitarchivierung, and the Electronic Resource Preservation and Access Network (ERPANET). Retrieved December 18, 2006 from: http://www.nla.gov.au/padi/

in the UK or the National Digital Information Infrastructure and Preservation Program (NDIIPP) in the US; others have become part of the ongoing work of organisations like scientific data centres, national libraries and archives.

Much of the focus in digital preservation research has been concentrated on technological issues, e.g. the development of preservation strategies and the definition of metadata standards to support these. However, as Lavoie and Dempsey (2004) have pointed out, digital preservation is as much about social and cultural processes as about technology. They note that digital preservation is a long-term commitment that will need to be co-operatively met by many different stakeholders. This will by no means be an easy challenge to address. For example, in a parallel case - the development of collaborative e-Science - David (2004) has argued that success in realising the "transformative potentialities" of *cyberinfrastructure* "is likely to be the resultant of a nexus of interrelated social, legal *and* technical changes," adding that social and legal requirements have, however, often been overlooked in the tendency to focus on technical issues.

> *Curiously, the institutional infrastructure requirements have tended to be overlooked, as though fulfilling them will be easily arranged; whereas they are every bit as complicated as the hardware and computer software, and indeed may prove much harder to devise and implement. This is particularly likely to be the case in regard to collaborative activities that are inter-organizational - the very sphere in which the vision of Grid-support seems to hold the greatest transformative potentialities.*

David and Spence (2003) have outlined the cultural and legal challenges as they relate to scientific collaboration and e-Science in more detail elsewhere, but their perception that social, cultural and legal issues will be difficult to solve would also seem to apply to co-operation on digital preservation.

The purpose of this introductory paper is to introduce some of the organisational, social and cultural issues that relate to the co-operation of the many different stakeholders involved in digital preservation. It does not aim to be comprehensive. It will first introduce the co-operation issue in the context of recent work on digital preservation, focusing on the Reference Model for an Open Archival Information System (OAIS), the concept of trusted repositories, and the institutional repository paradigm. It will then investigate two topics in slightly more detail: the concept of trust and the scope for inter-organisational co-operation on things like collection management. It is perhaps worth noting that the topic of co-operation also featured highly on the agenda of a recent workshop held in Washington, D.C. in May 2006 (Day & Hockx-Yu, 2006).

2. Contexts

This section will introduce how the idea of co-operative repository networks has been dealt with so far in digital preservation contexts. An explanation of how the OAIS Reference Model deals with co-operation will be followed by a look at the way distributed repository infrastructures have been covered by a series of influential working groups looking at particular digital preservation topics. A final section will briefly introduce institutional repositories and their growing requirements for co-operation on preservation.

2.1 Co-operation in the OAIS Reference Model

Co-operative approaches to preservation features in the highly influential Reference Model for an Open Archival Information System (OAIS), now approved as an international standard (ISO 14721:2003). Chapter six of the reference model - on archive interoperability - notes that the various stakeholders of repositories (users, producers, managers) may expect a certain level of co-operation with other services, e.g. users might want to use common finding aids, package descriptions or dissemination packages, producers may prefer standardised ways of submitting packages to different services, etc.

The model assumes that such co-operation can exist without the need for explicit federation (CCSDS 650.0-B-1, 2002, p. 6-1), but defines various technical levels of interaction between OAIS repositories before highlighting some potential management problems with federated services, chiefly focusing on the challenge of retaining autonomy in various kinds of association.

The technical levels of repository interaction defined by the OAIS model include *co-operating* repositories, which may define common standards for submission and dissemination; and *federated* repositories that provide access to an extended user community through common finding aids. There is also a category for *shared resources*, where OAIS repositories work together, e.g. to help reduce costs. Effectively, these enable the six functional entities identified by the OAIS reference model to be divided up between two or more co-operating repositories, e.g. for an archival storage function shared between two repositories (Figure 1)
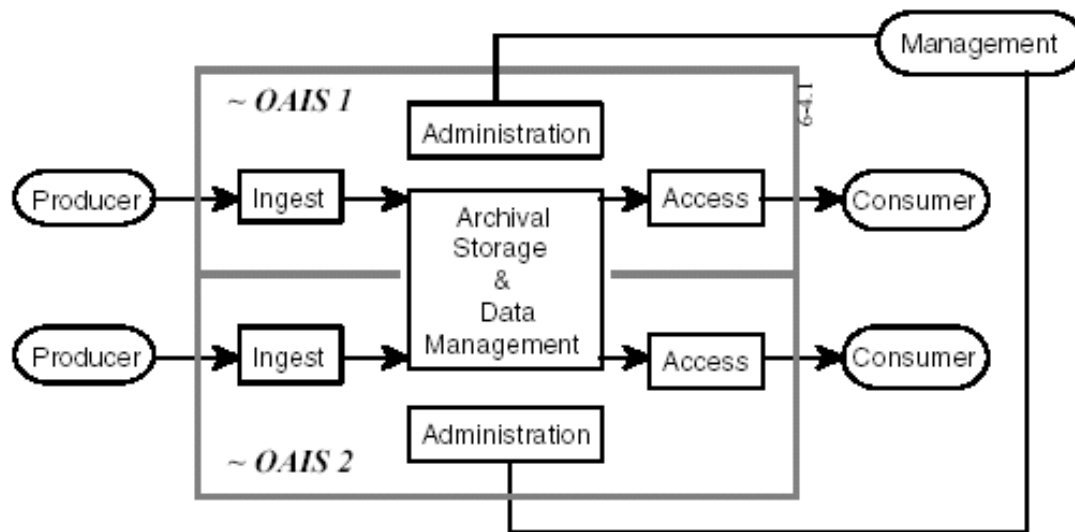

Figure 1: Archives with shared storage (CCSDS 650.0-B-1, 2002, Fig. 6-4)

2.2 Networks of Trusted Repositories and Repository Certification

The need for co-operation at various different levels was also identified as a key issue in the 1996 report of the Task Force on Archiving of Digital Information.[2] In its discussion of archival roles and responsibilities, the task force argued that the wide range of different stakeholders with interests in the preservation of digital information meant that the "most effective and affordable strategy of developing a system of digital archives" would be "to assume a distributed, rather than centralized, structure for collecting digital objects, protecting their integrity over the long term, and retaining them for future use" (Garrett & Waters, 1996, p. 21). The general principles of the strategy proposed by the task force were based on placing initial responsibility for preservation on the producers or owners of information, possibly in co-operation with third party services like libraries or archival organisations; while giving 'certified digital archives' the right and duty to exercise an aggressive rescue function if information was considered to be at risk (Garrett & Waters, 1996, p. 23).

> *No distributed system of digital archives will afford effective protection of electronic information unless it provides for a powerful rescue function allowing one agency, acting in the long-term public interest of protecting the cultural record, to override another's neglect of or active interest in abandoning or destroying parts of that record.*

The task force envisaged the emergence of various kinds of co-operative structures, including corporations, federations and consortia ranging over regional and national boundaries (p. 21). The task force did not see issues of selection and appraisal, i.e. questions about what information

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[2] For example, Donald Waters, co-chair of the task force, wrote a draft paper on the social organisation of archiving that expressly acknowledged the need for distributed responsibility for preserving digital information (Waters, 1995)

to carry forward, as within their particular scope, but they did make suggestions on the kinds of distributed infrastructures they felt were necessary for undertaking long-term preservation (e.g., Waters, 1995).

The task force emphasised the need for *trust* within these distributed infrastructures (Garrett & Waters, 1996, p 23

> *For assuring the longevity of information, perhaps the most important role in the operation of a digital archive is managing the identity integrity and quality of the archives itself as a trusted source of the cultural record. Users of archived information in electronic form and of archival services relating to that information need to have assurance that a digital archives is what it says it is and that the information stored there is safe for the long term.*

The report suggested the need for some kind of certification process that would be able to help establish this trust. Following this point up some years later, the Research Libraries Group (RLG) and OCLC Online Computer Library Center sponsored an international working group to investigate the attributes of trusted repositories in more detail. Their conclusions mainly focused on organisational requirements and they developed a list of seven overlapping attributes (RLG/OCLC Working Group on Digital Archive Attributes (2002):

- *Compliance with the OAIS Reference Model* - helping to ensure that there is shared understanding across the range of different stakeholders

- *Administrative responsibility* - a commitment to standards and best practices on operational matters, e.g. as relating to physical environment, backup and recovery procedures and agreements with depositors; ongoing risk management and contingency planning; transparency and accountability

- *Organisational viability* - demonstrating a commitment to the long-term stewardship of digital cultural assets, e.g. appropriate legal status, staffing levels and expertise; succession planning

- *Financial sustainability* - able to prove its financial sustainability over time, e.g. adhering to good business practices, having a sustainable business plan

- *Technological and procedural suitability* - demonstrating that all relevant preservation strategies have been considered, ensuring the existence of appropriate hardware and software, compliance with standards and best practices

- *System security* - with regard to preserving the bit-level integrity of data; policies for duplication and redundancy, authentication systems, firewalls and backup; written plans for disaster recovery

- *Procedural accountability* - the documentation of repository policies and practices, e.g. with regard to preservation strategies, relationships with third party services and user communities

The working group (p 17) also defined in slightly more detail the responsibilities of trusted repositories, including the need for organisations to understand their own requirements but also to identify which other organisations might be able to share certain responsibilities and how this might be arranged. They make the important point that comprehensive coverage within collections and effective interoperability across repositories will rely on a shared understanding of duties and roles. One of the group's specific recommendations (no. 3) identified the need for more research into co-operation (p. 38).

> *Archivists and librarians need more thorough understanding of how cooperative digital repositories and repository networks can be implemented and managed, including the use of third-party service providers. Models for the establishment of cooperative archiving services will be useful and necessary, as will be examples of service-level agreements as they apply to digital repositories (e.g., service-level agreements for external suppliers of archival storage).*

Following the Task Force on Archiving of Digital Information, the working group assumes that certification is a key part of supporting co-operative networks of repositories and other third party service providers (e.g. registries of representation information or storage services). The working group, therefore, recommended the development of a framework and process to support the certification of digital repositories. This led to the formation of a follow-up task force, this time sponsored by RLG and the US National Archives and Records Administration (NARA).

This RLG-NARA Digital Repository Certification Task Force focused on the identification of particular certification criteria and the delineation of a certification process that would be applicable to a wide range of different types of preservation repository. In August 2005, the task force published its draft *Audit checklist for the certification of trusted digital repositories* (RLG-NARA Task Force on Digital Repository Certification, 2005). This checklist defined criteria under a range of different headings, many of them derived from either the OAIS Model or the *Trusted Digital Repositories* report.

- *Organisation* - including governance and organisational viability, organisational structure, procedural accountability, financial sustainability, and contracts, licenses and liabilities

- *Repository functions, processes and procedures* - including ingest and acquisition of content, archival storage, preservation planning and strategies, data management, and access management

- *Designated community and the usability of information* - including the documentation of the designated communities, descriptive metadata, use and usability, and the verification of 'understandability'

- *Technologies and technical infrastructure* - including system infrastructures, the use of appropriate technologies, and system security (including disaster recovery)

The checklist is a comprehensive instrument that could be used for the self-evaluation of repositories or for the development of a system of independent review. Projects supported by the US Center for Research Libraries and the Digital Curation Centre are investigating the use of the draft checklist (Dale, 2005; Ross & McHugh, 2005; 2006).

2.3 Institutional Repositories and Co-operation

While all this work was in progress, the underlying repository landscape changed considerably, especially in universities and other research organisations. Political moves to encourage 'open access' (OA) to the outputs of publicly funded research - e.g. the Budapest Open Access Initiative[3] and OA mandates from research funding bodies - coupled with the widespread availability of open-source repository software and interoperability tools like the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) has led to the growing adoption of 'institutional repositories.' Crow (2002, p. 16) has defined these as "a digital archive of the intellectual product created by the faculty, research staff, and students of an institution..." While initially conceived as a means to facilitate access to research outputs (chiefly peer-reviewed research papers), it was soon realised that institution-based repositories also offered an opportunity for universities and other research organisations to reclaim responsibility for the management and distribution of a wide range of information types, including research papers, technical reports and working papers, scientific datasets, learning resources and even administrative records. In many cases, the setting-up of a repository implies an institutional commitment to the ongoing management of such information. For example, Lynch (2003) refers university-based institutional repositories as an 'organisational commitment' to the stewardship of digital materials, "including long-term preservation where appropriate, as well as organization and access or distribution. However, will not be necessary for all institutions with a repository (or repositories) to preserve content themselves. Instead, repositories will most likely co-operate with

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[3] Budapest Open Access Initiative (BOAI). Retrieved December 18, 2006 from http://www.soros.org/openaccess/

each other as well with shared services (e.g. registries of file format information) and dedicated long-term preservation services, which could be co-ordinated on a national level.

Two UK projects, SHERPA DP and Preserv, have investigated distributed architectures that enable the integration of preservation services with institutional repositories. Some of the wider organisational implications of linking UK repositories have been investigated in a scoping study commissioned by the Joint Information Systems Committee (Swan & Awre, 2006).

3. Levels of co-operation

Inter-repository co-operation can take place on a variety of different levels. Much ongoing research and development work has a practical focus on technical interoperability. This includes considerable work on preservation metadata (e.g., Day, 2004; 2005) and object packaging standards (e.g., Bekaert, De Kooning & Van de Walle, 2005; Waugh, 2006), as well as research into aspects of technical infrastructures, e.g. modular and service oriented preservation architectures (e.g., Shirky, 2002; Lavoie, Henry & Dempsey, 2006), co-operation on ingest and implementing preservation strategies (e.g., JaJa, 2006; Hunter & Choudhury, 2006), and the development of registries of representation information (e.g., Abrams & Seaman, 2003; Darlington, 2003; Giaretta, *et al.*, 2005). This paper focuses on issues of co-operation at the organisational level, which might include things like the development of co-operative organisational infrastructures or of national or international preservation policies.

Two recent reports have outlined in some detail the types of digital preservation networks available within some countries. The first of these (Verheul, 2006) focused on national library initiatives in 15 countries. Half of the libraries assessed were part of national networks, e.g. the Digital Preservation Coalition in the UK, the National Digital Information Infrastructure and Preservation Program (NDIIPP) in the US, and nestor in Germany. However, the nature of these networks vary; "sometimes the framework primarily provides funding and sometimes more practical facilities are offered to improve cooperation, such as coordinating offices, embedding within project organisation, websites, facilitating meetings and seminars" (Verheul, p. 56). The report notes that national libraries are often key players in facilitating co-operation on digital preservation on a national level and a number of countries are beginning to develop national strategies. International co-operation, at least for national libraries, seem to be mainly focused through well-established organisations like the International Federation of Library Associations and Institutions (IFLA) and the Conference of Directors of National Libraries (CDNL), although more specialised initiatives like the International Internet Preservation Consortium (IIPC) also exist. The second study (Severiens & Hilf, 2006) was undertaken for the German nestor initiative and was focused on developing a profile for a national long-term preservation policy. In this, various organisational scenarios are sketched: centralised, decentralised and decentralised with a level of some co-ordination. The report also contains a short review of co-ordination efforts in Europe, Australia and North America.

4. Some issues in more detail

The following section will introduce two co-operative issues in slightly more detail. The first is the need for co-operation on collection management, a policy-level issue that will need to be solved to help avoid duplication and wasted effort while retaining a level of redundancy in terms of geography and technical preservation approaches. The second picks up the discussion of trust from the issue of certification.

4.1 Collaborative collection management

Severiens and Hilf (2006, p. 10) argue that one of the basic tasks of a national long-term preservation strategy is to establish rules for the selection of resources. This is a natural area for intra-organisational co-operation, e.g. helping to reduce overall duplication of effort, but enabling co-ordinated decisions to be made about issues like the replication of content or the adoption of multiple preservation strategies for the same material. In practice, this will not just be about selection (and ingest), but will involve co-operation across the range of activities librarians refer to as collection development and management.

Collection development is a term that is used by the library community to refer to "the selection and acquisition of material for an expanding collection and decisions on the material to be included in that collection" (Law, 1991, p. 1). Guidelines from the IFLA (International Federation of Library Associations and Institutions) Acquisition and Collection Development Section say that the primary function of collection development policies is to provide guidance on selecting and deselecting resources from a collection (Biblarz, *et al.*, 2001). Typically, collection development decisions apply at different stages of an institution's workflow, including the selection, acquisition, processing, housing, weeding, retention, preservation, relegation and discarding of library materials. Historically, much of the focus in the library world has been on the development and implementation of written collection development policies and guidelines, although the practical value of these has sometimes been questioned (e.g., Hazen, 1995; Snow, 1996). Collection development is now usually viewed as being a part of the wider activity of collection management, which includes "collection policy development, materials budget allocation, selection, collection analysis, collection use and user studies, training and organisation of collection development staff, preservation, and cooperative collection development" (Branin, Groen & Thorin, 2000, p. 24). In research libraries at least, there has been an increasing emphasis in recent years on the need for co-operative collection development, partly in recognition of the fact that no single institution can aspire to collect the entire record of scholarship but also to save costs in physical storage. For example, a recent report commissioned by CURL (the Consortium of University Libraries) and the British Library investigated the potential for "space and cost-savings that might be made as a result of collaboration over the storage of little-used periodicals and serials" (Fielden, *et al.*, 2005, p. 99).

National and international co-operation on collection development is not a particularly new concept. In the research and national library domain it dates back at least to the Farmington Plan, a co-operative acquisitions programme that emerged in the 1940s to ensure the continued availability of foreign materials in the US research libraries. A more recent international initiative was IFLA's concept of Universal Availability of Publications (UAP), designed to match the growing availability of bibliographic records with facilitating international access to publications through document supply services. Thus, Line and Vickers (1983, p. 23) argued, "UAP aims at ensuring that access to bibliographic information on publications is matched by the availability of the publications themselves, and is thus the logical and necessary complement to UBC [Universal Bibliographic Control]." While the concept of UAP was primarily focused on supporting *access*, it was immediately clear that its implementation would depend upon the long-term stewardship of - in this case - printed publications. The UAP model delegated this key task to national organisations - mainly national libraries - arguing that these should be the supplier of last resort; "every country must be able to supply its own publications ... to any other country in the world" (Line & Vickers, 1983, p. 24). The idea, therefore, supported development of policies that facilitate the systematic acquisition and retention of published knowledge at the national level.

Co-operation between libraries has not always been successful. For example, Line (1997) has argued that it often focuses on the means of co-operation at the expense of the ends that co-operation is intended to serve. However, libraries and other custodial institutions have successfully co-operated on developing shared approaches to things like cataloguing, conservation activities and preservation reformatting (e.g., on producing unified registers of microform and digital masters). Preservation itself has been a major focus of co-operation. For example, a survey by Eden & Gadd (1999) revealed that UK libraries co-operated on acquisitions, on sharing conservation skills and facilities, and on disaster management.

In the digital era, all organisations with responsibilities for long-term preservation (not just libraries) will need to consider in detail the benefits of co-operation. The key to this will be maintaining a level of redundancy (e.g., with regard to different technical approaches to preservation or geographical distribution) while avoiding excessive (and unnecessary) duplication of effort. So, for example, it remains to be seen how many national or research libraries will need to preserve electronic journal content, given that Portico, PubMed Central and the National Library of the Netherlands e-Depot are beginning to maintain a growing number of titles (e.g.,

Day, 2007). This is a logical area for co-operation, but may face potential challenges from the 'free riding' problem.[4]

4.2 Certification and concepts of 'trust'

As we saw in section 2, the concept of trusted repositories is one that has received a lot of attention recently. In addition to the Audit Checklist developed by the RLG-NARA Task Force, there are a number of other potentially useful certification frameworks. For example, the Deutsche Initiative für Netzwerkinformation has developed the DINI-Zertifikat to facilitate the evaluation of open access repositories in Germany (Dobratz & Scholze, 2005). The certification process helps to highlight best practice with regard to system security, data integrity, unique identifiers and the provision of metadata, and the latest version (2007) does aim to support the formation of trustworthy, future-oriented services.[5] Other approaches to certification might focus more on quality control than on formal audit. More speculatively, it may be worth investigating the potential of library service quality frameworks like LibQUAL+(TM) (Cook, *et al.*, 2001) for evaluating third-party preservation services. The LibQUAL+ tool itself is used to measure library users' perceptions of service quality, which may not be immediately relevant in digital preservation contexts, but the underlying concept of service quality may be useful.

Furthermore, the exact nature of trust in preservation contexts has yet to be fully explored. Clifford Lynch has recently commented that what we are really talking about in this context is competence (Day and Hockx-Yu, 2006). In this regard, there is a vast literature on the trust and control nexus in the organisation and management science literature (e.g., Handy, 1995; Castelfranchi & Falcone, 2000; Currall & Epstein, 2003) that may be worth exploring further.

5. Conclusions

This paper has attempted to introduce some of the problems associated with the need for preservation repositories to co-operate with each other and third-party service providers within distributed infrastructures. The next steps will be to delineate in more detail the exact scope of this potential co-operation, as well as to investigate the issues of collaborative collection management and 'trust' in more detail.

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[4] This was raised by Donald Waters at the JISC-NDIIPP Digital Preservation Workshop (Day & Hockx-Yu, 2006)

[5] DINI-Certificate Document and Publication Services. Retrieved December 18, from http://www.dini.de/documents/DINI_certificate_eng_2006-10-12_draft.pdf

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