Digital preservation in the context of institutional repositories

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1. What is an institutional repository?

Institutional repositories are "digital collections that capture and preserve the intellectual output of a single or multi-university community" (Crow, 2002). While some repositories focus on particular subject domains, an institutional repository stores and makes accessible the educational, research and associated assets of an institution. Although most of the currently established institutional repositories are 'e-prints' repositories providing open access to the research outputs of a university or research institution, the content does not need to be limited to e-prints but could potentially include research data, learning material, image collections and many other different types of content.

2. The importance of institutional repositories

Institutional repositories are a new but important area within the educational landscape. Through free and unrestricted online availability, they make it easier for researchers to disseminate and share research outputs and thus support the open access goal of scholarly communication. As noted by SPARC (Scholarly Publishing and Academic Resources Coalition), institutional repositories are becoming a major component of the evolving structure of scholarly communication (Crow, 2002). In addition to authors, who gain visibility, and users, who find information more easily, the potential benefits of institutional repositories extend to institutions, which increase their research profile, and funders, who see wider dissemination of research outputs.

This has been recognised by funding bodies worldwide and there is an international trend for funding bodies to require publication of research results through repositories. To maximise the usage and impact of research the eight UK Research Councils, for example, issued a position statement on access to research outputs in June 2005 under the umbrella of Research Councils UK (RCUK). In the position statement (RCUK, 2005) the research councils have proposed to make it mandatory for papers which result from Council-funded research to be deposited in openly available repositories at the earliest opportunity.

The Joint Information Systems Committee (JISC) supports further and higher education in the UK by providing strategic guidance, advice and opportunities in the use of ICT to support teaching, learning, research and administration. JISC is funded by all the UK post-16 and higher education funding councils (http://www.jisc.ac.uk/). JISC has been playing a leading role in piloting and supporting the development and implementation of institutional repositories to enable the dissemination and sharing of research outputs. For instance, between 2002-5 it funded 14 projects as part of the Focus on Access to Institutional Resources (FAIR) Programme (http://www.jisc.ac.uk/index.cfm?name=programme_fair). These included:

- pilot repositories of e-prints and different types of content, such as Securing a Hybrid Environment for Research, Preservation and Access (SHERPA - http://www.jisc.ac.uk/index.cfm?name=project_sherpa) and Electronic Theses (Copeland, Penman and Milne (2005).
- projects which investigated cultural, legal, and interoperability issues, such as Metadata for Open Archiving (ROMEO).

The more recently (2005-8) funded Digital Repositories Programme (http://www.jisc.ac.uk/index.cfm?name=programme_digital_repositories) takes this work forward and continues JISC's work in encouraging the growth of repositories in universities and colleges across the UK. The 23 projects funded under this programme are exploring the many cultural, technical and management aspects of creating and managing institutional and other types of repositories. To advise and guide institutions on the benefits and related issues, JISC issued a briefing paper on digital repositories in August 2005 (Joint Information Systems Committee, 2005). Using part of its £80m. capital funding, JISC is currently planning further work to boost the development in this area by providing institutions with advice and guidance on repository management, with support in developing a critical mass of content, and with a national infrastructure to support resource discovery and digital preservation across federated repositories (http://www.jisc.ac.uk/index.cfm?name=funding_1005).

JISC's vision for digital repositories goes beyond just hosting institutional research outputs. It extends to the need for a network of distributed repositories for primary data, research papers, learning objects and other types of both formal and informal information. The goal is to help underpin a variety of uses and to begin to build the infrastructure required for the future to cater for the knowledge economy and to deal with the digital data deluge.

3. The need for digital preservation

As defined by Jones and Beagrie (2002), digital preservation refers to the series of managed activities necessary to ensure continued access to digital materials for as long as necessary. The ease with which digital information can be created, combined with the huge increase in computer power and network bandwidth, has led to the proliferation of a vast amount of 'born-digital' data, especially in science and engineering, where petabytes (10^{15} bytes) of data are being generated by scientific instruments on a daily basis. This data deluge has forced many to address the issue of long term preservation and curation so as to ensure that data generated today can survive the changes of technology and can be accessed in the future.

The challenge for digital preservation is not just the volume of data. The hardware and software used to store and access digital information are constantly upgraded and superseded. Technology obsolescence is generally regarded as the greatest technical threat to ensuring continued access to digital material. The speed of changes in technology means that the timeframe during which preservation action must be taken is very much shorter than for paper, often measured in just a few years.

Due to their relatively short existence, few institutional repositories so far have encountered problems with long-term access or experienced an unmanageably large volume of content. In addition, there is little consensus on the extent to which institutional repositories should be responsible for preservation. This is reflected in a wider debate recently started on the JISC repositories mailing list (LIS-ELIB Archives, 2006). Some argue that the purposes of open access institutional repositories are chiefly access, usage and impact, while preservation of institutions' published journal articles is already in other hands such as the publishers and the legal deposit libraries. The latter should therefore not be the *raison d'être* nor the motivation for self-archiving. Others regard long-term preservation an important function and think it should be addressed by institutional repositories from the start.

This disagreement, however, does not in any way weaken the case for institutional repositories playing a role in digital preservation. Even those who regard the institution as having only a short term responsibility for preservation of institutional research outputs (until these outcomes are formally published) and those who regard preservation as less of a priority than getting content into the repositories, do not deny that there is a preservation role for institutional repositories. The question is how far this role goes. The responsibilities of institutions (including data creators and depositors) versus those of other national bodies and organisations need to be clarified. The answer to this is intrinsically related to the mission of an institutional repository and perhaps also the type of content it holds.

The broad view of institutional repositories as a means to manage and preserve effectively an institution's knowledge base and intellectual assets entails that the content of institutional repositories will expand beyond e-prints to include research data, e-learning materials and other forms of institutional intellectual outputs, which are generally not published or preserved elsewhere. Researchers, students, staff and institutions will require ongoing availability and confidence in the future accessibility of the content within the repositories. Those running institutional repositories therefore naturally have the responsibility to ensure this for the content they are entrusted with managing by their institutions and researchers. It needs to be ensured that content within the repositories remains accessible and retains its authenticity, reliability and integrity for as long as it is needed. As Lynch (2004) has rightly pointed out, "An institutional repository needs to be a service with continuity behind it …Institutions need to recognise that they are making commitments for the long term".

The current experience with institutional repositories is that a significant cultural change is required for researchers to deposit material. A survey recently conducted by the JISC Rights and Rewards in Blended Institutional Repositories demonstrates that preservation is one of the main reasons why participants contribute teaching materials to an institutional repository. When asked about the reasons that would make participants more or less likely to contribute material in the future, "(repositories) help to manage and preserve resources" gained high percentages for 'much more likely' and 'likely' (Bates et al., 2006). Although considerations for teaching materials and academic papers are

different, this does suggest that guarantee of long-term preservation helps give authors more confidence in the future accessibility and more incentives to deposit content.

4. Digital preservation: issues

In order to understand the process necessary to achieve the long term digital preservation of objects placed within a repository, it is useful to break down what is understood as effective preservation. Wheatley (2004) summarised its key functional goals as follows:

- data is maintained in the repository without being damaged, lost or maliciously altered;
- data can be found, extracted and served to a user;
- data can be interpreted and understood by the user;
- the above can be achieved in the long term.

The first goal is a fundamental requirement that must be addressed by any digital repository. The second goal means that repositories need to support searching and retrieval to improve access to information. This is an area which has received much attention in the last few years and has been greatly facilitated by standards, such as the Open Archive Initiative Protocol for Metadata Harvesting (OAI-PMH), allowing service providers to create discovery services across repositories by recurrent metadata harvesting. The third and fourth goals are what digital preservation needs to achieve. It is not enough just to keep the original bit-stream that represents the information stored in a digital object. The challenge is to make sure that users can access the content that has been ingested into the repository in the past and make sense of its intellectual property, despite hardware and software changes over time.

Digital preservation is a complex process and there are many unsolved organisational, managerial and technical issues that make digital preservation a challenging task for those managing institutional repositories. The focus of many repository activities to date has been on creating repositories, depositing content, promoting discovery and access and/or encouraging the necessary cultural change. Digital preservation has not been embedded as an integral part of the repositories' workflow and there is neither much experience nor commonly agreed best practice as to how digital preservation is best performed.

Digital preservation requires new workflows, new skills and close co-operation across different professions ranging from traditional preservation management skills to computing science. The organisational structure to support this is not yet in place. The Digital Preservation Coalition (DPC) recently carried out a UK-wide survey to assess the nation's preservation needs. One striking result of the survey is the common lack of clarity in responsibilities for digital preservation, which has been seen by a majority of the respondents as a barrier to digital preservation (Waller and Sharpe, 2006). The lack of clarity in roles and responsibilities does not only apply to organisations internally, it also exists between organisations and between different stakeholders. Not all institutional repositories will choose, be able, or should be expected, to carry out full digital

preservation activities themselves. Some of these functions will be performed by external preservation service providers. More research is needed to investigate the relationship between the institutional repositories and external preservation service providers, and their respective roles and responsibilities. Clarification of roles and responsibilities and agreement for shared efforts, both at technical and organisational level, involving all stakeholders for digital preservation is an area that urgently needs to be addressed.

The fact that many institutional repositories rely on short-term funding makes it hard to make long-term stewardship commitments. Concern of sustainability contributes to the lack of active engagement from many researchers. The situation is further complicated because costs for preservation are, in general, difficult to calculate and are poorly understood and it is difficult to segregate costs for preservation from costs for access. Since the core funding for institutions does not grow in line with information growth, this makes it difficult to justify and make a case for digital preservation to institutional management. Two JISC funded projects, LIFE (Lifecycle Information for E-Literature) and eSPIDA (An effective Strategic model for the Preservation and disposal of Institutional Digital Assets), when completed, should provide useful insight into these issues and help institutions assess and justify the costs for digital preservation. LIFE (http://www.ucl.ac.uk/ls/lifeproject/) is a collaborative project between the British Library and University College London, which investigates methods to attribute costs of digital preservation to identified stages within the lifecycle of digital collections. The eSPIDA project (http://www.gla.ac.uk/espida/) is based at the University of Glasgow. It is developing a business-focused model to assess the value and the associated risks and costs of digital assets and explore ways to bring digital preservation to the core of institutional strategic planning.

Depositing intellectual assets into institutional repositories requires that all are able to trust the ability of the repository to secure the information over the long term. Trust is an issue that could become a significant barrier for institutional repositories and increase the complexity of digital preservation. Trust does not only relate to the longevity of the digital objects stored within the repository but also to the financial sustainability of the repository itself and the human aspects of competency and trustworthiness. Hirtle (2000), in a report which brings together the views of key commentators on the authenticity of digital objects states, "The fact that digital information is found within a trusted repository may become the base upon which all further assessment of action builds". The US Research Library Group (RLG) and OCLC have made significant progress in defining the attributes and responsibilities of trusted repositories (RLG-OCLC, 2002), which include the viability and financial sustainability of the organisation that operates the repository and the need for accountability. The RLG and the US National Archives and Records Administration (NARA) released a draft *Audit Checklist for the Certification of Trusted Digital Repositories* in August 2005 for determining whether a digital repository can be certified as a trusted location for digital collections. Although this work, and the related audit and certification mechanisms, are still in development, those involved in developing institutional repositories need to be aware of the requirements for becoming trusted digital repositories.

Another challenge is to maintain the balance between ease of deposit and the needs for preservation. The costs and risks associated with digital preservation tend to grow when a digital collection includes a large number of diverse file formats as was found in a study commissioned by JISC (James et al, 2003). It seems a good practice to prescribe the file formats accepted by a repository and limit the number to a few that are based on open standards. However, this consideration should not become a barrier that prevents authors from depositing content into the repository. For the convenience of authors, most repositories probably will accept formats other than those preferred but will perform format migration for archival and preservation purposes.

It should be stressed that it is not possible or perhaps desirable to keep everything that has been created. Digital preservation involves selection and appraisal, which are criteria and processes for identifying information for long-term retention and preservation. Selection and appraisal are iterative decision-making points within the lifecycle of a digital object connected to its active use and can be applied to help ensure institutional resources are devoted to the long-term availability of the most valuable digital assets. Guidance on good records management practices and how appraisal can be done within the context of institutional repositories, for different types of content, is needed to help decision making and answer the questions "what to keep?" and "how long to keep?". In addition, there is a need for more tools such as the Decision Tree for Selection of Digital Materials for Long-term Retention, developed by the DPC, to assist institutions in defining selection policies (Digital Preservation Coalition, 2002).

Technical issues and challenges related to digital preservation include a lack of practical implementations of preservation standards and a lack of technical knowledge, in general, of what information is required to support the digital preservation process within the institutions. Little preservation metadata, for example, is currently being collected by institutional repositories. In order to increase productivity and ease the task of preservation for individual institutions, there is a need for new, shared preservation services and information infrastructure. Desktop tools and software for institutional repositories need to include functionalities to support and enable the collection of preservation metadata, during the creation and the ingest process. We also need persistent identifiers services and registries for file format and registries for 'representation information' ('representation information' is a term used to refer to all information required to access and interpret a digital object). Moreover, there is a need for more automation and tools, for example for automatic metadata generation and extraction, and for automatic file format recognition and validation.

5. The Open Archival Information System Reference Model

The question of how to preserve and maintain access to digital information over the long term is far from being satisfactorily answered. However, the Open Archival Information System (OAIS) Reference Model has been widely adopted and used to inform the development of preservation tools and repositories. OAIS was an initiative started by the Consultative Committee for Space Data Systems (CCSDS) of the National Aeronautics and Space Administration (NASA). It became an ISO standard in 2003. The OAIS

Reference Model is a conceptual framework for a generic archival system which is committed to a dual role of preserving and providing access to information.

Central to the reference model is an open archival information system (OAIS) which is "an organisation of people and systems that has accepted the responsibility to preserve information and make it available for a Designated Community" (Lavoie, 2004). The reference model includes an OAIS Functional Model that describes the functional components which collectively fulfill the system's preservation and access responsibilities. It also defines the external environment within which the OAIS operates and includes an information model which provides a high-level description of the information objects managed by the archive.

The high-level functional model can be represented diagrammatically in Figure 1(CCSDS, 2002).

Take in Figure 1

Figure 1: OAIS functional entities
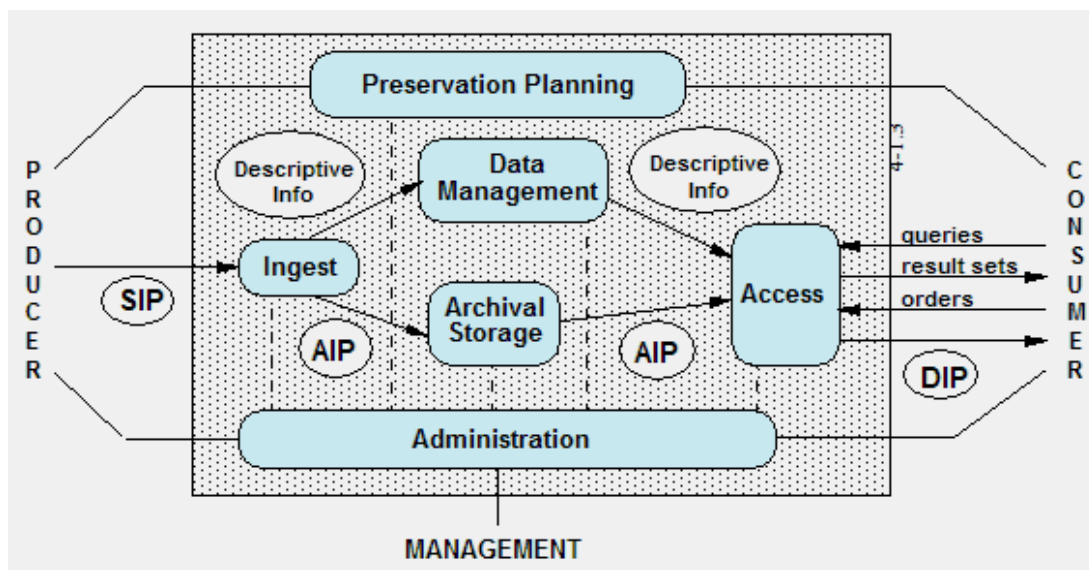
The functional components of an OAIS include:

- *Ingest* - services and functions that accept information submitted by Producers and prepare it for storage and management within the archive
- *Archival storage* - manages the long-term storage and maintenance of the digital materials entrusted to the OAIS, to make sure they remain complete and renderable over the long term. Media refreshment and format migration for example are typical procedures that would be undertaken by the archival storage function.
- *Data management* - maintains descriptive metadata to support search and retrieval of the archived content, and administration of internal operations.

- *Preservation planning* - designs preservation strategy based on evolving user and technology environment
- *Access* - manages processes and services that locate, request, and receive delivery of the content within the archival store
- *Administration* - responsible for day-to-day operations and the co-ordination of the five other OAIS services.

The OAIS Reference Model also introduced the important concept of 'Designated Community', which has been defined by CCSDS as "an identified group of potential Consumers who should be able to understand a particular set of information. The Designated Community may be composed of multiple user communities (CCSDS 2002)". This, in essence, refers to the users who possess the necessary knowledge base to understand independently the information as it is preserved and made available by the OAIS. Its usefulness is in that it helps to draw the boundary and to determine the amount of metadata that needs to be kept and managed to support the preservation process. A broader scope of the Designated Community implies less specific domain knowledge, therefore will, in general, require more metadata to render and understand the preserved information over the long term. Serving the needs of the designated community requires thorough understanding of the users and their knowledge base. This will enable managers of institutional repositories to determine what information needs to be developed and maintained to ensure the usability of the repository content now and into the future. In addition, it also helps to define how to present and enable access to the content and may even determine its actual format. These considerations in turn all have a direct impact on the long-term preservation.

It is important to bear in mind that the OAIS Reference Model is a high-level conceptual framework. It does not include details on implementations and does *not* ensure consistency or interoperability between implementations. Its strength is that it provides common terminology and concepts for describing repository architectures and comparing implementations. The reference model has been used by a variety of organisations to inform the planning and design of digital repositories of many different types.

It is also important to know that not all the proposed functions need to be undertaken by a single repository. Some functions can possibly be fulfilled by external service providers and experiments are being carried out with disaggregated models.

6. JISC digital preservation strategy and key initiatives

Ensuring long-term preservation of, and continuing access to, scholarly and educational resources is an important strategic area for JISC. As an organisation working on behalf of the funding councils and the academic community, JISC has undertaken various activities to help institutions address the challenges of digital preservation and to advance the UK digital preservation agenda. Guided by the *Continuing Access and Digital Preservation Strategy* (Beagrie, 2002*)* and its implementation plan, JISC's vision is to create a mix of national, and perhaps regional and institutional services, to support digital preservation. The strategy also recognises the importance of good records management and advocates a

lifecycle approach towards the management of digital resources where the inter-dependencies between each stage of the lifecycle are being emphasised. Moreover, the strategy stresses the complexity of digital preservation and the importance of collaboration and partnerships with other national and international organisations.

To date, key initiatives by JISC in the area of digital preservation include:

- Feasibility and scoping studies covering major areas of JISC and institutional digital collections to assess preservation risks and retention criteria. Findings and recommendations by these studies have helped inform and prioritise JISC's development work. The recommendations made by the *Data Curation for e-Science in the UK* report (Lord and MacDonald, 2003) for example led to the establishment of the Digital Curation Centre (DCC) in 2004. The DCC aims to solve the extensive challenges of digital preservation and to provide research, advice and support services to UK institutions (http://www.dcc.ac.uk).

- Community calls to engage institutions directly in examining, testing or implementing emerging standards and tools in an operational environment. A Call for Proposals issued by JISC in 2004 (JISC, 2004) for example resulted in the funding of 11 projects in institutional digital preservation and asset management, with a specific focus on long-term strategies and procedures. Although most of the projects are still ongoing, this programme has been named one of the "ten promising digital preservation initiatives" (RLG DigiNews Staff, 2005).

- JISC's UK-wide remit has given it a unique position to develop national initiatives and services on behalf of the sector to tackle the issues which are difficult for institutions to address individually. The Arts and Humanities Data Services (AHDS), the UK Data Archive (UKDA) and the DCC are national centres of expertise co-funded by JISC and the Research Councils to aid the creation, acquisition and preservation of digital resources and to provide research, advice and support services to UK institutions.

- Digital preservation is not solely an issue for JISC but an activity that involves many stakeholders. JISC has formed collaboration and partnerships with various organisations to jointly tackle the challenges of long-term digital preservation. In addition to co-fund the above-mentioned national initiatives, JISC is a full member of the Digital Preservation Coalition (http://www.dpconline.org) and a founder member of the UK Web Archiving Consortium (http://www.webarchive.org.uk/). JISC has also formed a formal partnership with the British Library and digital preservation is a key area of work within this partnership. Moreover, JISC is a member of the Office of Science and Technology (OST) e-Infrastructure working group on digital preservation and a member of the European Task Force for Permanent Access to Records of Science (http://tfpa.kb.nl/frame-inhoud.html), both charged with the tasks of identifying

and putting in place the necessary research programme and infrastructure to support long-term access to scientific information.

6.1 SHERPA DP and PRESERV

Two projects that are worth a special mention are SHERPADP and PRESERV, which explore different models for the provision of digital preservation services for institutional repositories. Both projects are funded under the JISC Digital Preservation and Asset Management Programme and will run until early 2007.

a) *SHERPA DP: Creating A Persistent Preservation Environment for Institutional Repositories* (http://ahds.ac.uk/about/projects/sherpa-dp/)

Not all institutions possess the required expertise, skills or resources to ensure long-term preservation and access to digital resources, the SHERPA DP project led by the Arts and Humanities Data Service (AHDS) directly challenges this problem by piloting a shared preservation infrastructure for institutional repositories based on the OAIS Reference Model. The functional components and associated activities defined by the OAIS Model will be distributed among the participating institutional repositories and the AHDS, each taking responsibility for different functions, with AHDS acting as the provider of preservation services. This removes the need for individual repositories to develop their own services and employ scarce preservation management skills and expertise locally. The project will also investigate the business case for this model and seek to establish an economic cost model that could be used to ensure its long-term sustainability.

b) *Preserv – Preservation Eprint SERVices* (http://preserv.eprints.org/)

The Preserv project is led by the University of Southampton in partnership with Oxford University, The National Archives (TNA) and the British Library (BL). The project investigates and develops an ingest service, based on the OAIS Reference Model for institutional repositories, built using the EPrints software developed at Southampton University (http://www.eprints.org). The EPrints software will be adapted to allow the collection and dissemination of preservation-oriented metadata. PRONOM, the file format registry developed by The National Archives is being incorporated into the ingest service for automatic file format identification and verification. The BL will build and test an exemplar preservation service using preservation metadata collected by the institutional repository. The potential of this approach is that an OAIS implementation external to the institutional repositories could be built over a network of distributed and co-operating services.

The models for preservation services being explored by SHERPA DP and Preserv may be a way forward to tackle collectively the issue of long-term preservation within the setting of institutional repositories.

7. Conclusion

Digital preservation is not a unique problem that institutional repositories face alone. The pressures on information providers for digital preservation and continued access will continue to intensify over time. JISC's interest in digital repositories closely relates to its strategy to support institutions in long-term digital asset management and preservation. JISC has made substantial progress to date and will continue its work in both areas. The issues and challenges related to long-term digital preservation and the gaps in information infrastructure identified earlier in this paper, are the priority areas where JISC will focus its effort and investment.

It must be stressed that the wide deployment of institutional repositories also provides new opportunities for digital preservation. Much could be done to consider digital preservation from the outset, to involve the authors in contributing preservation metadata during the creation and ingest process and to embed digital preservation into the repositories workflow, which will ease the later preservation tasks. One of the benefits of bringing digital assets into a managed repository framework is the promise of future proofing against technology obsolescence. This is an opportunity to move beyond just rescuing digital objects to building the infrastructure required to manage them from the start.

We are working towards a future in which digital preservation is fully integrated into the life-cycle of information management; not a separate activity.

Editor's Note
This paper is an updated version of a presentation given at the Joint Internet-Based Sources (JIBS) User Group meeting "Are institutional repositories taking over the world?" held at the British Geological Survey, in September 2005. Available at: http://www.jibs.ac.uk/meetings/workshops/repositories/HockxYuJIBSSep2005.ppt

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