A Metadata Approach to Digital Preservation

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Abstract

Selection and metadata issues which surround the preservation of digital information are discussed, in particular, the assignment of "collection levels" to Web materials to ensure preservation, and some Preservation Metadata Element Sets (PMES) which have been identified as informed by the Open Archival Information System (OAIS) Reference Model. A metadata framework that can support a broad range of digital preservation activities-a Core PMES-is proposed, together with a general criteria based on "collection levels" to express preservation decision and responsibility for the resource at the time of selection.

Keywords: *Collection Management, Digital Preservation, Preservation Metadata, Selection for Preservation.*

1 Introduction

"Technology burns history, leaving no material residue", a statement attributed to Paul de Man, tells its message loud and clear. Indeed, it is now common knowledge that "digital information is fragile in ways that differ from traditional technologies, such as paper or microfilm"[13]. Digital information includes those resources that have been digitized from an analog state and those that only exist in the digital domain, the so-called "born-digital" resources. Sustainable technical solutions to preserve both digitized and born-digital resources are still being tested. There is clearly a growing awareness that digital preservation is a critical issue, calling for measures that go beyond immediate archiving [33]. There is lively debate among proponents of different approaches as well as an interest in developing standards which should ease but not solve the preservation problem. There are a number of very good projects underway attempting to develop workable approaches and "best practice" archiving models. One internationally prominent example is the Reference Model for an Open Archival Information System (OAIS) being developed by the Consultative Committee for Space Data Systems as a new ISO standard [7]. The OAIS model is important for digital preservation standards and strategies because it defines the functions and requirements for a digital archive by providing terminology, conceptual data models, and functional models for interoperable open archives. It also defines the nature of "information packages" in terms of both their content and what is needed to understand, access and manage the content. Since digital preservation is such a broad area, this paper specifically focused on the critical role of "preservation metadata" to capture the context of a resource and the processes defining and surrounding its use.

2 Metadata to support preservation

The importance of metadata for library and recordkeeping systems is well accepted. Catalog information, "finding aids", provenance, and administrative information (e.g. location, condition, or usage data) provide additional context that makes a document or record more meaningful, accessible, and useful. In fact, much of the literature on digital archives, including OAIS, focuses on metadata - often to the exclusion of the actual documents or records that are to be stored [28]. While waiting for some "tried and tested" preservation solutions , extensive metadata for the meantime is our best way of minimizing the risks of a digital object becoming inaccessible. Discussions of metadata in the library community have largely centered on issues of resource description and discovery. There is, however, a growing awareness that metadata has an important role in digital resource management, including preservation. Regardless of whether emulation-based or migration-based preservation strategies [1] are adopted, the long-term preservation of digital information will involve the creation and maintenance of metadata.

Properly used, metadata can:

- Identify the name of the resource, who created it, who reformatted it, and other descriptive information;

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- Provide unique identification and links to organizations, files, or databases which have more extensive descriptive metadata about this resource (this is particularly important in the event that the digital file and its metadata become s eparated);
- Explain the technical environment needed to view the resource, including applications and version numbers needed, decompression schemes, other files that need to be linked to it, etc. [2].

2.1 Emerging PM models

The event-aware model explains that "a particular metadata description is often a portrayal of a snapshot of some entity taken in a particular state, i.e. a perceived stability of the entity over a particular time and place [16]. The granularity of that snapshot varies across metadata vocabularies." For example, a Dublin Core description, intended for relatively basic resource discovery, is a particularly coarse granularity snapshot. Interestingly, the Helsinki University Library (HUL)[31,32] identified its preservation metadata elements based on Dublin Core and extended it even further than the normal qualification or refinement in accordance to its library's specific preservation needs. Elements have element qualifiers (called sub-elements) but these element qualifiers can also have sub-elements labeled "extra qualification". Overall, this approach has three levels: element, element qualifier, and extra qualification. Let us look at some HUL metadata elements that have been identified to describe the preservation process:

- element: **Description**
  - element qualifier: ofPreservation
    - extra qualification: strategy
    - extra qualification: actions
    - extra qualification: toolsUsed
    - extra qualification: changes
- element: **Relation**
  - element qualifier: isReplacedBy
  - element qualifier: isFormatOf
  - element qualifier: hasFormat
- element: **Date**
  - element qualifier: dateGathered

Preservation metadata, therefore, may be used to store all this technical information that supports

Table 1. Different Types of Metadata and Some Examples

Type	Definition	Examples
Administrative	Metadata used in managing and administering information resources	- Acquisition information - Rights and reproduction tracking - Documentation of legal access requirements - Location information - Selection criteria for digitization - Version control and differentiation between similar information objects - Audit trails created by recordkeeping systems
Descriptive	Metadata used to describe or identify information resources	- Cataloging records - Finding aids - Specialized indexes - Hyperlinked relationships between resources - Annotations by users - Metadata for recordkeeping systems generated by records creators
Preservation	Metadata related to the preservation management of information resources	- Documentation of physical condition of resources - Documentation of actions taken to preserve physical and digital versions of resources, e.g., data refreshing and migration
Technical	Metadata related to how a system functions or metadata behave	- Hardware and software documentation - Digitization information, e.g., formats, compression ratios, scaling routines - Tracking of system response times - Authentication and security data, e.g., encryption keys, passwords
Use	Metadata related to the level and type of use of information resources	- Exhibit records - Use and user tracking - Content re-use and multi-versioning information

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preservation decisions and actions [3]. In contrast to descriptive metadata schemas (e.g. MARC, Dublin Core), which are used in the discovery and identification of digital objects, preservation metadata largely falls into the category of administrative metadata, assisting in the management of information [9]. However, in order to understand this concept of metadata better, it would be helpful to break it down into categories that reflect key aspects of metadata functionality [4], although overlapping among the functions can not really be avoided as seen in Table 1.

As such, preservation metadata has, therefore, become a popular area for research and development in the archive and library communities. Archivists and records managers have concentrated on the development of recordkeeping metadata. Examples are the Pittsburgh Project called the "Functional Requirements for Evidence in Recordkeeping" [11], and the work done at the University of British Columbia called the "Protection of the Integrity of Electronic Records" project [24] which focused more on the system requirements for electronic recordkeeping. The latter has now progressed to a more international level in the InterPARES (International Research on Permanent Authentic Records in Electronic Systems) project [15]. Like resource discovery metadata, recordkeeping metadata helps describe and locate information. But more importantly, it helps control and manage information in a way that preserves its integrity and authenticity, and enables it to serve as evidence of business activity over time. On the other hand, there are groups that have dealt with defining metadata specifications for particular needs. For example, the library and information community represented by the Research Libraries Group (RLG) constituted a Working Group on Preservation Issues of Metadata [26] with the aim of ensuring that information essential to the continued use of digital resources be captured and preserved in an accessible form. This Working Group defined the semantics of sixteen metadata elements considered essential for preserving a digital master file over the long term. Meanwhile, the National Library of Australia (NLA) developed its own logical data model [22] to help identify the particular entities and their associated metadata that need to be supported within its PANDORA (Preserving and Accessing Networked Documentary Resources of Australia) proof-of-concept archive.

The Joint European Union-National Science Foundation (EU-NSF) Working Group on Metadata [29] agrees that defining a logical framework that subsumes or reconciles a variety of data models would be desirable and is, in fact, a major research challenge with implications for the exchange and reuse of different types of metadata for a broad range of applications. As mentioned in the first part of this paper, the OAIS model is one such framework based on standards for metadata and interoperability among systems. The goal is to allow archival material to flow seamlessly from one archive to another over time and to ensure consistent access on the part of users [13]. This model has been utilized by several initiatives developing preservation metadata sets for it provides a useful reference point to ensure that all relevant information required for preservation has been included. Important questions that should be considered, however, are the following [8]:

- How much specificity can be added to the metadata description, while at the same time maintaining broad applicability? (From actual experiences, we also know that the more complex the semantic set, the less likely it is to be implemented).
- How much can we automate?
- Who is responsible for the gathering and describing of those required information which cannot be automated?
- What level and type of staff will be involved?
- How much is it all going to cost? Will all this detailed description work and complexity be worth all the trouble (to attain the goal of long-term preservation and access to digital resources)?

2.2 A Proposed Core PMES

Most projects dealing with digital preservation recognized at an early stage that metadata is important. The OAIS Taxonomy of Information Object Classes, the information requirements identified for preservation used by several of these projects, was based on the concepts first described in the 1996 Task Force Report [25] as those features that determine information integrity -content, fixity, reference, provenance, and context. Accordingly, the OAIS Taxonomy divides Preservation Description Information (PDI) into Reference Information, Context Information, Provenance Information, and Fixity Information.

The White Paper produced by the OCLC/RLG Working Group on Preservation Metadata [23] gives a very detailed comparison of the Preservation Metadata Element Sets (PMES) of

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the CURL Exemplars in Digital Archives project (CEDARS), the National Library of Australia's (NLA) PANDORA Project, and the Networked European Deposit Library (NEDLIB) as mapped to the OAIS information model [6,9,17,18]. The three PMES are compared according to the following criteria:

- their rationales and objectives;
- their underlying framework; and
- the elements themselves.

The same purpose and method were basically employed in this paper which started from scratch almost one and a half years ago using the same three projects, the same reference model, and the same objective of converging existing preservation metadata sets. The three projects seem to share the view that the primary purpose of preservation metadata is ***to document the information necessary to facilitate decision-making*** on the part of preservation managers, and ***to maintain access to the content of archived digital objects***. This is clearly shown by the finding that the three projects focus mainly on the Provenance and Representation Information components of the OAIS information model.

The CEDARS Project generally adhered to the OAIS Model [6], but the proposed preservation metadata element set is not intended to include descriptions of all archival functions because there are separate areas in OAIS for the administration and management functions. On the other hand, NEDLIB's scheme focuses strictly on preservation metadata [17], and not on metadata that have to be preserved (which is the focus of the DC Working Group on Administrative Metadata) [14]. Only the National Library of Australia attempted to develop a metadata set that may be described at collection-level, object-level, and sub-object level [18]. This model assumes that the digital object is the primary focus of management and description, and file and collection descriptions are created when appropriate.

After doing a comparison of the OAIS-based Preservation Metadata sets, this study synthesized the preservation metadata elements common to the three projects (found below) which can be considered "core" or essential for long-term preservation.

Summary of elements:

Preservation Description Information

1. Reference Information
    1.1 Persistent Identifier
    1.2 Date of Creation
    1.3 Existing Descriptive Metadata
2. Context Information
    2.1 Relation
3. Provenance Information
    3.1 Origin
    3.2 Custody history
    3.3 Change history
    3.4 Original technical environments
    3.5 Purpose for preservation
    3.6 Rights management
4. Fixity Information
    4.1 Authentication indicator

Content Information

5. Representation Information
    5.1 Object Structure
    5.2 Object Semantics

Definitions for each element of the "core" set are presented below:

Preservation Description Information

1. Reference Information

Persistent Identifier
An identifier or "permanent name" for an object that identifies it uniquely and persistently.

Date of Creation
Date expressed in a standardized form when the manifestation came into being.

Existing Descriptive Metadata
Any metadata record which has been generated for the resource.
Example: MARC records, Dublin Core

2. Context Information

Relation
Specifies any other information objects which were judged, at the time of ingest, to be significantly related to the ingested digital object.

3. Provenance Information

Origin
Contains a description of the original digital object prior to ingest; in addition, where the production of the object has involved digitizing, the production process can also be described here.

Custody history
Contains the identity of individuals or organizations responsible for the storage of the digital object from the date of its creation until the digital archive became responsible for the storage of the digital object, and records when they were responsible.

Modification history
Describes any changes which anyone responsible for the storage of the digital object made, from the time of creation of the digital object until the digital object became the responsibility of the digital archive.

Original technical environments

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Contains information about the operating environment of the original digital object at the time of ingest, including information on relevant hardware and operating systems, together with the software products that would have been required in order to use it.
Example:
Prerequisites: Adobe Acrobat Reader 3.0
Documentation: refer to Adobe Acrobat Reader 3.0 manual

Purpose for preservation
Describes the reasons why the digital object was preserved and deposited in the archive.
Example: legal deposit, for access, etc.

Rights management
Contains links to copyright statement which could include name of publisher, date of publication, place of publication, rights warning, contracts or rights holders, permissions.

4. Fixity Information

Authentication indicator
The mechanism used to ensure the digital object's authenticity.
Example: Digital certificate

Content Information

5. Representation Information

Object Structure
Provides a mechanism for transforming the preserved digital object (stored as a byte-stream) into the structured set of digital components needed in order to access and render its content. An example would be information on the object's underlying abstract form description.

Object Semantics
Provides the mechanisms which allow the specific digital object to be rendered. Examples are information on the object's platform, parameters, input format, output format etc.

3 Collection-Level Description

The enormous quantity of digital information being produced, its sometimes questionable quality, and the resource constraints on those taking responsibility to preserve for long-term access, makes selection inevitable. In fact, in the digital world, the act of selecting for preservation has become a process of constant reselection. We have to intervene continually to keep digital files alive. Indeed, many are saying that the preservation of digital data should begin at the time of creation. Ideally, the creator should make all decisions about file format, software and hardware, and even complexity of documentation, in light of the intended longevity of the object [30]. Hence, this paper also looked into the selection approach of web resources for purposes of preservation. A general criteria based on the concept of "collection levels" is proposed to express preservation decision on and responsibility for the resource at the time of selection.

Materials on the Web can be divided into two categories: those that are provided with open access and those for which there are access restraints. A library can easily collect open access materials that the creators have made publicly available, without restriction, by simply downloading the web pages over the Internet. In the case of the Berkeley Digital Library SunSITE (based at the University of California, Berkeley) [10], materials can be chosen for preservation at any point once selected. The said project adapted the "collection level" approach to digital materials from the traditional collection levels for print-based materials which is shown in Table 2.

Print-based collection level designations are still useful within the digital realm, but more information is required for digital collections. Table 3 shows that the Berkeley Digital Library SunSITE [UCB] proposes four levels of collecting which may also include designation of preservation commitment, while the Arts and Humanities Data Service (AHDS) in the U.K. [5] has identified six levels (Archived, Served, Brokered, Linked, Finding Aids, & De-accessioned), and the National Library of Canada has three levels (Archived, Served, and Linked) [19,20]. Materials in any category except "Archived" may be re-designated from one level to another as required to meet changing information needs, remote server accessibility or responsiveness, local resource demands, etc. Material that receives the "Archived" designation cannot be downgraded to a lower status. Adapting policies to the digital environment in examples such as these is likely to be the most ***cost-effective means of ensuring appropriate management and continued access to the most important digital resources***. The synthesized "collection levels" may be explored as possible attributes or qualifiers for the PMES as indication of preservation decision on the resource.

Figure 1 is an extract from the Berkeley Digital Library SunSITE Collection [10] to illustrate how "collection levels" are currently applied in its Web collection. All the materials in this selection

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Table 2. Traditional collection levels for print-based materials

LEVELS	*DESCRIPTION*
Comprehensive :	a collection to include all significant works of recorded knowledge in all applicable languages for a defined and limited field.
Research:	a collection which includes the major dissertations and independent research, including materials containing research reporting new findings, scientific experimental results, and other information useful to research.
Study :	collection which is adequate to support undergraduate and most graduate course work, i.e. which is adequate to maintain knowledge of a subject required for limited or generalized purposes.
Basic:	a highly selective collection which serves to introduce and define the information available elsewhere.
Minimal:	a subject in which few selections are made beyond very specific works.

Table 3. Comparison of collection levels

LEVELS	*UCB*	*AHDS*	*NLC*
Archived: Material is hosted here and the library intends to keep intellectual content of material available "permanently."	**O**	**O**	**O**
Served: Material is hosted here, but the library has not yet made commitment to keeping it available.	**O**	**O**	**O**
Mirrored: Copy of material residing elsewhere is hosted here, and the library makes no commitment to archiving. Another institution has primary responsibility for content and its maintenance.	**O**	**X**	**X**
Brokered: Material is physically hosted elsewhere and maintained by another institution but the library has negotiated access to it; includes metadata and links in its catalog; library users can locate and cross-search it.	**X**	**O**	**X**
Linked: Material is hosted elsewhere, and the library points to it at that location; no control over the material.	**O**	**X**	**X**
Finding Aids: Electronic finding aids and metadata held by the library to facilitate discovery and searching; this metadata is associated with library's digital collections or elsewhere, but may be stored, managed and maintained separately from them.	**X**	**O**	**X**
De-accessioned: Accessioned resources that have not been retained after review.	**X**	**O**	**X**

Legend: ***O*** *means collection level is being used,* ***X*** *means otherwise.*

are labeled "Served" on the left side (with its own icon), and this means that the materials are hosted at Berkeley but the library has not yet made commitment to keeping them available.

Figure 1. Example

Served — Advanced Papyrological Information System
Includes the Tebtunis Papyri, the largest U.S. collection of papyri from a single site.

Served — Aerial Photography Online
A collection of aerial photographs of the San Francisco Bay Area and Yosemite National Park.

Served — The American Heritage Project
A shared database of SGML-encoded finding aids describing and providing access to collections documenting American history and culture.

The Harvard University Library's Digital Repository Service (DRS), on the other hand, identified three levels of service in its digital preservation guidelines in terms of file formats (for both images and text) [12]:

- Level 1 – approved formats, assured preservation (e.g. XML, TIFF)
- Level 2 – likely formats, preservation will be attempted (JPG, MP3, PhotoCD)
- Level 3 – unlikely formats, preservation not possible (e.g. Word files, PDF).

Basically, the owner selects appropriate format based on level of service. Preservation costs vary according to level, and there are tradeoffs to consider between cost to create vs. cost to preserve. Best practice is to deposit at least one version in a "Level 1" format even if it is not the delivery version.

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4 Conclusions

(1) There is a rapidly growing body of digital resources for which there are legal, ethical, economic and/or cultural imperatives to retain for long-term preservation and access. If active steps are not taken to protect these digital materials, they will inevitably become inaccessible within a relatively brief time frame.
(2) At present, selection (i.e. high quality) for collection building and preservation is mainly human-driven and involves the decision-making process for including or excluding electronic material from the collection. The selection process is highly dependent on local conditions.
(3) The OAIS Reference Model is applicable to any archive. By applying the OAIS Model, libraries can benefit from the advantages of international standardization. By using a common reference model, a common terminology and a common conceptual framework, it is much easier to share ideas and exchange experiences.
(4) The description of collections will become increasingly important in the context of networked library services. A strong view is emerging that libraries need to complement item-based description with description at a higher level. This will complement current work in the archives community and that descriptions at this shared level of granularity will facilitate cross-domain working. Hence, while the value of collection-level description is recognized, there is no standardized way of doing it. UKOLN has developed a preliminary approach in describing the JISC Current Collections [32], and it has prepared a report that examines collection description in library, archive, and museum domains. How this "fonds" principle can be maximized for preservation purposes still remains to be seen.
(5) Digital preservation is an essentially distributed process including a range of different stakeholders who become involved with digital resources at particular phases of their life cycle. To increase the prospects for digital preservation and reduce their costs, different groups of stakeholders need to become more aware of how their particular involvement with a digital resource ramifies across its life cycle.
(6) Whatever the longer term preservation methods adopted for an individual resource, all resources will need to be wrapped for preservation [27,28]. Wrapping will involve encapsulating or linking the resource to adequate reference (e.g. description of data types, operations, relationships) and preservation description (e.g. reference, provenance, context, and fixity) information. The precise metadata requirements of each digital object will vary, and the metadata required for each digital resource could be drawn from a metadata repository.
(7) Some more ongoing concerns for future research in relation to the whole of digital preservation are the following:

- ability of digital preservation methods to scale (considering that there exists a large number of valuable legacy databases);
- inter-linking of preserved digital objects;
- interoperability of digital archives (OAIS could be a good starting point);
- cost and financial models;
- legal issues (especially IPR).

Notes

[1] The Cedars Project provided working definitions of both the emulation and migration strategies, whereby in the former, digital materials are stored in their original format as a bit stream and software/hardware emulators are used to mimic the behavior of obsolete hardware platforms and emulate the relevant operating system to allow for access. The latter employs a set of organized tasks designed to achieve the periodic transfer of digital materials from one hardware/software configuration to another, or from one generation of computer technology to a subsequent generation. Its purpose is to preserve the integrity of digital objects and to retain the ability for clients to retrieve, display, and otherwise use them in the face of constantly changing technology.

[2] Conversion projects would use additional metadata elements such as the capture device, resolution, compression, source material, etc.

[3] Metadata elements useful in preservation might include: identifiers; hardware, operating system and software required to access a document; physical details of tangible format publications such as CD-ROM, floppy disks; encoding standard and version; migration history and its success; data to assist determining authenticity; rights management information; versions and dates.

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