Digital Stacks: Turning a Current Prototype into an Operational Service

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Abstract. The presentation outlines the *Digital Stacks* project, whose aim is to set up a prototype of a long term digital preservation system for electronic documents published in Italy and made public via digital communication network, according to the legal deposit law. In the first part the technical architecture and the metadata management problems are outlined; the second part concerns the legal and agreements framework of the project, the organizational model and the service model. Also the sustainability issue is briefly addressed.

1 Introduction

The *Digital Stacks* project aims to set up a prototype of a long term digital preservation system for electronic documents published in Italy and made public via digital communication network, according to the legal deposit law (L. 106/2004, DPR 252/2006). The project was originally established in 2006 by the *Fondazione Rinascimento Digitale,* by the *Biblioteca Nazionale Centrale di Firenze* and by the *Biblioteca Nazionale Centrale di Roma*.

The first part of this presentation will take into account the technical architecture of *Digital Stacks* but, of course, it is well known that digital preservation is more than just a technical process. Strategies to avoid bit loss or to prevent hardware and software dependencies are only a part of the issue. *Digital Stacks* of course have to deal with other problems, including economic implications (sustainability), selection problems (what is important to preserve for future generations), legal aspects, cooperation between legal deposit institutions[1]. Some of these aspects will be addressed in the second part of the presentation.

For the purposes of the project, Digital Preservation could be defined as a public service to be provided by trusted digital repositories in order to ensure for deposited digital resources viability, "renderability", authenticity and availability for designated communities[2].

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[1] Brian Lavoie, Lorcan Dempsey, *Thirteen ways of looking at ... digital preservation*, <<D-lib magazine>> 10(2004), 7/8 http://www.dlib.org/dlib/july04/lavoie/07lavoie.html

[2] This definition is based on:
a) *Trustworthy Repositories Audit & Certification (TRAC)*
http://www.crl.edu/sites/default/files/attachments/pages/trac_0.pdf (for the concept of "trusted digital repositories");

The name of the project recalls the stacks of the legal deposit libraries. As stated by a historical European project on digital preservation (NEDLIB)[3]: "For us, as memory organizations, this means we have to move from paper-based stacks to digital stacks".

In other words the name of the project *Digital Stacks* intentionally recalls the term used to refer to the stacks of legal deposit libraries.

In most aspects digital stacks are comparable to conventional ones: digital resources must be preserved for the long term; digital stacks grow as new resources are added; modification and deletion is not an option; it is impossible to predict the usage frequency of stored digital resources; and it is likely that some resources will be seldom or never be used [4].

It is worth noting that nine years later, a search query for "Digital stacks" on Google will return the same expression used within the context of digital preservation: "Digital stacks: rather than boxes, shelves, and climate controlled environments, digital information must be stored in containers, file systems, and secure servers"[5].

2   Technical Architecture

The aim of the project was to set up an infrastructure based on a *long term framework*. Taking into account the fact that component failures are the norm rather than the exception[6], the infrastructure is based on data replication (different machines located in different sites) and on simple and widespread hardware components, non vendor-dependent, which can easily be replaced (in other words simple personal computers).

The infrastructure does not rely on custom or proprietary software but is based on an open source operating system and utilities (widespread acceptance means less dependencies).

b) Luciana Duranti, *Un quadro teorico per le politiche, le strategie e gli standards di conservazione digitale: la prospettiva concettuale di InterPARES,* <<Bibliotime>>, 9(2006), 1 http://didattica.spbo.unibo.it/bibliotime/num-ix-1/duranti.htm (to assess the *authenticity* of a digital resource, the *public service* must be able to establish its *identity* and demonstrate its *integrity*)

c) PREMIS 2.0, 2008 , PREsevation Metadata: Implementation Strategies, http://www.loc.gov/standards/premis/ (for the concepts of "Viability: Property of being readable from media" and "Renderability" "Render: To make - [by the means of a computer] - a Digital Object perceptible to a user, by displaying (for visual materials), playing (for audio materials), or other means appropriate to the Format of the Digital Object").

d) *OAIS*. *Reference model for an Open Archival Information System,* ISO 14721:2003 (for the concept of *archive* and *designated community:* "an organization that intends to preserve information for access and use by a designated community)

3 NEDLIB = NETworked European Deposit Libraries 1997-2000: http://nedlib.kb.nl/

4 *The **large-scale** archival storage of digital objects / Jim Linden, Sean Martin, Richard Masters, and Roderic Parker,* 2005, http://www.dpconline.org/docs/dpctw04-03.pdf

5 http://www.pedalspreservation.org/About/stacks.aspx

6 *The Google file system* / Sanjay Ghemawat, Howard Gobioff, and Shun-Tak Leung,, 2003, http://labs.google.com/papers/gfs-sosp2003.pdf

Nowadays an ordinary personal computer could easily store up to 8 TB (equipped with four 2000 GB hard disks) using widespread and inexpensive SATA[7] technology

Data replication relies on open source disk synchronization utility (rsync[8]); to avoid hardware dependencies, ex. g. disk controllers, RAID[9] is not used.

It is worth noting that in the passage from prototype to service we changed the *Dark Archive* architecture. In this site the original plan was to use an offline storage system (ex. g. LTO[10] tapes). However for the operational service we decided to use the same technology used in the two "light archives" (i. e. online storage using just simple personal computers). Note that the use of the term online does not change the purpose of the dark archive that is "to function as a repository for information that can be used as a fail-safe during disaster recovery[11]".

Even though LTO is a robust and reliable solution, it introduces technology dependencies,ex. g. "robots", and media management problems. For the same reasons we decided not to use a HSM[12] (Hierarchical storage management) system, since their different implementation is based on proprietary systems.

Comparing all the costs of online and offline storage is not an easy task. For instance regarding SATA disks we can say that their cost is decreasing day by day while their capacity is increasing, but it is difficult to estimate the so called total cost of ownership of a tape based solution[13]. Taking into account all the pros and cons, we concluded that the most convenient solution is online storage on simple and easily replaceable personal computers ("easily replaceable" means replaceable with no or minor impact on the overall architecture).

The only drawback to this approach is in fact an ecological problem: the power consumption of the storage computers and the carbon dioxide emissions. However in recent years "green computer" technology (i. e. more energy-efficient versions of computers) is gaining widespread market awareness. Moreover the Solid State Drive (SSD)[14] is a rapidly developing technology and this solution could significantly reduce the energy consumption of the storage computers in the near future.

The current *Digital Stacks* prototype is now turning into an operational service based on two main deposit sites (managed by the *Biblioteca Nazionale Centrale di Firenze* and by the *Biblioteca Nazionale Centrale di Roma*) and a dark archive (managed by the *Biblioteca Nazionale Marciana*). Of course the *Fondazione Rinascimento Digitale* will continue to support and promote the *Digital Stacks* operational service.

Each main site is composed of a set of autonomous and independent nodes. In turn each node on a given site has a mirror node on the other site: the *Digital Stacks* service does not rely on "master site / mirror site" architecture and each site will contain, in a symmetrical way, both master nodes and mirror nodes (see Figure 1).

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[7] http://it.wikipedia.org/wiki/Serial_ATA

[8] http://it.wikipedia.org/wiki/Rsync

[9] http://it.wikipedia.org/wiki/RAID

[10] http://en.wikipedia.org/wiki/Linear_Tape-Open

[11] http://www.webopedia.com/TERM/D/dark_archive.html

[12] http://en.wikipedia.org/wiki/Hierarchical_storage_management

[13] http://digitalcuration.blogspot.com/2009/07/online-and-offline-storage-cost-and.html

[14] http://en.wikipedia.org/wiki/Solid-state_drive

Each physical file is replicated twice on different computers within the same node. The dark archive also contains two copies of this file on two different computers. As a result within *Digital Stacks* each physical file is replicated six times.
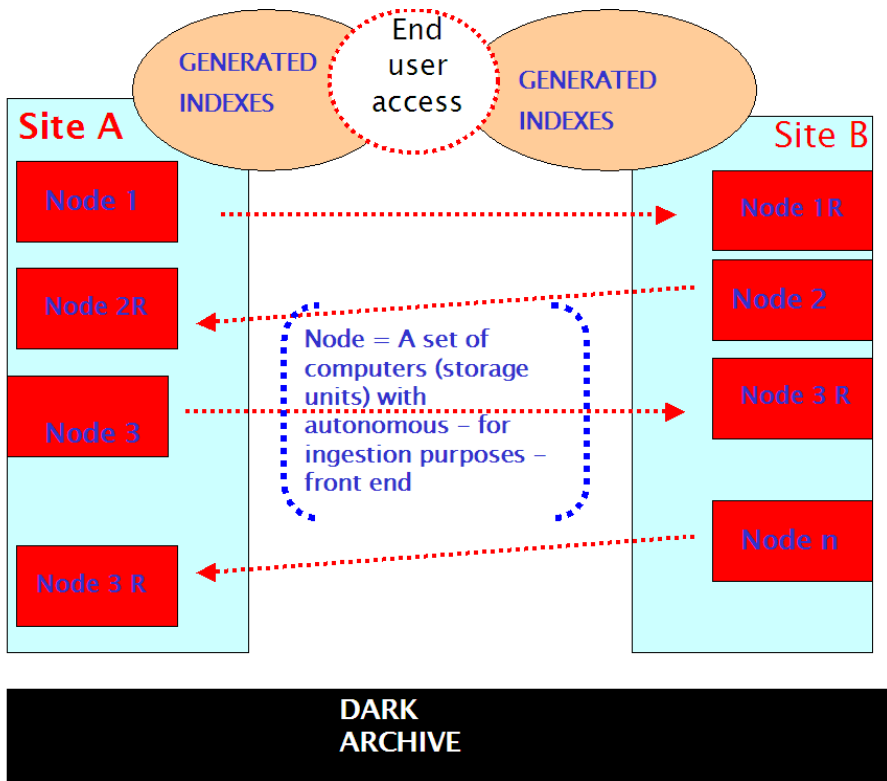

Fig. 1. Digital Stacks technical architecture overview

Setting up one main site in Florence close to the Arno river and the Dark Archive in Venice with the well known "acqua alta" (or high tide) problem, could result in a relevant threat for the security of the overall service. One important decision was to locate all the hardware at an external data center (or collocation center[15]).

Certification to ISO 27001[16] international security standard will be the basic pre-requisite for the selection of a data center. Each institution (Florence, Rome and Venice) will select three different data centers owned and managed by three different companies (to reduce the risk of "domino" effects).

Moreover we decided that the three collocation centers have to be distant from each other by at least 200 km (to reduce the risk of natural threats). This architecture

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[15] http://en.wikipedia.org/wiki/Colocation_centre

[16] ISO/IEC 27001:2005 "specifies the requirements for establishing, implementing, operating, monitoring, reviewing, maintaining and improving a documented Information Security Management System within the context of the organization's overall business risks"

based on certification to ISO 27001 international security standard will form the basis for a domain specific certification of *Digital Stacks* as trusted digital repository (during the prototype phase we tried to apply DRAMBORA[17] but also TRAC[18] was taken into account).

3   Metadata

The *Digital Stacks* core is quite simple. *Digital Stacks* could ingest two kinds of files:

- ▪ data wrapped in WARC containers: a WARC (ISO 28500) container aggregates digital objects for ease of storage in a conventional file system[19].
- ▪ metadata wrapped in MPEG21-DIDL containers[20]: MPEG21-DIDL (ISO 21000) is a simple and agnostic container suitable for the representation of digital resources (sets of metadata conformant to different schemas).

To conclude this first part it is worth noting that *Digital Stacks* within this architecture has to face the metadata management problem *(*also known as "lake or river model"[21]).

A long term archive can not rely on the "lake model" (stores of metadata based on few schemas and fed by a few principal sources). A long term archive has to face stores of metadata based on schemas[22] that can change over time and which are fed by many streams. It could only be based only on a "river model".

In a long term archive there will be different metadata schemas originating from, using the PREMIS language, different agents (ex. g. OAI-PMH metadata harvesters, metadata extractors like JHOVE, librarians, etc). Every schema is subject to change over time. Semantic overlap elements belonging to different schemas (ex. g. PREMIS, MIX) will probably be the norm rather than the exception.

Since metadata are the only mean for controlling data it is essential to control metadata to avoid the risk of the "Babel model". We are currently working on that by taking into account the fact that there are no tools available. The are some interesting directions: crosswalks like MORFROM[23] (demonstration OCLC web service, limited

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[17] http://www.repositoryaudit.eu/

[18] *Trustworthy Repositories Audit & Certification (TRAC)*
http://www.crl.edu/sites/default/ files/attachments/pages/trac_0.pdf

[19] IISO 28500:2009 "specifies the WARC file format: to store both the payload content and control information from mainstream Internet application layer protocols, such as the Hypertext Transfer Protocol (HTTP), Domain Name System (DNS), and File Transfer Protocol (FTP); to store arbitrary metadata linked to other stored data"

[20] ISO/IEC 21000-2:2005: " The Digital Item Declaration Model describes a set of abstract terms and concepts to form a useful model for defining Digital Items [...], is based upon the terms and concepts defined in the above model. It contains the normative description of the syntax and semantics of each of the DIDL elements, as represented in XML".

[21] http://orweblog.oclc.org/archives/001754.html

[22] Schema is used here as http://www.w3.org/XML/Schema: "XML Schemas express shared vocabularies and allow machines to carry out rules made by people"

[23] *Toward element-level interoperability in bibliographic metadata / Carol Jean Godby, Devon Smith, Eric Childress,* 2008, http://journal.code4lib.org/articles/54

to bibliographic metadata) and *Dspace* future plans ("HP and MIT also have a re-
search project called SIMILE that is investigating how to support arbitrary metadata
schemas using RDF[24] "). This is not an easy project: incidentally it seems that the web
site of the project is no longer being updated.

4   Legal Framework and Service Model

The second part of the presentation concerns both the legal and agreements frame-
work of the project and the service model we propose.

The most recent Italian law on legal deposit (L. 106/2004, DPR 252/2006) pro-
vides for a trial period for legal deposit on a voluntary basis of electronic documents,
which are defined by the law as "documents disseminated via digital communication
network". This legislation can be regarded as a strong commitment for national librar-
ies to set up the foundations of a Digital Preservation Network that could, on the basis
of the results of the trial period or just for specific components, also encompass elec-
tronic resources of other domains, different from those of the libraries. As it is well
known, the "commitment" is one of the requirements of a trusted digital repository[25].

The test is funded by *MiBAC, General Direction for Libraries*; the *Fondazione
Rinascimento Digitale* (FRD) will support the project with human and financial re-
sources, as with the former project *Magazzini digitali*. As stated, the test will be car-
ried out by the *National Library of Florence* (BNCF) and the *National Library of
Rome* (BNCR), as main sites for preservation and access, and the *Marciana National
Library* of Venice (BNM), which will act as an off-line dark archive for preservation
purposes and redundancy, but not for public access. We would like to point out here
the following three main goals:

- To implement an organizational model suitable for creating the national and
  regional archives of electronic publishing production, as provided by the law,
  and for being extended on a larger scale;
- To implement a service model suitable for balancing the right-holders inter-
  ests in the protection of contents with the final users interests in accessing
  the contents;
- To implement a *system* suitable for ensuring long term preservation and ac-
  cess to digital contents, as well as their authenticity (identity and integrity).

In order to achieve these goals a legal and agreements framework is needed, also for
balancing different interests of all the involved stakeholders:

- **An agreement between the three MiBAC libraries and the FRD**, in order
  to set specific roles and responsibilities of each institution from different
  points of view: scientific, technical, operational and financial, and to set up a
  steering committee for all management, monitoring and results assessment
  activities. It will also be of utmost importance to define an organizational

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[24] http://www.dspace.org/faq/FAQ.html
[25] *Trustworthy Repositories Audit & Certification (TRAC)*   http://www.crl.edu/sites/default/
files/attachments/pages/trac_0.pdf

and financial sustainability plan, after the 36 months trial period. The signature of this agreement is underway just in these days;

- **An agreement about the access to and the use of legal deposit digital contents, to be signed between the three National Libraries and each electronic publisher** (or electronic content provider) joining the test. The current Italian legislation (Art. 38, paragraph 2, DPR 3 may 2006, n. 252) provides for a free access via computer net to legal deposit documents that are originally freely accessible on the net and an access restricted to registered users inside the deposit institutions premises to the documents whose access is originally subject to a license. In both cases the copyright law must be adhered to. The agreement should provide for the following points:

  - BNCF and BNCR will periodically harvest the agreed publisher's electronic documents (harvesting is the cheaper and easier way of feeding the archive, also from the publishers' point of view, provided that copyright is adhered to);
  - In the case of license subject documents, the publisher will provide the libraries with all the necessary clearances, and the file formats will also be agreed (WARC etc);
  - Documents will be stored in multiple copies in BNCF and BNCR, and off-line in BNM; the libraries will be allowed to store the documents in ISO 27001 certified external data centers;
  - Digital archives will be ISO 14721-2003 OAIS compliant, and will be certified as trusted;
  - BNCF, BNCR and BNM will ensure long term preservation and access of the deposited documents, and will track any changes in the same documents;
  - BNCF, BNCR and BNM will be allowed to perform any necessary actions (refreshing, duplication, migration etc) in order to achieve long term preservation and access of the deposited documents;
  - Only registered users will be allowed to access and consult the documents subject to license on multiple workstations (without printers and USB-ports) on the Local Area Networks of BNCF and BNCR; all user actions will be tracked;
  - Files printing and/or downloading will be subject to specific agreements, a compensation system for right-holders will be provided for if necessary (e.g. for protected documents not available on the publisher's web site);
  - Access and consultation will also be allowed to regional deposit libraries, in the same way, but only to deposited documents of those publishers whose registered office is in the same region of the deposit library (this could be a critical point to agree upon, but it is in line with the law and with the Italian tradition of legal deposit of analogical material) .

To the purpose of extending the test-basis, the project will take the following main types of electronic resources into account:

- Legal deposit born digital resources, i.e. e-journals, and also Ph. D. digital thesis, resulting from specific agreements with universities;
- Digital resources resulting from digitization projects funded by the Italian Digital Library Initiative, mainly in the memory institutions range and only for master copies;

The latter issue of this presentation concerns sustainability: as it is known, access to born digital e-journals is normally subject to a license. A typical provision of these licenses concerns the perpetual access to the licensed contents. It is a provision of the utmost importance for libraries and their users, and the only way for libraries to maintain the availability of the contents they have paid for over the time. At the same time however it is a provision that can be fulfilled only through a dedicated organizational and technical infrastructure, i.e. a trusted digital repository. It is unlikely the publishers will manage such an infrastructure. So this kind of service could be provided by the legal deposit libraries network, and its value could be part of the negotiation with publishers[26].

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[26] A **comparative** study of e-journals archiving solutions. A JISC funded investigation. Final report, May 2008 / Terry Morrow, Neil Beagrie, Maggie Jones, Julia Chruszcz. http://www.slainte.org.uk/news/archive/0805/jiscejournalreport.pdf