# Practical considerations for implementing preservation strategies

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# Session overview

- The fragility of digital content
- Digital preservation approaches
- The OAIS model
- Metadata and shared infrastructures
- Some final comments

# The fragility of digital content

The main technical issues

# General comments

- Digital information is dependent on its technical environment
- Physical objects are subject to:
  - Physical deterioration
  - Technology obsolescence
- Relatively short timescales

# Media longevity

- Media has a short (or unknown) life
- Technical solutions:
  - Periodic copying of data bits on to new media or types of media (refreshing)
  - Longer lasting media
  - Migrating to good-quality microform or paper (!)
- In an organised preservation system, regular routines (quality checking, backup, replication, refreshing, etc.) will help solve the media longevity issue
- The key is having managed processes in place

# Technology obsolescence (1)

- A set of much bigger problems
- Software dependence
  - Digital content is, at least in part, dependent on the configurations of hardware and software (applications and operating systems) that were originally used to interpret  or display them
- Hardware and software obsolescence
  - Application software and operating systems are upgraded regularly
  - Hardware becomes obsolete or needs repair

# Technology obsolescence (2)

- Technical solutions
  - Various preservation strategies have been developed to cope with the obsolescence problem
  - For the most part, these depend on the existence of a continual programme of active management (life cycle management)
  - Supported by systems that implement the various functional entities identified by the Reference Model for an Open Archival Information System (OAIS)
  - Preservation strategies can only be seen in this wider context

# Multiple layers of meaning (1)

- Digital objects are logical entities not fixed to any one particular physical carrier
- Three layers (Thibodeau, 2002):
  - Physical objects: the actual bits stored on a particular medium
  - Logical objects: defines how these bits are used by application software, based on data types (e.g. ASCII); in order to understand (or preserve) the byte-streams, we need to know how to process them
  - Conceptual objects: what humans deal with in the real world, meaningful units of information

# Multiple layers of meaning (2)

- On which of these layers should preservation activities focus?
  - We need to preserve the ability to reproduce the objects, not just the bits
  - In fact, we could change the bits and logical representation and still reproduce an authentic conceptual object

# Authenticity and integrity

- Digital information can easily be changed (e.g., by design or accident)
- How can we trust that an object is what it claims to be?
- Mechanisms are available at the bit level (e.g. checksums), but will this be sufficient?

# Problems of scale

- An increasing flood of 'born-digital' data
  - Data deluge in science and engineering
    - Petabytes generated by high throughput instruments, streamed from sensors and satellites, etc.
  - The World Wide Web
    - Comprises billions of pages + "deep Web"
    - Internet Archive = >1 petabyte, and growing @ 20 Tb. per month (http://www.archive.org/)
  - 5 exabytes of *new* information created in 2002:
    - http://www.sims.berkeley.edu/research/projects/how-much-info-2003/

# Some general principles (1)

- Most of the technical problems associated with long-term digital preservation can be solved if a life-cycle management approach is adopted
  - i.e. a continual programme of active management
  - Ideally, combines both managerial and technical processes, e.g., as in the OAIS Model
  - Many current systems (e.g. repository software) are attempting to support this approach
  - Preservation strategies need to be seen in this wider context
  - Preservation needs to be considered at a very early stage in an object's life-cycle

# Some general principles (2)

- Need to identify and understand the 'significant properties' (essence) of an object
  - Focuses on  what is deemed essential (performance)
  - Helps with choosing an acceptable preservation strategy
  - The relative importance of:
    - Content
    - Appearance and behaviour (look and feel)
    - Context
    - Structure
  - This is the area where decision support tools might be most useful

# Some general principles (3)

- Encapsulation may have some benefits
  - Surrounding the digital object - at least conceptually - with all of the information needed to decode and understand it (including software)
  - Produces autonomous 'self-describing' objects, reduces external dependencies; linked to the Information Package concept in the OAIS Reference Model
- We should keep the original byte-steam, just in case … (?)

# Digital preservation strategies

# Preservation strategies

- A continuum of strategies
  - Some approaches focus on preserving the essential characteristics of objects
    - Migration
    - Persistent archives
  - Some approaches focus on preserving aspects of the technology
    - Technology preservation
    - Technology emulation
  - Also includes:
    - Digital archaeology (emergency rescue)

# Technology preservation

- The preservation of an information object together with all of the hardware and software needed to interpret it
  - Successfully preserves the look, feel and behaviour of the whole system (at least while the hardware and software still functions)
  - May have a role for historically important hardware
  - Problems with storage and ongoing maintenance, missing documentation
  - Would inevitably lead to 'museums' of “ageing and incompatible computer hardware” -- Mary Feeney
  - May have a short-term role for supporting the rescue of digital objects (digital archaeology)

# Technology emulation (1)

- Preserving the original bit-streams and application software; running this on emulator programs that mimic the behaviour of obsolete hardware
- Emulators change over time
  - Chaining, rehosting
  - Emulation Virtual Machines
    - Running emulators on simplified 'virtual machines' that can be run on a range of different platforms
    - Virtual machines are migrated so the original bit-streams do not have to be

# Technology emulation (2)

- Benefits:
  - Technique already widely used, e.g. for emulating different hardware, computer games
  - Retains use of the 'original' bytestream
  - Reduces the need for regular object transformations (but emulators and virtual machines may themselves need to be migrated)
  - Retains ‘look-and-feel’
  - May be the only approach possible where objects are complex or dependent on executable code
  - Less 'understanding' of formats is needed; little incremental cost in keeping additional formats

# Technology emulation (3)

- Issues
  - Which organisations have the technical skills necessary to implement the strategy?
  - Preserving 'look and feel' may not be needed for all objects
  - It will be difficult to *know* definitively whether user experience has been accurately preserved
- Conclusions
  - Promising family of approaches
  - Needs further practical application and research

# Information migration (1)

- Managed transformations
  - A set of organised tasks designed to achieve the periodic transfer of digital information from one hardware and software configuration to another, or from one generation of computer technology to a subsequent one - CPA/RLG report (1996)
  - Abandons attempts to keep old technology (or substitutes for it) working
  - A 'known' solution used by data archives and software vendors (e.g., a linear migration strategy is used by software vendors for some data types, e.g. Microsoft Office files)
  - Focuses on the *content* of objects

# Information migration (2)

- Main types (from OAIS Model)
  - Refreshment
  - Replication
  - Repackaging
  - Transformation
- Issues
  - Labour intensive
  - There are severe problems with ensuring the 'integrity and authenticity' of objects
  - Transformations need to be documented (part of the preservation metadata)

# Information migration (3)

- Uses
  - Seems to be suitable for dealing with large collections of similar objects
  - Migration can often be combined with some form of standardisation (normalisation) process, e.g., on ingest to:
    - ASCII (for text)
    - Bit-mapped-page images (for images)
    - Well-defined XML formats (for structured documents or datasets)
  - Migration on Request (CAMiLEON project)
    - Keep original bit-streams, migrate the rendering tools

# Digital archaeology

- Not so much a preservation strategy, but the default situation if we fail to adopt one
- Using forensic techniques to recover digital content from obsolete or damaged physical objects (media, hardware, etc.)
  - A time consuming process, needs specialised equipment and (in most cases) adequate documentation
  - Considered to be expensive (and risky)
  - Remains an option for content deemed to be of value

# Choosing a strategy (1)

- Preservation strategies are not in competition (different strategies will work together)
  - Suggestion that we should keep the original bits (with some documentation) in case better preservation technologies emerge in the future
- But the strategy chosen has implications for:
  - The technical infrastructure required (and metadata)
  - Collection management priorities
  - Rights management
    - e.g, Owning the rights to re-engineer software
  - Costs

# Choosing a strategy (2)

- Decision support for preservation, e.g.
  - Preservation strategies
  - Target formats for transformations
- Examples:
  - Nationaal Archief (Netherlands) testbed project
  - Vienna University of Technology utility analysis-based metrics
  - Both developed further by the Digital Preservation cluster of the DELOS Network of Excellence
  - http://www.dpc.delos.info/

# The OAIS Reference Model

# OAIS background

- Reference Model for an Open Archival Information System (OAIS)
  - Development led by the Consultative Committee for Space Data Systems (CCSDS)
  - Issued as CCSDS Recommendation (Blue Book) 650.0-B-1 (January 2002)
  - Also adopted as: ISO 14721:2003
    - Currently under review
  - http://public.ccsds.org/publications/archive/650x0b1.pdf

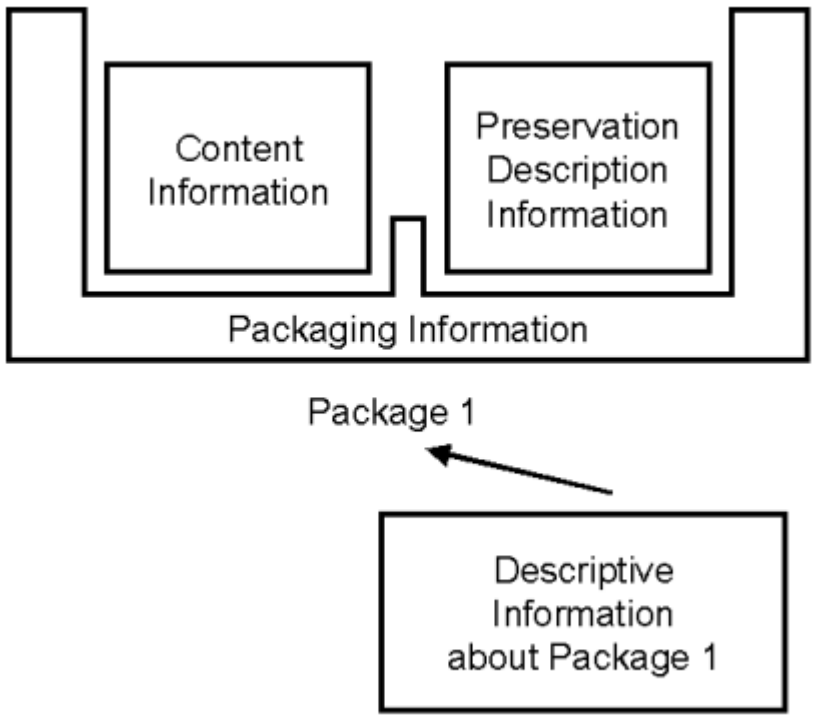
# OAIS definitions

- Provides definitions of terms that need to have well-defined meanings, e.g.:
  - Archival Storage, Content Data Object, Designated Community (key term), Ingest, Metadata, Representation Information, etc.
  - OAIS = "An archive, consisting of an organization of people and systems, that has accepted the responsibility to preserve information and make it available for a Designated Community" (OAIS 1.7.2)

# OAIS high level concepts (1)

- The *environment* of an OAIS (Producers, Consumers, Management)
- Definitions of *information*, Information Objects and their relationship with Data Objects
- Definitions of *Information Packages*, conceptual containers of Content Information and Preservation Description Information

# OAIS high level concepts (2)




***ationships (Figure 2-3)***

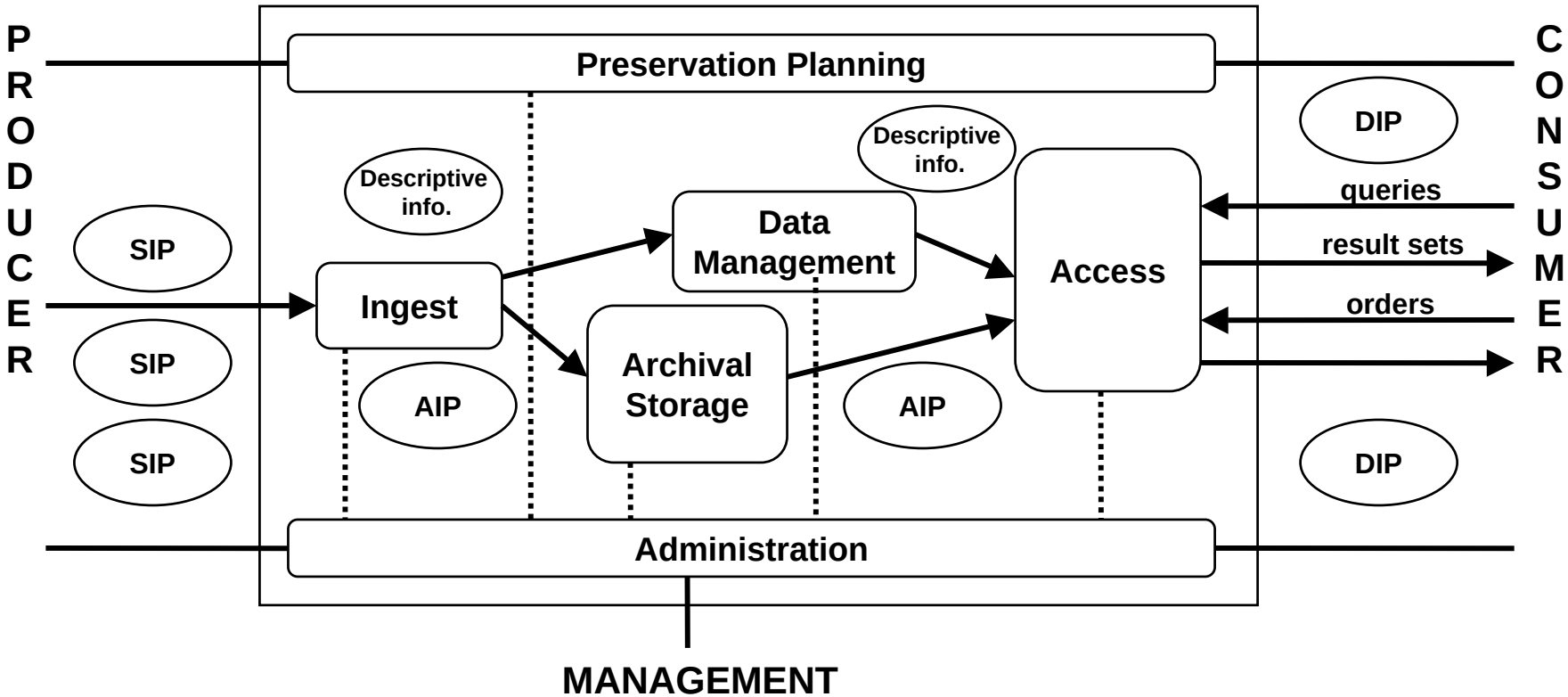
# OAIS mandatory responsibilities

- Negotiating and accepting information
- Obtaining sufficient control of the information to ensure long-term preservation
- Determining the "designated community"
- Ensuring that information is **independently understandable**, i.e. without the assistance of those who produced it
- Following documented policies and procedures
- Making the preserved information available

# OAIS Functional Model (1)

- Six entities
  - Ingest
  - Archival Storage
  - Data Management
  - Administration
  - Preservation Planning
  - Access
- Described using UML diagrams

# OAIS Functional Model (2)




*OAIS Functional Entities (Figure 4-1)*

# OAIS Information Model (1)

- Information Object (basic concept):
  - Data Object (bit-stream)
  - Representation Information (permits “the full interpretation of Data Object into meaningful information”)
- Information Object Classes:
  - Content Information
  - Preservation Description Information (PDI)
  - Packaging Information
  - Descriptive Information

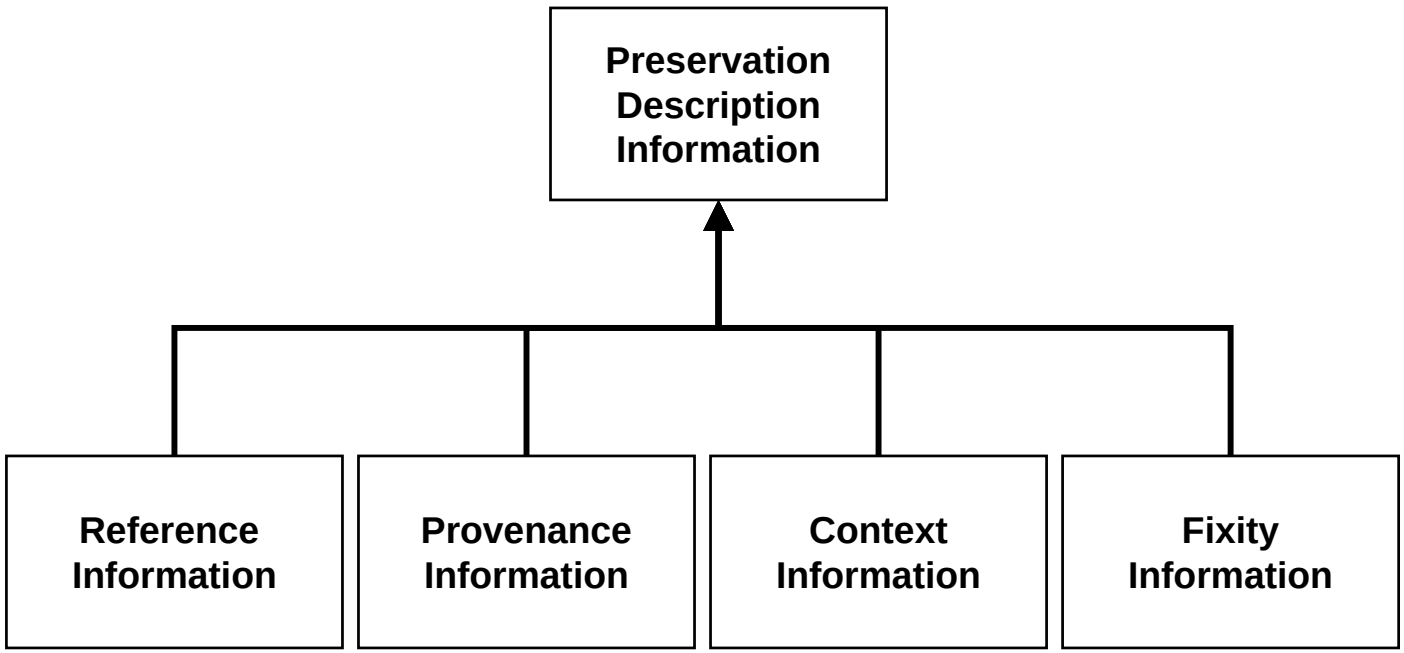
# OAIS Information Model (2)

- Information package:
  - Container that encapsulates Content Information and PDI
  - Packages for submission (SIP), archival storage (AIP) and dissemination (DIP)
  - AIP = "... a concise way of referring to a set of information that has, in principle, all of the qualities needed for permanent, or indefinite, Long Term Preservation of a designated Information Object"

# OAIS Information Model (3)

- Archival Information Package (AIP):
  - Content Information
    - Original target of preservation
    - Information Object (Data Object & Representation Information)
  - Preservation Description Information (PDI)
    - other information (metadata) “which will allow the understanding of the Content Information over an indefinite period of time”
    - A set of Information Objects
    - Based on categories discussed in CPA/RLG report: *Preserving Digital Information* (1996)

# OAIS Information Model (4)




***PDI Preservation Description Information (Figure 4-16)***

# OAIS Information Model (5)

- Also defines:
  - Archival Information Units and Archival Information Collections
  - Information Package transformations, e.g. for Ingest and Access
  - Preservation perspectives:
    - Migration, e.g refreshment, replication, repackaging, transformation
    - Preservation of look and feel (e.g., emulation, virtual machines)
  - Archive interoperability, e.g. federation

# Implementing OAIS (1)

- Fundamentals:
  - OAIS is a reference model (conceptual framework), NOT a blueprint for system design
  - It informs the design of system architectures, the development of systems and components
  - It provides common definitions of terms … a common language, means of making comparison
  - But it does NOT ensure consistency or interoperability between implementations

# Implementing OAIS (2)

- ISO 14721:2003, published in early 2003 - follows the text made available by the CCSDS
- However, the earlier versions of the model made available by the CCSDS informed implementations long before then
- Three broad areas of influence:
  - Preservation metadata schemas
  - Architecture and system design
  - Conformance criteria for repositories

# Metadata and shared infrastructures

# The importance of metadata (1)

- All digital preservation strategies depend - to a greater or lesser extent - on the creation, capture and maintenance of metadata
- Preservation metadata:
  - The "information a repository uses to support the digital preservation process," specifically "the functions of maintaining viability, renderability, understandability, authenticity, and identity in a preservation context" (PREMIS Data Dictionary, 2005)
  - Cuts across older categorisations of metadata (descriptive, administrative, structural)

# The importance of metadata (2)

- Recordkeeping metadata:
  - "Structured or semi-structured information that enables the creation, registration, classificatoin, access, preservation and disposition of records through time and within and across domains" … [they] "can be used to identify, authenticate, and contextualize records; and the people, processes and systems that create, manage, maintain and use them and the policies that govern them"
  - The definition used in ISO 23081
  - Much stronger focus on organisational contexts

# PREMIS metadata (1)

- PREMIS Working Group
  - Preservation Metadata: Implementation Strategies
  - Working Group sponsored by OCLC and RLG
  - Reviewed earlier Metadata Framework document and existing practice
  - Focused on implementation and definition of 'core' metadata
  - PREMIS Data Dictionary (May 2005)

# PREMIS metadata (2)

- PREMIS Data Dictionary
  - Less explicitly based on OAIS Information Model structure than older OCLC/RLG Framework
  - Based on own data model
  - Defines some of the semantic units for: Objects, Events, Agents, Rights
  - Supports automatic capture, where possible
- PREMIS also provides:
  - An XML implementation, e.g. for use in a packaging format like METS (Metadata Encoding and Transmission Standard)
  - Maintenance activity (Library of Congress)

# The need for shared infrastructures

- For example: registries for sharing information about, or for identifying or validating formats,
  - There is "… a pressing need to establish reliable, sustained repositories of file format specifications, documentation, and related software" (Lawrence, *et al*., Risk management of digital information (CLIR, 2000)
    - DSpace 'bitstream format registry'
    - Global Digital Format Registry (GDFR)
      - » Some components exist, e.g. Typed Object Model, JHOVE tool
    - DCC Representation Information registry

# Some final comments

# Some key points to remember (1)

- Most of the technical problems associated with long-term digital preservation can be solved if a life-cycle management approach is adopted
  - Preservation needs to be considered at a very early stage in an object's life-cycle
  - There also needs to be continuous re-evaluation of policies and practical approaches adopted
- There is a need to identify and understand the 'significant properties' of an object
  - There is a need to make (and articulate) difficult choices
  - Trade-offs with costs

# Some key points to remember (2)

- Metadata is important
  - But is an area of much uncertainty
  - Evolving standards like the PREMIS Data Dictionary and ISO 23081 will help, but there is no substitute for detailed requirements analysis

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