



Mitigating Risk of Data Loss in Preservation Environments

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Topics



- **Preservation environments**
 - Authenticity, integrity, infrastructure independence
- **Types of data loss risk**
 - Media, hardware, software, operations, user
- **Data grid technology**
 - Mechanisms for replication, federation
- **NARA research prototype persistent archive**
 - Federation of three data grids

Preservation



- Archival processes through which a digital entity is extracted from its creation environment, and then supported in a preservation environment, while maintaining authenticity and integrity information.
- Extraction process requires insertion of support infrastructure underneath the digital material
- Goal is infrastructure independence, the ability to use any commercial storage system, database, or access mechanism

InterPARES - Diplomats



- **Authenticity - maintain links to metadata for:**
 - Date record is made
 - Date record is transmitted
 - Date record is received
 - Date record is set aside [i.e. filed]
 - Name of author (person or organization issuing the record)
 - Name of addressee (person or organization for whom the record is intended)
 - Name of writer (entity responsible for the articulation of the record's content)
 - Name of originator (electronic address from which record is sent)
 - Name of recipient(s) (person or organization to whom the record is sent)
 - Name of creator (entity in whose archival fonds the record exists)
 - Name of action or matter (the activity for which the record is created)
 - Name of documentary form (e.g. E-mail, report, memo)
 - Identification of digital components
 - Identification of attachments (e.g. digital signature)
 - Archival bond (e.g. classification code)

InterPARES - Diplomats



- **Integrity - maintain links to metadata for**
 - Name(s) of the handling office / officer
 - Name of office of primary responsibility for keeping the record
 - Annotations or comments
 - Actions carried out on the record
 - Technical modifications due to transformative migration
 - Validation

Preservation Approach



- **Provide mechanisms to:**
 - Create archival context for the content
 - Context is preservation metadata (provenance, administrative, descriptive, structural, behavioral)
 - Content is the submitted digital entity
 - Assert integrity - the consistency between the context and the content
 - Track operations done on material and update context
 - Assert authenticity - that the material represents the original document
 - Track the chain of custody
 - Manage technology evolution (encoding standard, storage repository, information repository, access methods)

Types of Risk



- **Media failure**
 - Replicate data onto multiple media
- **Vendor specific systemic errors**
 - Replicate data onto multiple vendor products
- **Operational error**
 - Replicate data onto a second administrative domain
- **Natural disaster**
 - Replicate data to a geographically remote site
- **Malicious user**
 - Replicate data to a deep archive

How Many Replicas



- **Three sites minimize risk**
 - Primary site
 - Supports interactive user access to data
 - Secondary site
 - Supports interactive user access when first site is down
 - Provides 2nd media copy, located at a remote site, uses different vendor product, independent administrative procedures
 - Deep archive
 - Provides 3rd media copy, staging environment for data ingestion, no user access

Replication of Name Spaces



Data Access Methods (Web Browser, DSpace, OAI-PMH)



Storage Repository

- Storage location
- User name
- File name
- File context (creation date,...)
- Access constraints

Could rely on a single storage system to provide backup mechanisms for each name space and the files

Data Grids



- **Manage shared collections that are distributed across administrative domains**
 - Location of item, access controls, checksums
- **Implement infrastructure independence**
 - Standard operations for interacting with multiple types of storage repositories
- **Implement presentation independence**
 - Standard APIs to support porting of user interfaces

Data Grids Provide a Level of Indirection for Each Naming Convention



Data Access Methods (C library, Unix, Web Browser)

Data Collection

Storage Repository

- Storage location
- User name
- File name
- File context (creation date,...)
- Access constraints

Data Grid

- Logical resource name space
- Logical user name space
- Logical file name space
- Logical context (metadata)
- Control/consistency constraints

Data is organized as a shared collection

Federating Name Spaces



- **To maintain authenticity, name spaces and authenticity metadata are also replicated across administrative domains**
 - Need to preserve identity of archivists, access controls on users, audit trails on operations performed, and links from authenticity metadata to the electronic records
- **Use data grids to manage synchronization of name spaces across federated data grids.**

Federation



Data Access Methods (Web Browser, DSpace, OAI-PMH)

Data Collection A

Data Collection B

Data Grid

- Logical resource name space
- Logical user name space
- Logical file name space
- Logical context (metadata)
- Control/consistency constraints

Data Grid

- Logical resource name space
- Logical user name space
- Logical file name space
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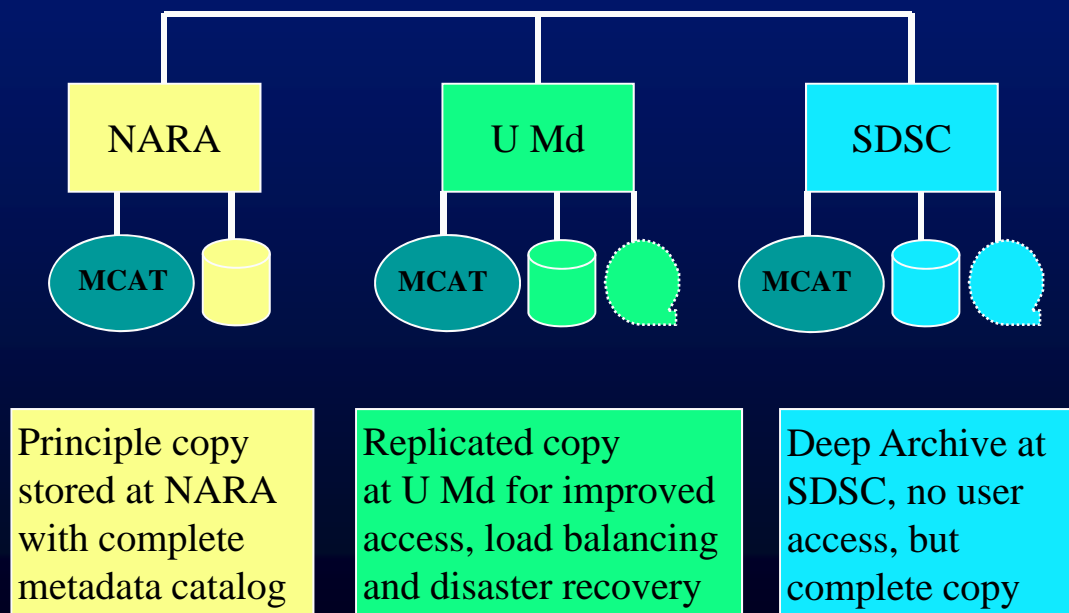
Access controls and consistency constraints
on cross registration of name spaces



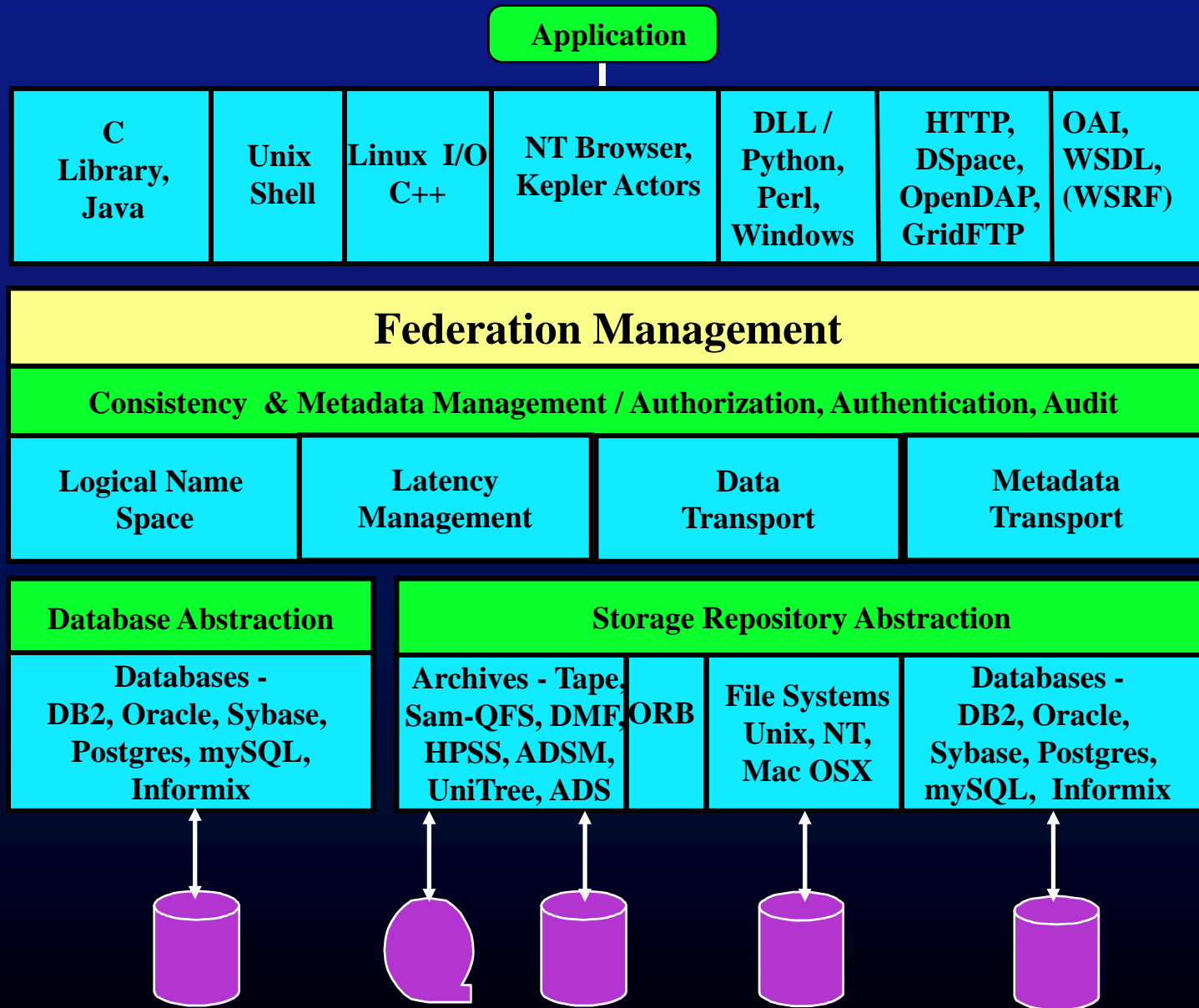
Demonstrate preservation environment

- Authenticity
- Integrity
- Management of technology evolution
- Mitigation of risk of data loss
 - Replication of data
 - Federation of catalogs
- Management of preservation metadata
- Scalability
 - EAP collection
 - 350,000 files
 - 1.2 TBs in size

Federation of Three Independent Data Grids



Storage Resource Broker 3.3.1



Scalability



- **Billions of records**
 - Supported by commercial databases
- **Billions of files**
 - Not supported by file systems or archives
- **Data grid mechanisms to enable scalability**
 - Load leveling across multiple storage systems
 - Aggregation of small files in containers

Storage Resource Broker Collections at SDSC (2/22/2005)	GBs of data stored	Number of files	Number of Users
Data Grid	Ê	Ê	Ê
NSF/ITR - National Virtual Observatory	53,862	9,536,751	100
NSF - National Partnership for Advanced Computational Infrastructure	31,263	6,435,338	380
Hayden Planetarium - Evolution of the Solar System visualizations	7,201	113,600	178
Public collections - NSF/NPACI - Joint Center for Structural Genomics	5,455	3,405,266	67
NSF/NPACI - Biology and Environmental collections	20,364	52,159	67
NSF - TeraGrid, ENZO Cosmology simulations	155,980	1,157,168	3,176
NIH - Biomedical Informatics Research Network	9,830	6,632,159	241
Miscellaneous static collections	8,013	161,352	241
Digital Library	Ê	Ê	Ê
NLM - Digital Embryo image collection	720	45,365	23
NSF/NPACI - Long Term Ecological Reserve	253	8,892	36
NSF/NPACI - Grid Portal	2,620	53,048	460
NIH - Alliance for Cell Signaling microarray data	559	71,318	21
NSF - National Science Digital Library SIO Explorer collection	2,654	1,052,202	27
NSF/NPACI -Transana education research video collection	92	2,387	26
NSF/ITR - Southern California Earthquake Center	99,010	2,074,138	64
Persistent Archive	Ê	Ê	Ê
NHPRC Persistent Archive Testbed (Kentucky, Ohio, Michigan, Minnesota)	90	372,947	28
UCSD Libraries archive	4,147	408,050	29
NARA- Research Prototype Persistent Archive	991	455,094	58
NSF - National Science Digital Library persistent archive	3,572	26,918,638	136
TOTAL	404 TB	59 million	5,167

Scalability



- **Bulk operations**

- Bulk file registration into metadata catalog
- Bulk file loading onto storage system
- Bulk metadata load
- Parallel I/O streams for data movement

- **System interoperation**

- From local file system to data grid
- Between storage systems within a data grid
- Between data grids

Infrastructure Independence



- Ability to incorporate new technology within preservation environment, while maintaining authenticity and integrity
- All components of the preservation environment will evolve
 - Storage systems
 - Access mechanisms - transport protocols
 - Security mechanisms
 - Metadata standards
 - Data encoding format

Examples of Extensibility



- **Storage Repository Driver evolution**
 - Initially supported Unix file system
 - Added archival access - UniTree, HPSS
 - Added FTP/HTTP
 - Added database blob access
 - Added database table interface
 - Added Windows file system
 - Added project archives - Dcache, Castor, ADS
 - Added Object Ring Buffer, Datascope
 - Adding GridFTP version 3.3
- **Database management evolution**
 - Postgres
 - DB2
 - Oracle
 - Informix
 - Sybase
 - mySQL (most difficult port - no locks, no views, limited SQL)

Examples of Extensibility



- **The 3 fundamental APIs are C library, shell commands, Java**
 - Other access mechanisms are ported on top of these interfaces
- **API evolution**
 - Initial access through C library, Unix shell command
 - Added inQ Windows browser (C++ library)
 - Added mySRB Web browser (C library and shell commands)
 - Added Java (Jargon)
 - Added Perl/Python load libraries (shell command)
 - Added WSDL (Java)
 - Added OAI-PMH, OpenDAP, DSpace digital library (Java)
 - Added Kepler actors for dataflow access (Java)
 - Adding GridFTP version 3.3 (C library)

For More Information



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Preservation Strategies



- **Emulation**
 - Migrate the display application onto new operating systems
 - Equivalent to forcing use of candlelight to look at 16th century documents
- **Transformative migration**
 - Migrate the encoding format to the new standard
 - Migration period is expected to be 5-10 years
- **Persistent object**
 - Characterize the encoding format
 - Migrate the characterization forward in time

Persistent Objects



Display Applications

1980

1990

2000

2010

2020

Characterize standard manipulation operations

Characterize encoding format - data structure

1980

1990

2000

2010

2020

Digital Entities