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

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InterPARES - Diplomatics

- **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 - Diplomatics

- **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

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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

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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

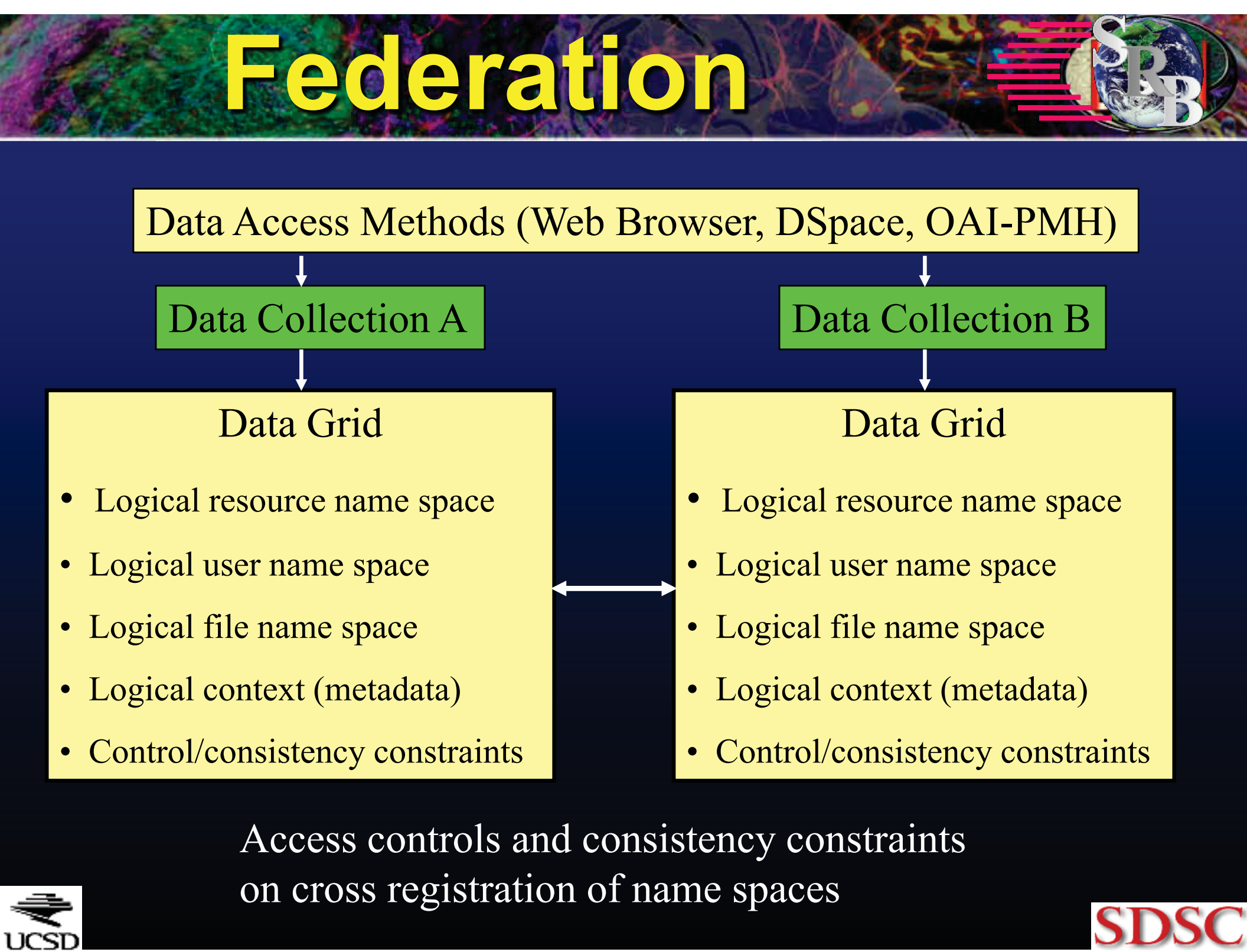
- Logical resource name space
- Logical user name space
- Logical file name space
- Logical context (metadata)
- Control/consistency constraints

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



Access controls and consistency constraints
on cross registration of name spaces

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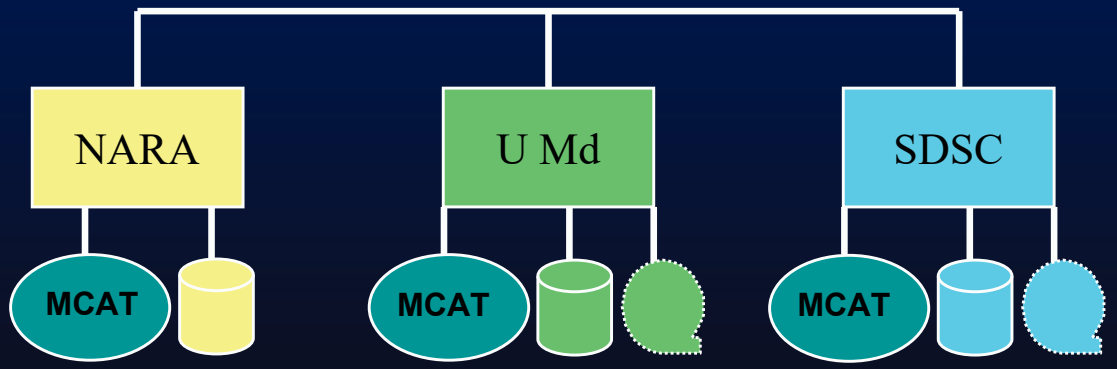
National Archives and Records Administration - Research Prototype Persistent Archive

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



Principle copy stored at NARA with complete metadata catalog

Replicated copy at U Md for improved access, load balancing and disaster recovery

Deep Archive at SDSC, no user access, but complete copy

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Storage Resource Broker 3.3.1

Application

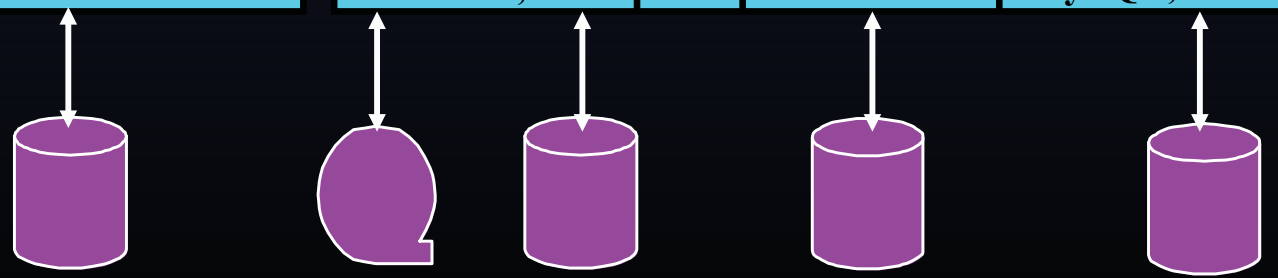
C Library, Java	Unix Shell	Linux I/O C++	NT Browser, Kepler Actors	DLL / Python, Perl, Windows	HTTP, DSpace, OpenDAP, GridFTP	OAI, WSDL, (WSRF)

Federation Management

Consistency & Metadata Management / Authorization, Authentication, Audit

Logical Name Space	Latency Management	Data Transport	Metadata Transport

Database Abstraction	Storage Repository Abstraction			
Databases - DB2, Oracle, Sybase, Postgres, mySQL, Informix	Archives - Tape, Sam-QFS, DMF, HPSS, ADSM, UniTree, ADS	ORB	File Systems Unix, NT, Mac OSX	Databases - DB2, Oracle, Sybase, Postgres, mySQL, Informix



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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	Ź	Ź	Ź
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	Ź	Ź	Ź
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	Ź	Ź	Ź
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

Scalabilty

- **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

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