Preservation Environment Federation

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Motivation

- **Collection formation (preservation) driven by a common purpose**
  - Sharing of data for analysis
  - Preservation of data for re-use
- **Appraisal policy determines what will be admitted into the collection**
- **Retention policy determines what will remain in the collection**
- **Sustainability depends on whether a community exists with a common purpose for the collection**
- **Policies based on the common purpose drive appraisal, retention, sustainability**

Assessing Preservation

- **Preservation environments** validate **assertions** about authenticity, integrity, chain of custody, original order, trustworthiness
- A demonstration that the **assertions** are being conserved is the **migration of records** between two independent preservation environments
- **Federation** of preservation environments corresponds to a **virtual migration**
- If a preservation environment meets **federation** requirements that enforce assertions, the preservation environment is **viable**.

Perspectives on Preservation (1)

- **Preservation is the process by which records are extracted from their creation environment and preserved in the preservation environment**
  - Approach focuses on representation information for records such as provenance, data format, manipulation services, knowledge community
  - OAIS model

EU CASPAR Project

- **Cultural, Artistic, and Scientific knowledge for Preservation Access and Retrieval**
- **Developing "representation information" based on the OAIS model for describing records**
  - Provenance information
  - Format characterization
  - Behaviour (parsing routines) characterization
  - Characterization of the creation process
- **Supporting Trustworthy Repository Assessment Criteria**
- **David Giaretta <D.L.Giaretta@rl.ac.uk>**

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Perspectives on Preservation (2)

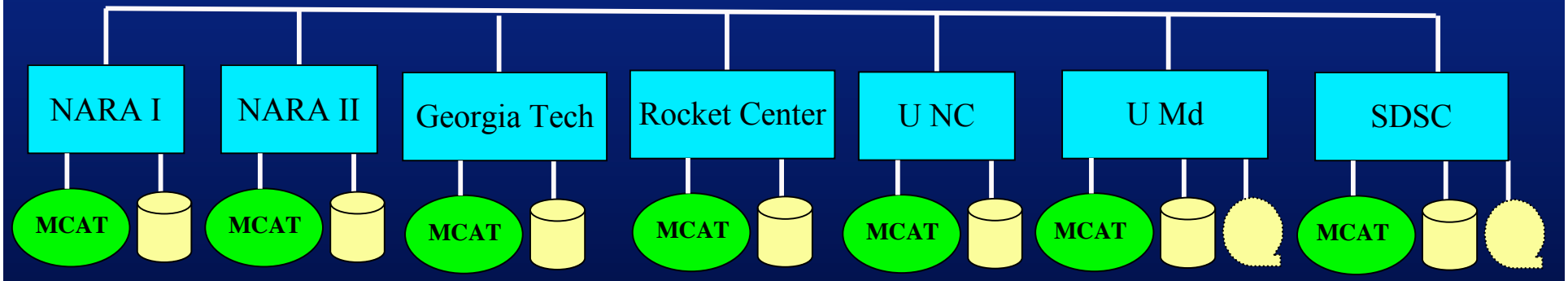
- **Preservation is communication with the future**
  - We know that we will have more sophisticated technology in the future.
  - We will need to migrate our records from the obsolete current technology to the future technology
    - At the point in time when new technology is added, both the old and new technology are present
  - Interoperability problem solved by data grids

Transcontinental Persistent Archive Prototype (TPAP)

- **Use data grid technologies to implement two independent preservation environments:**
  - Storage Resource Broker - SRB data grid
  - Integrated Rule-Oriented Data System - iRODS data grid
- **Manage properties required for**
  - Authenticity
  - Integrity
  - Chain of custody
  - Original order
  - Trustworthiness

National Archives and Records Administration Transcontinental Persistent Archive Prototype

Federation of Seven
Independent Data Grids



Extensible environment, can federate with additional research and education sites. Each data grid uses different vendor products.

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EU SHAMAN Project

- **Sustaining Heritage through Multivalent Archiving**
- **Developing vendor-independent parsing routines for office products**
  - Encapsulating the parsing routines in iRODS micro-services so today's formats can be parsed in the future
- **Paul Watry <P.B.Watry@liverpool.ac.uk>**

SRB - iRODS Migration

- With the incorporation of the SHAMAN format parsing technology, will have migrated all components of the TPAP to new technology
- A preservation environment is viable if records can be migrated to an independent solution while retaining authenticity, integrity, chain of custody, original arrangement, trustworthiness

Perspectives on Preservation (3)

- **Preservation is the management of communication from the past**
  - We cannot make assertions about authenticity, integrity, and chain of custody unless we know the preservation management policies and procedures used by prior archivists
  - We need representation information about the preservation environment itself - available in the iRODS Rule-Oriented Data System

Representation Information for Preservation Environments

- Assessment criteria (trustworthiness, authenticity)
- Preservation management policies
- Preservation management procedures
- Persistent state information describing status of preservation environment
- Persistent state information tracking audits of actions

Preservation Environment

iRODS - integrated Rule-Oriented Data System

Data Management Environment	Conserved Properties	Control Mechanisms	Remote Operations
Management Functions	Assessment Criteria	Management Policies	Management Procedures
	iRODS Data grid – Management virtualization		
Data Management Infrastructure	Persistent State	Rules	Micro-services
	SRB Data grid – Data and trust virtualization		
Physical Infrastructure	Database	Rule Engine	Storage System


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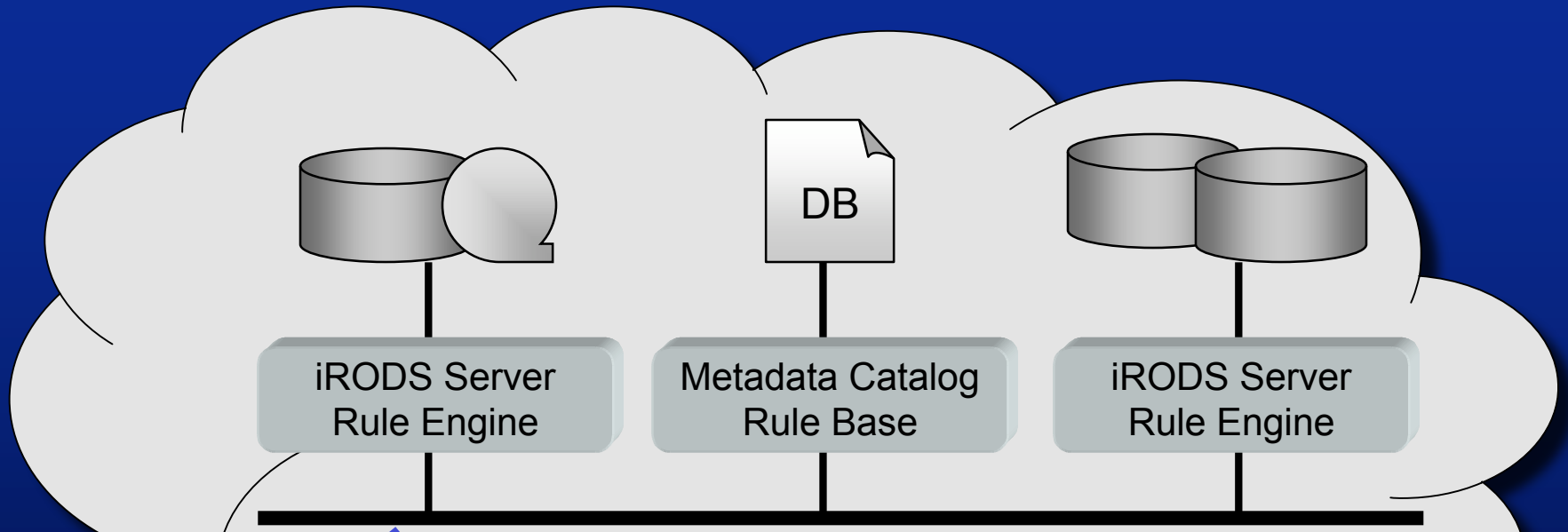
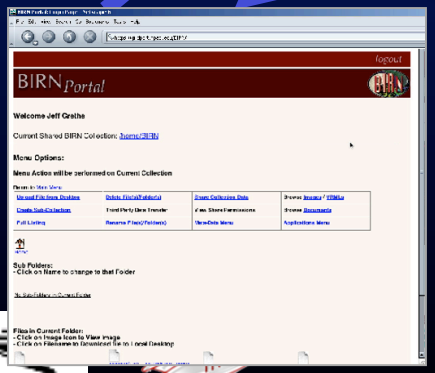
TPAP - Rule-Based Data Grid

- **iRODS "integrated Rule-Oriented Data System" data grid technology**
  - Generic software used to implement preservation environments, digital libraries, real-time sensor systems
- **The iRODS system casts preservation policies as rules that control the execution of preservation processes.**
  - Rules can also be defined that validate assertions about the preservation environment such as integrity and authenticity
- **RLG/NARA Trustworthy Repositories Audit & Certification: Criteria and Checklist (TRAC)**
  - Demonstrate the creation of a set of rules that can be automatically enforced by an iRODS data grid

Using an iRODS Data Grid - *Details*





- User asks for data
- Data request goes to iRODS Server
- Server looks up information in catalog
- Catalog tells which iRODS server has data
- 1st server asks 2nd for data
- The 2nd iRODS server applies rules

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iRODS Rule Base

- **Management policies written as rules that**
  - Enforce preservation properties on accession
  - Periodically perform administrative tasks
  - Support deferred operations for recovery from problems
- **Assertions are written as rules that**
  - Query state information for desired outcome
  - Parse audit trails for compliance over time
- **Preservation environments validate assertions about authenticity, integrity, chain of custody, original order, trustworthiness**

Record Migration

- **Migration of records into another preservation environment is done through a Structured Information Resource interface**
  - Standard set of operations that extract information from the remote information resource that are needed for subsequent operations
  - Migrate records and representation information for both the records and the preservation environment
- **A successful migration shows that the records have been preserved correctly**

Federation

- **Federation is the creation of the management policies and procedures that organize two independent data grids into a shared collection**
  - Common properties are enforced across records in both environments
  - The common properties can enforce assertions required for a viable preservation environment
- **Federation policies define the criteria under which records can be exchanged between the preservation environments**

Conclusion

- **Asserting the viability of a preservation environment can be demonstrated by:**
  - Comparing to an assessment standard - TRAC
  - Migrating records between two independent systems and showing properties are conserved
  - Establishing the federation polices and procedures that enable such migration
- **Federation of preservation environments is equivalent to virtual migration of records**
- **Federation policies that meet assessment criteria enable viable preservation environments**

More Information

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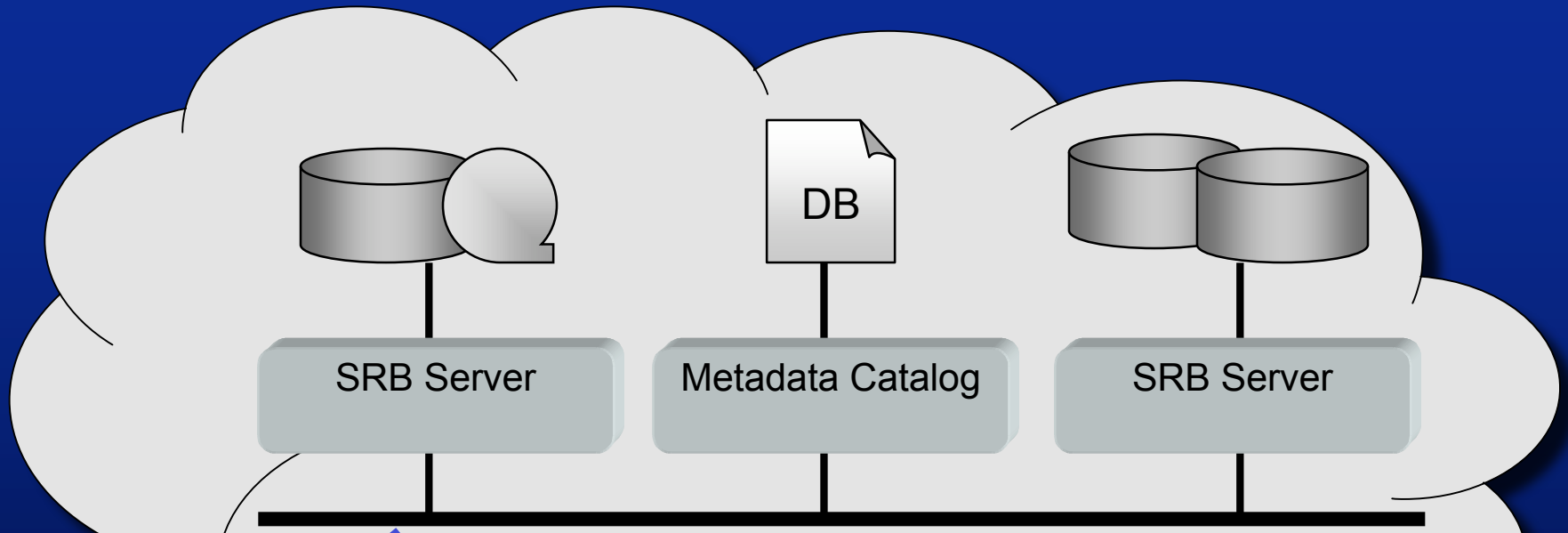
Why Data Grids?

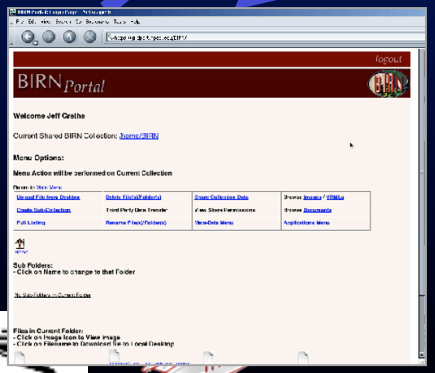
- **Provide generic distributed data management mechanisms**
  - Preservation environments are inherently distributed
  - Organize distributed data into shared collections
- **Support authenticity, integrity, chain of custody**
  - Logical name spaces (files, users, storage systems)
  - Preservation metadata
  - Replicas, versions, time-stamped backups
  - Optimized data transport (parallel I/O)
  - Authentication and authorization across domains
  - Support for containers (Archival Information Packages)
  - Support for community specific clients
  - Support for vendor specific storage protocols

Transcontinental Persistent Archive Prototype - SRB

- **Distributed Data Management Concepts**
  - Data virtualization
    - Storage system independence, can easily incorporate new storage systems
  - Trust virtualization
    - Administration independence, manage authentication and authorization independently of the storage system
- **Risk mitigation**
  - Federation of multiple independent data grids
    - Operation independence, can build a deep archive

SRB Data Grid





- Data are owned by the data grid
- Users are authenticated by the data grid
- Authorization is done with access controls
- Authentication/authorization stored in MCAT
- Centralized information management
- Shared data collection

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Perspectives on Preservation (4)

- **Preservation is the management of preservation information about each record, and tracking of the preservation actions that have occurred.**
  - Does a metadata standard define the required preservation processes and policies?
  - Do the preservation policies define the required preservation metadata (state information)?
- **Preservation metadata is a consequence of the chosen preservation management policies**

Advantage of SRB Data Grid

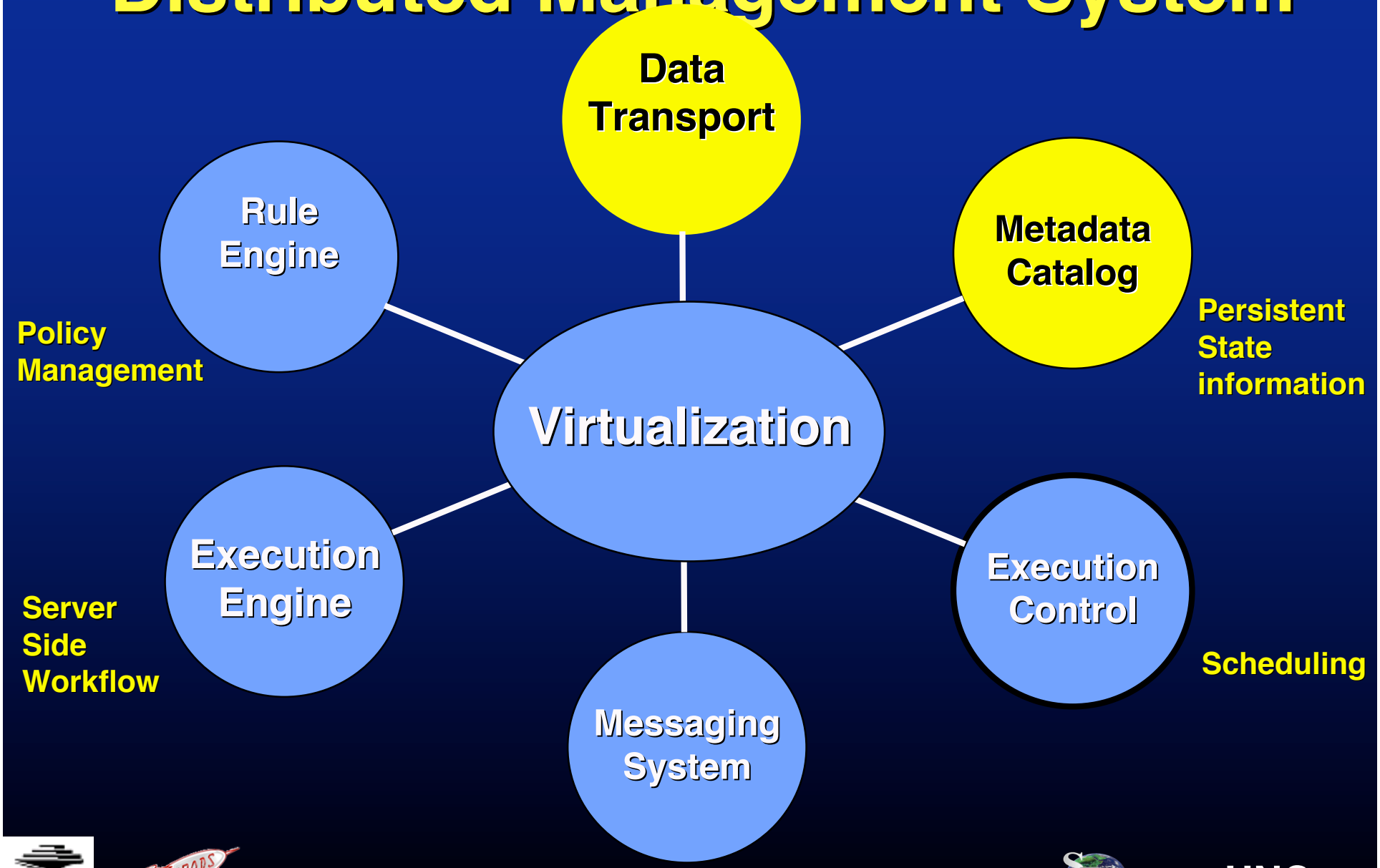
- **Generic infrastructure**
  - Used in other data management applications
- **Scalable**
  - Manages hundreds of millions of files and petabytes of data
- **Extensible**
  - Can add new storage systems dynamically, create new record series, add new archivists
- **Trustworthy**
  - Consistent management of preservation metadata

	As of 12/11//2006			As of 2/25/2008		
	Data_size (in GB)	*Count (files)*	*Curators*	*Data_size (in GB)*	*Count (files)*	*Curators*
Data Grid						
NSF/NVO	110,615.00	16,381,466	100	88,216.00	14,550,030	100
NSF/NPACI	35,909.00	7,458,960	380	43,684.00	7,643,389	380
PZONE	24,755.00	14,208,012	68	29,851.00	19,506,972	68
NSF/LDAS-SALK	163,706.00	176,897	67	211,542.00	173,806	67
NSF/SLAC-JCSG	18,494.00	1,945,302	55	26,100.00	2,675,426	55
NSF/TeraGrid	269,332.00	7,300,999	3,267	286,390.00	7,289,445	3,267
NCAR	2.00	8	2	76,255.00	435,597	2
LCA	1,834.00	39,611	2	4,544.00	78,289	2
NIH/BIRN	18,921.00	18,499,588	385	20,400.00	40,747,060	445
Others	8,013.00	161	227	8,013.00	161	227
Digital Library						
NSF/LTER	257.00	41,152	36	260.00	42,080	36
NSF/Portal	2,620.00	53,048	460	2,620.00	53,048	460
NIH/AFCS	733.00	94,686	21	733.00	94,686	21
NSF/SIO Explorer	2,681.00	1,201,719	27	3,053.00	1,220,303	27
NSF/SCEC	168,931.00	3,545,070	73	168,933.00	3,545,122	73
LLNL	8,176.00	335,540	5	18,934.00	2,338,384	5
CHRON	932.00	830,354	5	13,278.00	6,496,025	5
Persistent Archive						
NARA	4,713.00	5,992,817	58	5,036.00	6,409,726	58
NSF/NSDL	5,699.00	50,446,490	136	8,618.00	85,004,112	136
UCSD Libraries	5,080.00	1,077,202	29	5,210.00	1,720,463	29
NHPRC/PAT	3,756.00	527,695	28	2,575.00	1,050,795	28
RoadNet	2,057.00	712,534	30	3,886.00	1,792,185	30
UCTV	7,111.00	2,045	5	7,140.00	2,081	5
LOC	9,921.00	252,046	8	6,644.00	192,517	8
EarthSci	3,306.00	499,137	5	6,317.00	661,894	5
Total	877 TB	131 million	5479	1.04 PB	203 million	5539

Why iRODS?

- **Next-generation data grid technology**
  - Open source software - BSD license
- **Unique capabilities**
  - Virtualizes management policies across sites
    - Maps management policies to rules
    - Enforces rules at each remote storage location
- **Highly extensible modular design**
  - Management procedures are mapped to micro-services that encapsulate operations performed at the remote storage location
  - Add rules, add micro-services, add state information
- **Layered architecture**
  - Separation of client protocols from storage protocols

Distributed Management System



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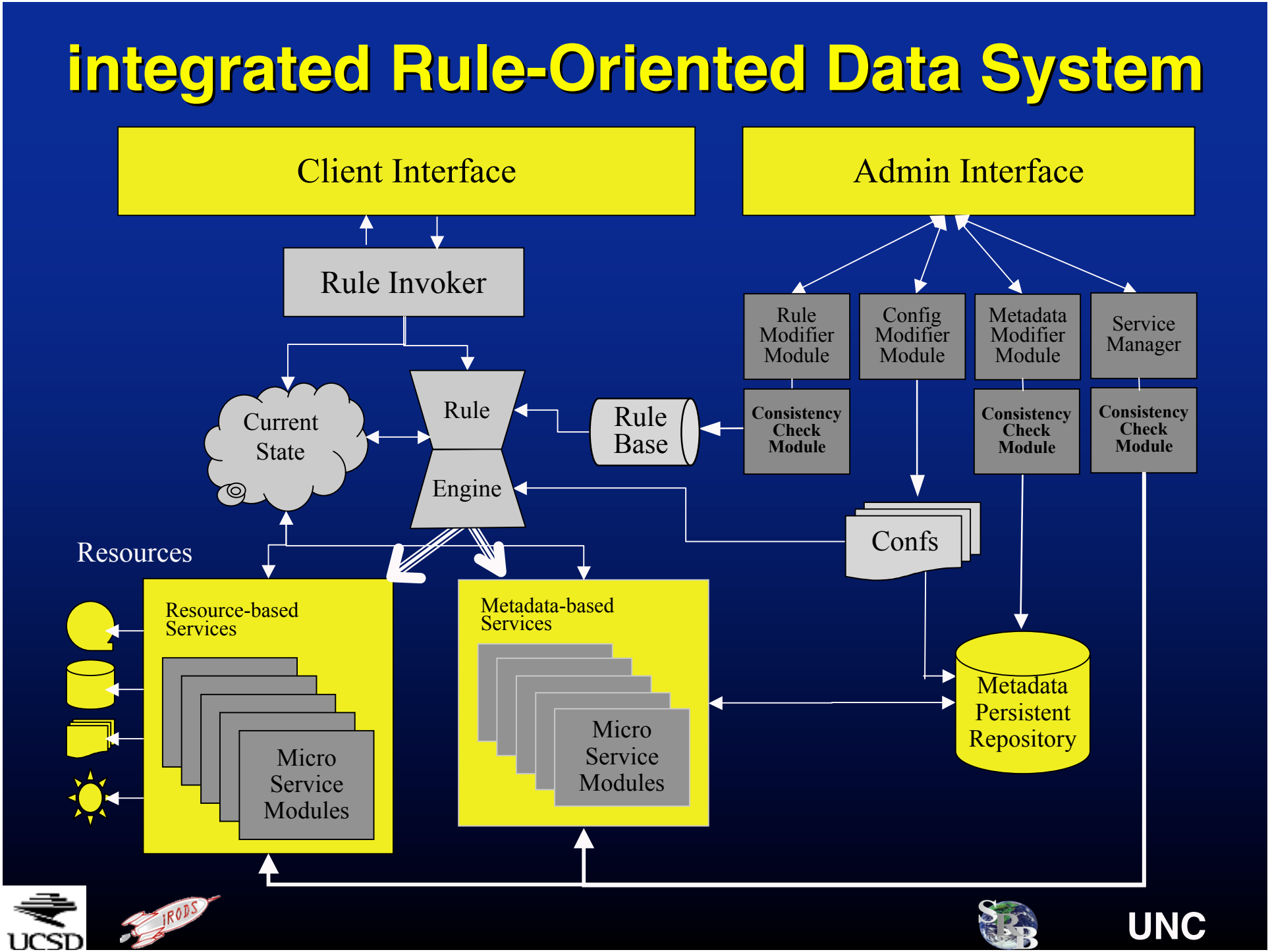
integrated Rule-Oriented Data System



Rule Specification

- **Rule - Event : Condition : Action set : Recovery Procedure**
  - Event - atomic, deferred, periodic
  - Condition - test on any state information attribute
  - Action set - chained micro-services and rules
  - Recovery procedure - ensure transaction semantics in a distributed world
- **Rule types**
  - System level, administrative level, user level

Data Grid Capabilities

- **Logical file name space**
  - Directory hierarchy / soft links
  - Versions / backups / replicas
  - Aggregation / containers
  - Descriptive metadata
  - Digital entities
- **Authentication and authorization**
  - GSI, challenge-response, Shibboleth
  - ACLs, audit trails
  - Checksums, synchronization
  - Logical user name space
  - Aggregation / groups

Data Grid Capabilities

- **Remote procedures**
  - Atomic / deferred / periodic
  - Procedure execution / chaining
  - Structured information
- **Structured information**
  - Metadata catalog interactions / 205 queries
  - Information transmission
  - Template parsing
  - Memory structures
  - Report generation / audit trail parsing

Data Grid Capabilities

- **Rules**
  - User / administrative / internal
  - Remote web service invocation
  - Rule & micro-service creation
  - Standards / XAM, SNIA
- **Installation**
  - CVS / modules
  - System dependencies
  - Automation

Collaborations

- **EU PLANETS - Preservation and Long-term Access through Networked Services**
  - Characterization of information content
- **UK Digital Curation Centre**
  - **Moore, R., "Towards a Theory of Digital Preservation", IJDC Volume 3, Issue 1, June, 2008.**
- **DIGcCurr2007 - International Symposium in Digital Curation**
  - University of North Carolina, Chapel Hill
- **DSpace - digital library**
  - MIT
- **FEDORA - digital library middleware**
  - Cornell

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Theory of Data Preservation

- **Prove compliance of the data management system with specified assertions**
- **Three components**
  1. Define the purpose for the collection: assessment criteria, management policies, and management procedures
  2. Analyze completeness of the system
     - For each criteria, persistent state is generated that can be audited
     - Persistent state attributes are generated by specific procedure versions
     - For each procedure version there are specific management policy versions
     - For each policy, there are evaluation criteria
  3. Audit properties of the system
     - Periodic rules validate assessment criteria

Components of a Preservation Environment

- **Preservation access mechanisms**
  - Clients for retrieving DIPs, submitting SIPs
- **Preservation policies**
  - Rules that control what can be done by whom
- **Preservation procedures**
  - Micro-services that execute the procedures
- **Preservation infrastructure**
  - Choice of storage system, rule engine, database

Preservation Rules

- **Authenticity**
  - Rules that quantify required descriptive metadata
  - Rules that verify descriptive metadata is linked to records
  - Rules that govern creation of AIPs
- **Integrity**
  - Rules that verify records have not been corrupted
  - Rules that manage replicas
  - Rules that recover from corruption instances
  - Rules that manage data distribution
- **Chain of custody**
  - Persistent identifiers for archivists, records, storage
  - Rules to verify application of access controls
  - Rules to track storage location of records

RLG/NARA - TRAC Criteria

- **Assessment categories**
  - Organizational infrastructure
  - Digital Object Management
  - Technologies, Technical Infrastructure and Security
- **Example criteria**
  - **B6.4 Repository has documented and implemented access policies (authorization rules, authentication requirements) consistent with deposit agreements for stored objects.**

Mapping to a Set of Rules

- *List staff who have archivist execution permission on collection*
- *List all persons with access permissions on collection*
- *Analyze audit trails to verify identity of all persons accessing the data, and compare their roles with desired access controls*
- *Generate report listing all persons who accessed or applied archival functions on the collection*
- *Compare report with the deposition agreement*

RLG/NARA Assessment

- **Are developing 105 rules that implement the TRAC assessment criteria**

90	*Verify descriptive metadata and source against SIP template and set SIP compliance flag*
91	*Verify descriptive metadata against semantic term list*
92	*Verify status of metadata catalog backup (create a snapshot of metadata catalog)*
93	*Verify consistency of preservation metadata after hardware change or error*

Representation Information - Records

- SIP compliance flag
- Location of ingestion SIP
- Original record ID
- Master copy flag
- Formal acceptance flag
- Audit log of all applied micro-services by person and date
- Format type
- Size
- Checksum and validation date
- Replica locations
- Provenance metadata

Representation Information

- **Users**
  - Allowed roles - archivist, management, owner
  - Training courses taken and dates
  - Involvement with a collection
- **Resources**
  - Audit log of all error incidents
  - Cost per TB of storage and date defined
  - Audit log of all upgrades

Representation Information

- **Rules**
  - Rule type
  - Version number
- **Micro-services**
  - Audit log of all changes
  - Version number
- **Structured information**
  - Template defining preservation attributes
  - Template for SIP format
  - Template for AIP format
  - Template to map from SIP template to AIP template

Structured Information

- **Observe that half of the rules deal with structured information**
  - Extraction of structured metadata
    - Accession templates
    - Parsing of submission information packages
  - Creation of structured documents
    - Dissemination Information Packages
    - Archival Information Packages
    - Status reports
  - Define templates to characterize the information structure
- **iRODS Mounted Collection interface manages structured information**

Electronic Records Archive

- **Analyzed capabilities list**
  - Identified 600 functions that should be automated by the data grid
  - Reduced the number of required micro-services to 177
  - Derived 212 metadata attributes that are needed
  - Again, half of the attributes are related to characterizations of structured information

iRODS Development

- **NSF - SDCI grant "Adaptive Middleware for Community Shared Collections"**
  - iRODS development, SRB maintenance
- **NARA - Transcontinental Persistent Archive Prototype**
  - Trusted repository assessment criteria
- **NSF - Ocean Research Interactive Observatory Network (ORION)**
  - Real-time sensor data stream management
- **NSF - Temporal Dynamics of Learning Center data grid**
  - Management of IRB approval

iRODS Development Status

- **Production release is version 1.0**
  - January 24, 2008
- **International collaborations**
  - SHAMAN - University of Liverpool
    - Sustaining Heritage Access through Multivalent ArchiviNg
  - UK e-Science data grid
  - IN2P3 in Lyon, France
  - DSpace policy management
  - Shibboleth - collaboration with ASPIS

Planned Development

- GSI support (1)
- Time-limited sessions via a one-way hash authentication
- Python Client library
- GUI Browser (AJAX in development)
- Driver for HPSS (in development)
- Driver for SAM-QFS
- Porting to additional versions of Unix/Linux
- Porting to Windows
- Support for MySQL as the metadata catalog
- API support packages based on existing mounted collection driver
- MCAT to ICAT migration tools (2)
- Extensible Metadata including Databases Access Interface (6)
- Zones/Federation (4)
- Auditing - mechanisms to record and track iRODS metadata changes

For More Information

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