# Transcontinental Persistent Archive Prototype

## Policy-Driven Data Preservation

Reagan W. Moore

University of North Carolina at Chapel Hill

rwmoore@renci.org

http://irods.diceresearch.org

NSF OCI-0848296 “NARA Transcontinental Persistent Archives Prototype” (2008-2012)
NSF SDCI 0721400 “Data Grids for Community Driven Applications” (2007-2010)


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Topics

- Transcontinental Persistent Archive Prototype
  - Use data grid technology to build a preservation environment
  - Conduct research on preservation concepts
    - Infrastructure independence
    - Enforcement of preservation properties
    - Validation of assessment criteria
    - Automation of administrative processes
  - Demonstrate preservation on selected NARA digital holdings
    - Applicability of generic infrastructure


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Why Data Grids?

- Organize distributed data into shared collections
  - Virtualize collection properties
    - Manage retention, disposition, distribution, replication, integrity, authenticity, chain of custody, access controls, provenance, representation information, descriptive information, logical arrangement
  - Provide uniform interface to multiple storage systems
    - Manage interactions with Unix, Linux, Mac, Windows based storage systems
    - Enable use of multiple client interfaces across all storage systems
    - Provide scalability mechanisms such as optimized data transport (parallel I/O, single message small file transfer)


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Observation # 1

- Data grids support virtualization of collections
  - Preservation is the extraction of records from the environment in which they were created, and the import of the records into a persistent archive
  - This requires the management of the properties of the collection independently of the choice of technology and the construction of an archival form

# Observation # 2

- Preservation is communication with the future
  - We know that technology in the future will be more sophisticated than technology today
- Data grids manage technology evolution
  - At the point in time when new technology becomes available, both the old and new systems can be accessed simultaneously
  - Records can be migrated from the old technology to the new technology


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Observation #3

- Preservation is the management of communication from the past
  - To make assertions about the preservation policies and procedures that were applied in the past, the persistent archive must manage and enforce consistent policies and procedures
  - Long-term preservation requires periodic validation of assessment criteria to ensure continued trustworthiness


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL
UCSD


# Data Preservation Challenges

- Data driven research generates massive data collections
  - Data sources are remote and distributed
  - Collaborators are remote
  - Wide variety of data types: observational data, experimental data, simulation data, real-time data, office products, web pages, multi-media
- Collections contain millions of files
  - Logical arrangement is needed for distributed data
  - Discovery requires the addition of descriptive metadata
- Long-term retention requires migration of output into a reference collection
  - Automation of administrative functions is essential to minimize long-term labor support costs
  - Creation of representation information for describing file context
  - Validation of assessment criteria (authenticity, integrity)


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Data Management Steps

- Logical Arrangement
  - Organization of material into collections
- Metadata
  - Descriptive / provenance / context
- Policies for managing the data
  - Administrative / Access / Redaction / Validation
- Processes for manipulating the data
  - Calibration / coordinate projection / physical data
- Access mechanisms
  - Web / workflow / digital library
- Workflows for data analysis and processing
  - Server side remote procedures / client side

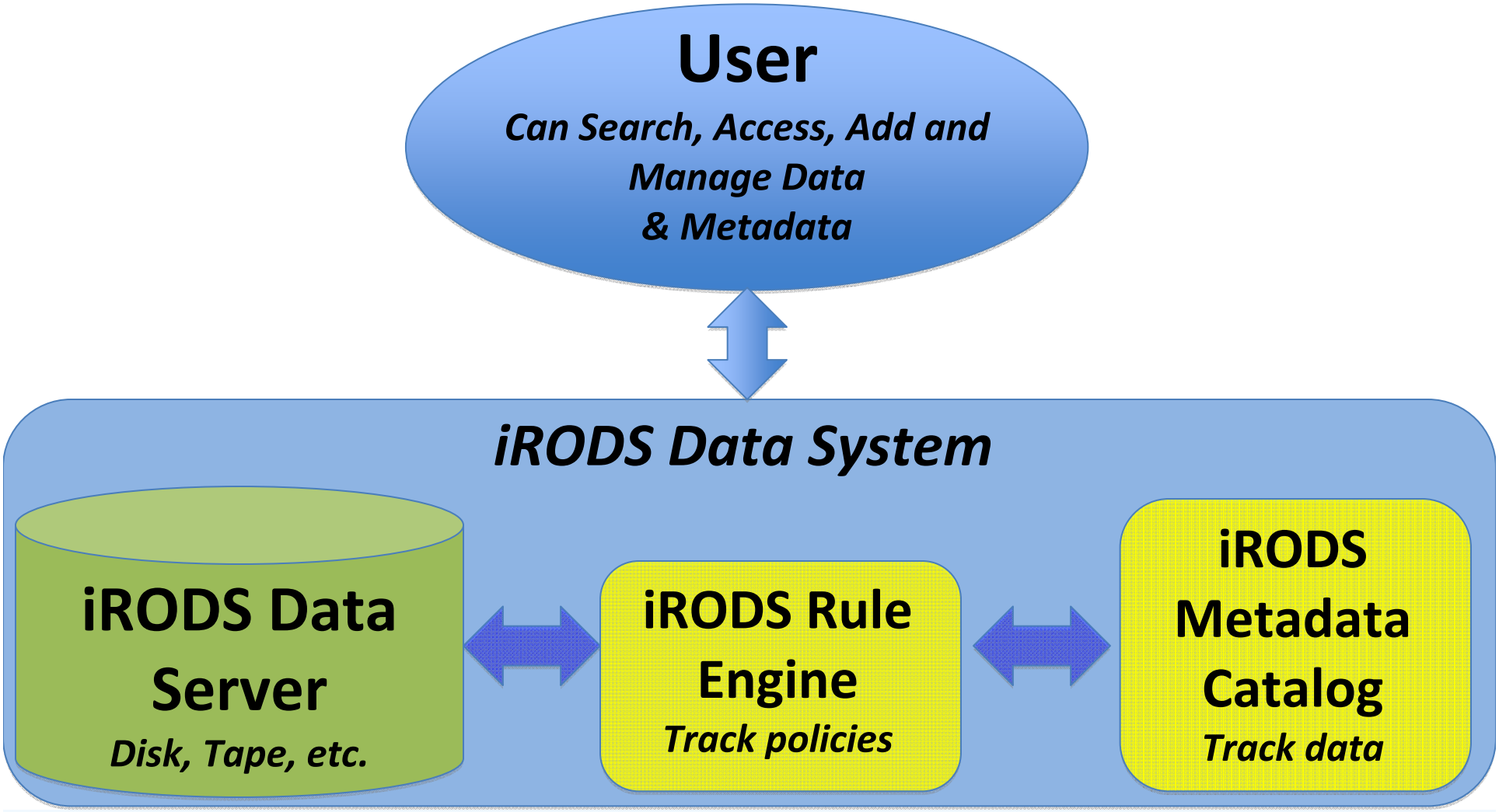

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Preservation is an Integral Part of the Data Life Cycle

- Organize project data into a shared collection
- Publish data in a digital library for use by other researchers
- Preserve reference collection for use by future research initiatives
- Compare new reference collection against prior state-of-the-art data
- Enable data-driven analyses that dynamically optimize research


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Overview of iRODS Data System




*Access data with Web-based Browser or iRODS GUI or Command Line clients.

# Policy-based Data Management

- Turn management policies into computer actionable rules
  - Support dynamic rule base updates
- Turn management processes into remotely executable computer procedures
  - Apply procedural workflow at the storage system to filter, subset, manipulate data
  - Minimize the amount of data pulled over the network
  - Automate administrative tasks
- Validate assessment criteria
  - Automate validation of collection properties
  - ISO MOIMS-rac


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Generic Data Management Systems

## iRODS - integrated Rule-Oriented Data System

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

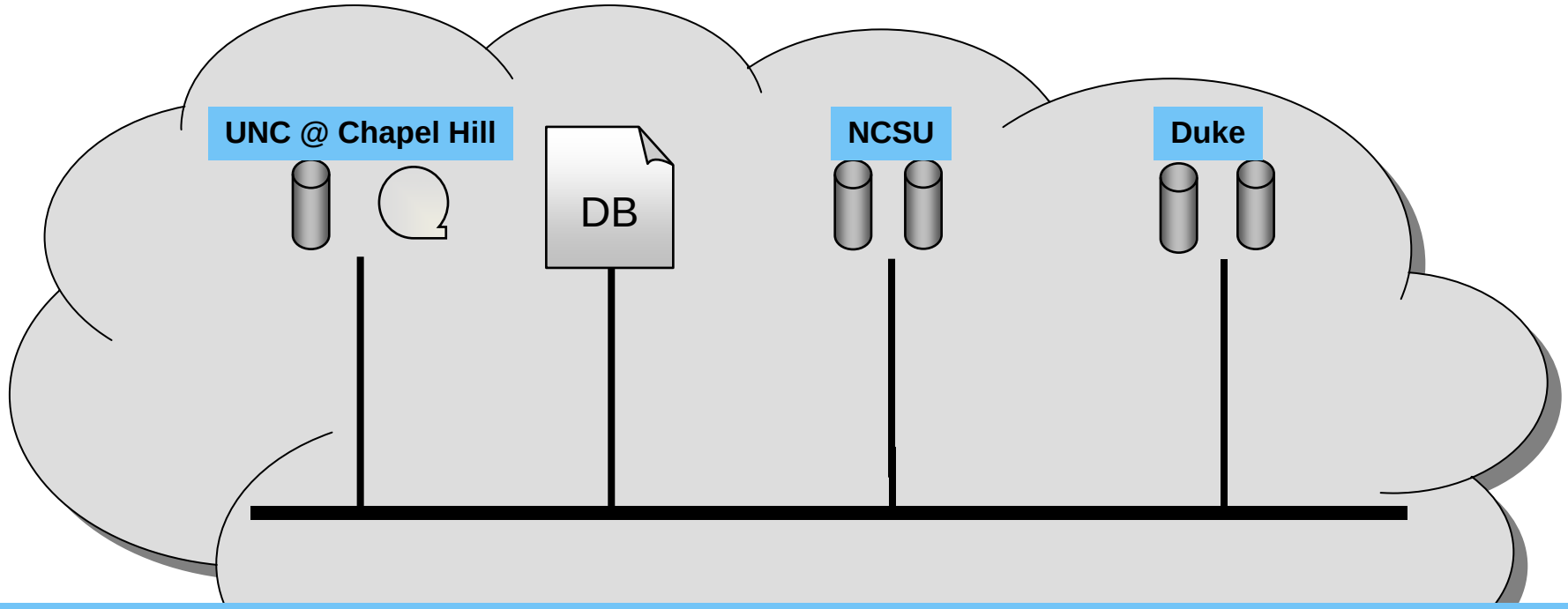

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Policies

- Administrative
  - Retention, disposition, distribution, replication, deletion, registration, synchronization, integrity checks, IRB approval flags, addition of users, addition of resources
- Ingestion / Access
  - Metadata extraction, logical organization, derived data product generation, redaction, time-dependent access controls
- Validation
  - Authenticity verification, chain of custody, repository trustworthiness, audit trails


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

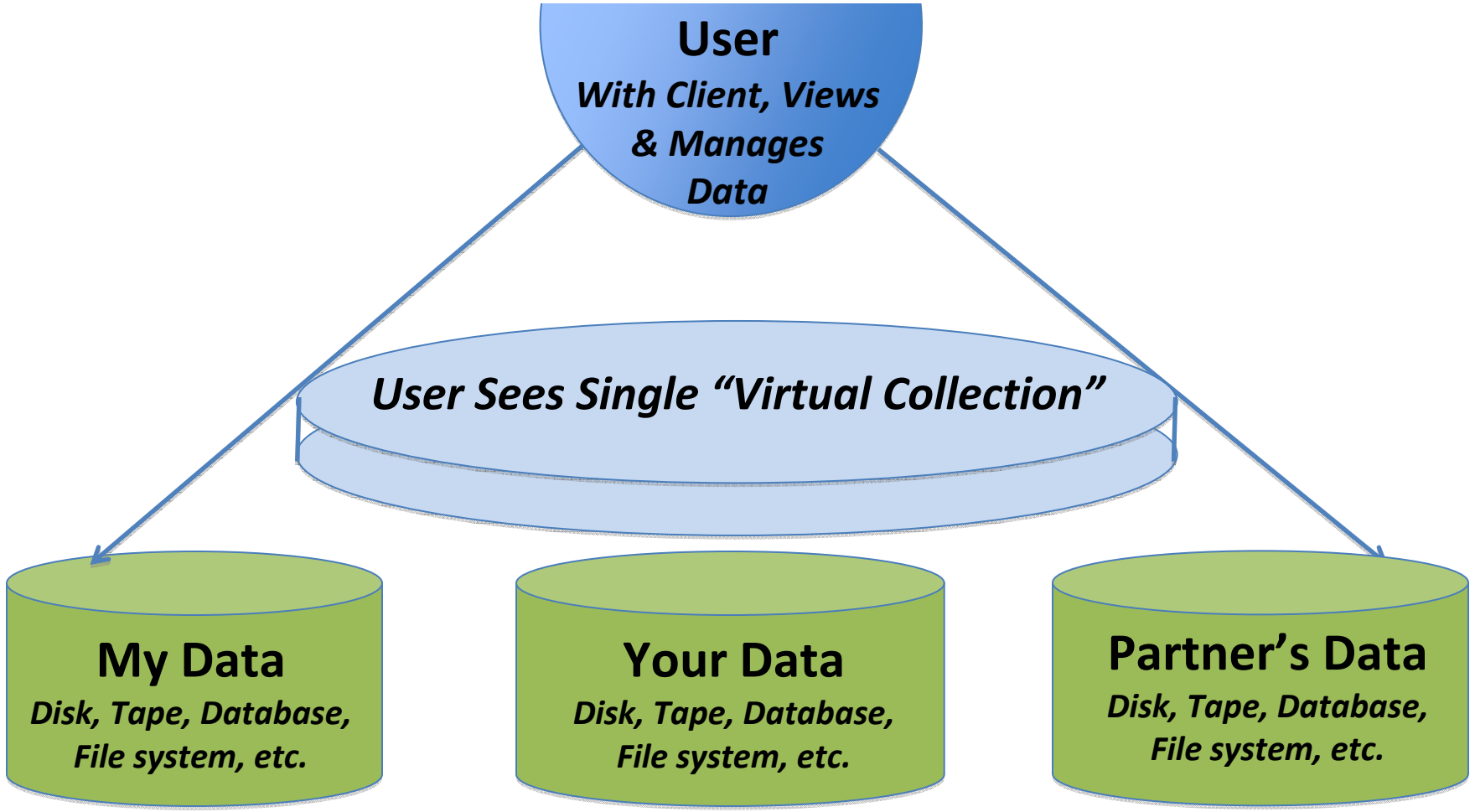

# Building a Shared Collection




**Have collaborators at multiple sites, each with different administration policies, different types of storage systems, different naming conventions.**

**Assemble a self-consistent, persistent distributed shared collection to support a specific purpose.**

# iRODS Shows Unified "Virtual Collection"



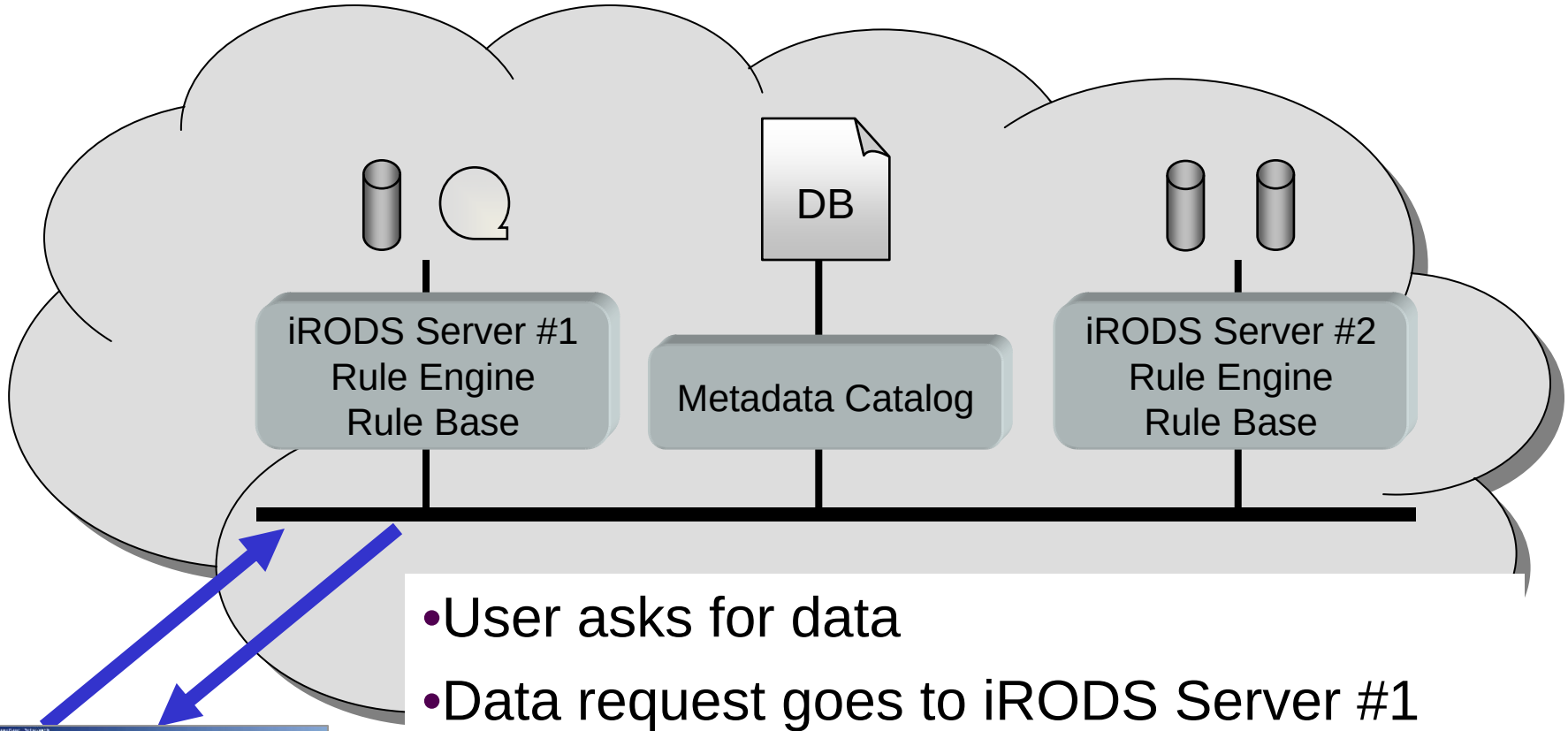

**The iRODS Data Grid installs in a "layer" over existing or new data, letting you view, manage, and share part or all of diverse data in a unified Collection.**

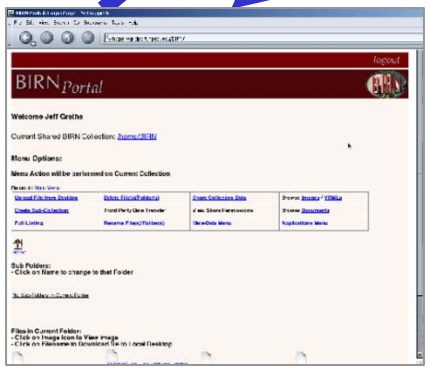
# iRODS - Integrated Rule Oriented Data System

1. Shared collection assembled from data distributed across remote storage locations
2. Server-side workflow environment in which procedures are executed at remote storage locations
3. Policy enforcement engine, with computer actionable rules applied at the remote storage locations
4. Validation environment for assessment criteria
5. Consensus building system for establishing a collaboration (policies, data formats, semantics, shared collection)


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Using a Data Grid - *Details*



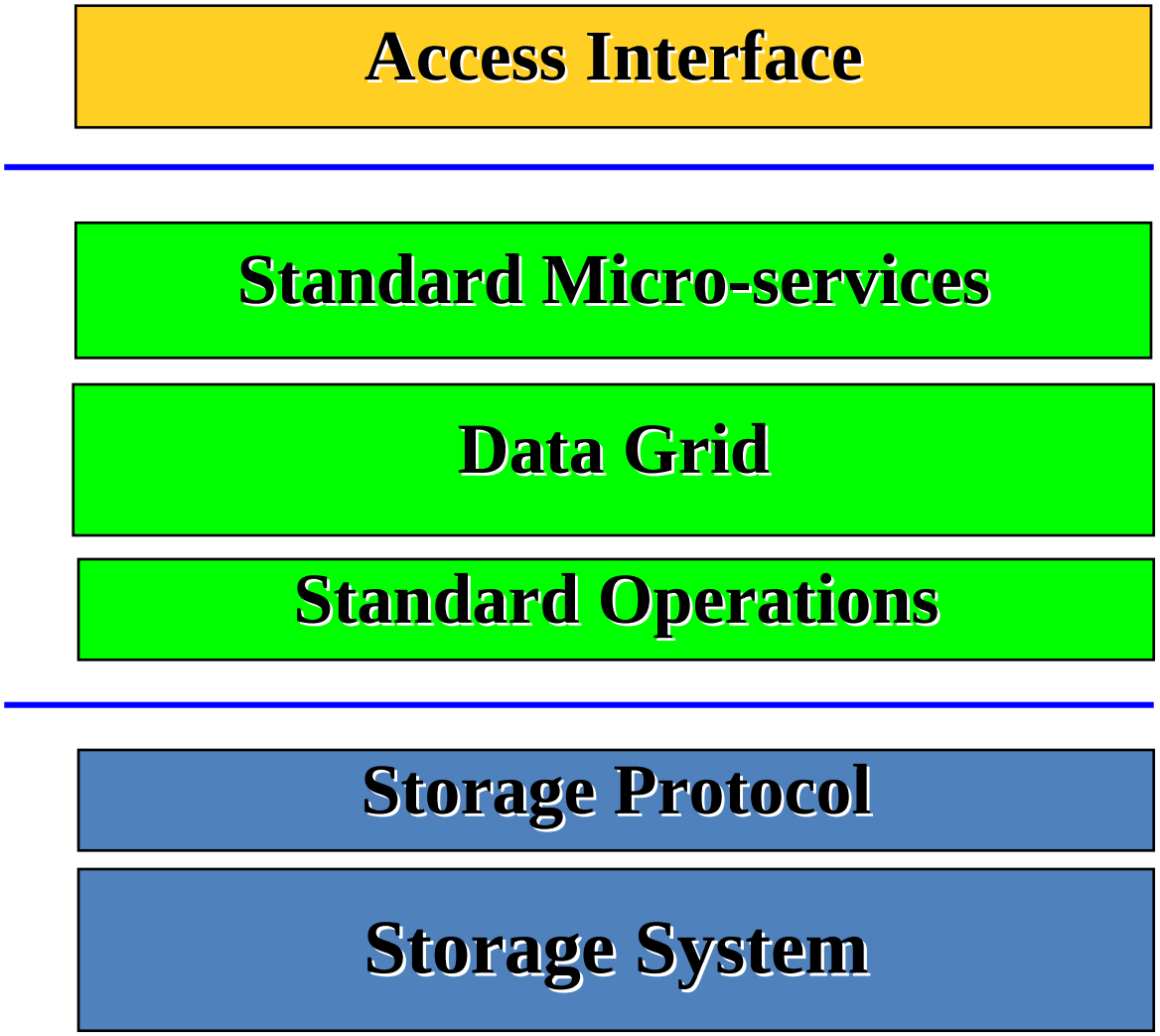

- User asks for data
- Data request goes to iRODS Server #1
- Server looks up information in catalog
- Catalog tells which iRODS server has data
- 1st server asks 2nd for data
- The 2nd iRODS server applies rules

# Architecture

- Highly extensible, modular architecture
  - Peer-to-peer servers interact to form a data grid
- Layered architecture
  - Clients
  - Rules
  - Micro-services
  - Storage drivers
  - Structured information resource drivers


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Data Virtualization




Map from the actions

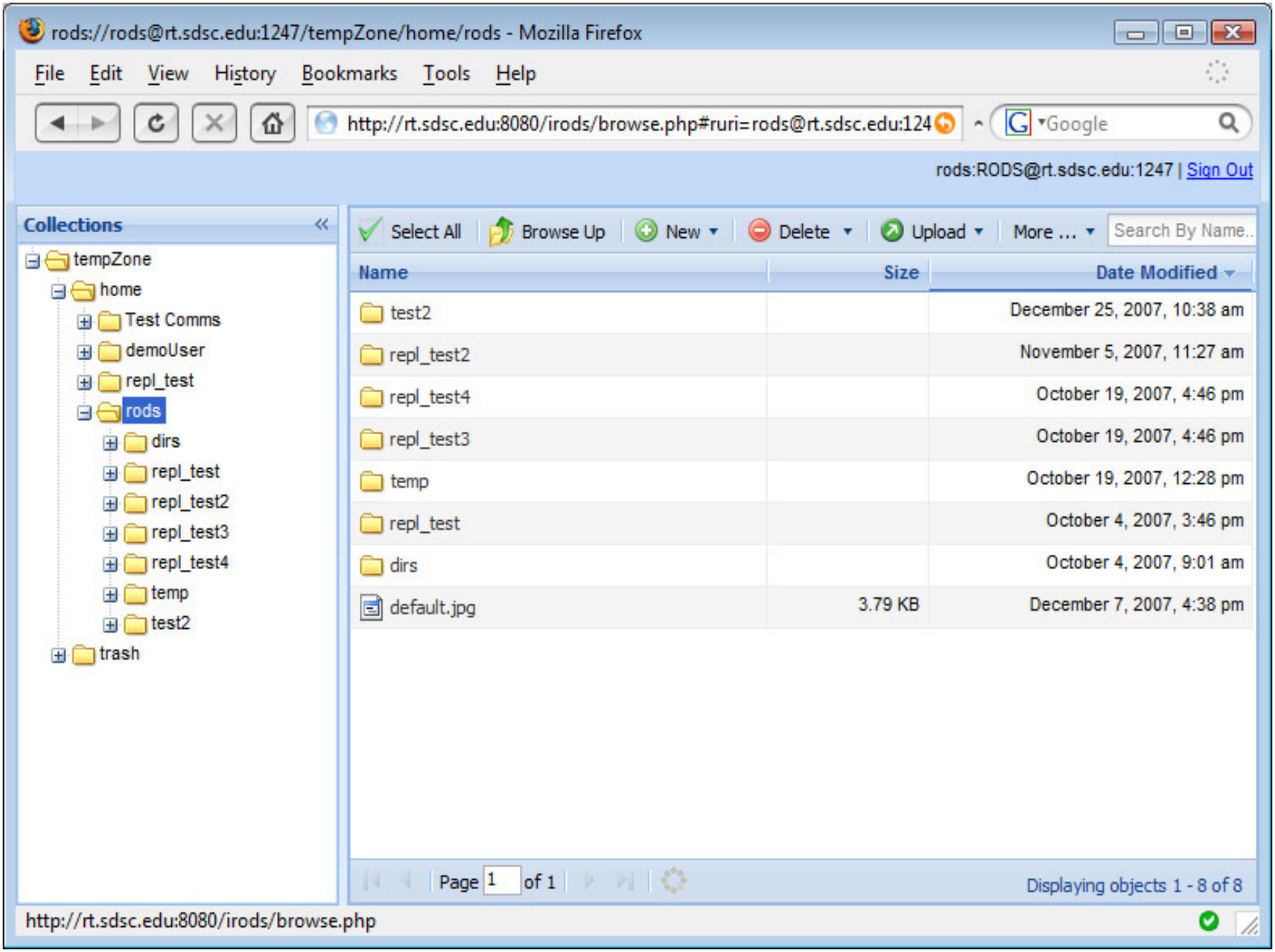
requested by the access method to a standard set of micro-services. The standard micro-services are mapped to the operations

supported by the storage system

# User Interfaces

| | |
|---|---|
| • C library calls | - Application level |
| • Unix shell commands | - Scripting languages |
| • Java I/O class library (JARGON) | - Web services |
| • SAGA | - Grid API |
| • Web browser (Java-python) | - Web interface |
| • Windows browser | - Windows interface |
| • WebDAV | - iPhone interface |
| • Fedora digital library middleware | - Digital library middleware |
| • Dspace digital library | - Digital library services |
| • Parrot | - Unification interface |
| • Kepler workflow | - Grid workflow |
| • Fuse user-level file system | - Unix file system |


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL



rods://rods@rt.sdsc.edu:1247/tempZone/home/rods - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://rt.sdsc.edu:8080/irods/browse.php#ruri=rods@rt.sdsc.edu:124
Google
rods:RODS@rt.sdsc.edu:1247 | Sign Out
Collections
tempZone
home
Test Comms
demoUser
repl_test
rods
dirs
repl_test
repl_test2
repl_test3
repl_test4
temp
test2
trash
Select All
Browse Up
New
Delete
Upload
More ...
Search By Name..
Name
Size
Date Modified
test2
December 25, 2007, 10:38 am
repl_test2
November 5, 2007, 11:27 am
repl_test4
October 19, 2007, 4:46 pm
repl_test3
October 19, 2007, 4:46 pm
temp
October 19, 2007, 12:28 pm
repl_test
October 4, 2007, 3:46 pm
dirs
October 4, 2007, 9:01 am
default.jpg
3.79 KB
December 7, 2007, 4:38 pm
Page 1 of 1
Displaying objects 1 - 8 of 8
http://rt.sdsc.edu:8080/irods/browse.php

# iRODS Rules

- Server-side workflows

  Action | condition | workflow chain | recovery chain
- Condition - test on any attribute:
  - Collection, file name, storage system, file type, user group, elapsed time, IRB approval flag, descriptive metadata
- Workflow chain:
  - Micro-services / rules that are executed at the storage system
- Recovery chain:
  - Micro-services / rules that are used to recover from errors

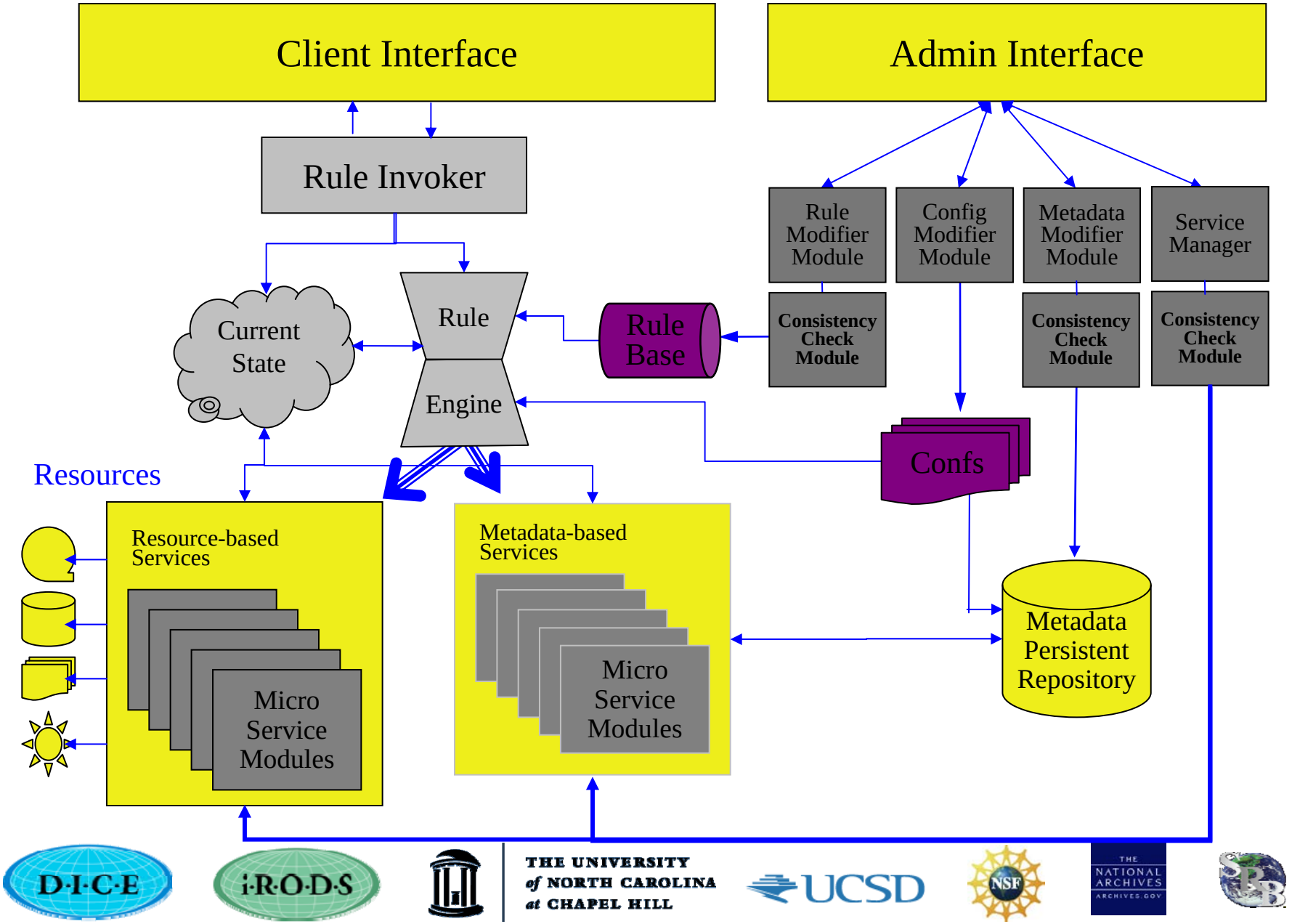

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# ISO MOIMS-repository assessment criteria

- Are developing 150 rules that implement the ISO 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*** |

# integrated Rule-Oriented Data System



# Generic Infrastructure

- Data grids - sharing data
- Digital libraries - publishing data
- Persistent archives - preserving data
- Processing pipelines - analyzing data
- Real-time data management - federation of streams
- Integrated workflows - server and client side

- Switch applications by switching management policies
  - Build reference policy sets for each type of application


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Scale

- Tens of millions to hundreds of millions of files
- Hundreds of terabytes to petabytes of data
- Hundreds of metadata attributes
- Hundreds of collaborators
- Tens to hundreds of policies
- Distributed internationally
- Federations of tens of data grids
- Thousands to tens of thousands of users


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


| | 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 |

# Applications

- Institutional repositories
  - Carolina Digital Repository at University of North Carolina
  - Duke Medical Archive
- Regional data grids
  - RENCI data grid linking 7 engagement centers in North Carolina
  - HASTAC data grid linking humanities collections across 9 UC campuses
- National data grids
  - NARA Transcontinental Persistent Archive Prototype
  - NSF Temporal Dynamics of Learning Center data grid
  - NSF Ocean Observatories Initiative data grid
  - NASA Center for Computational Sciences archive
  - JPL Planetary Data System data grid
- International data grids
  - Australian Research Collaboration Service - ARCS
  - French National Library


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

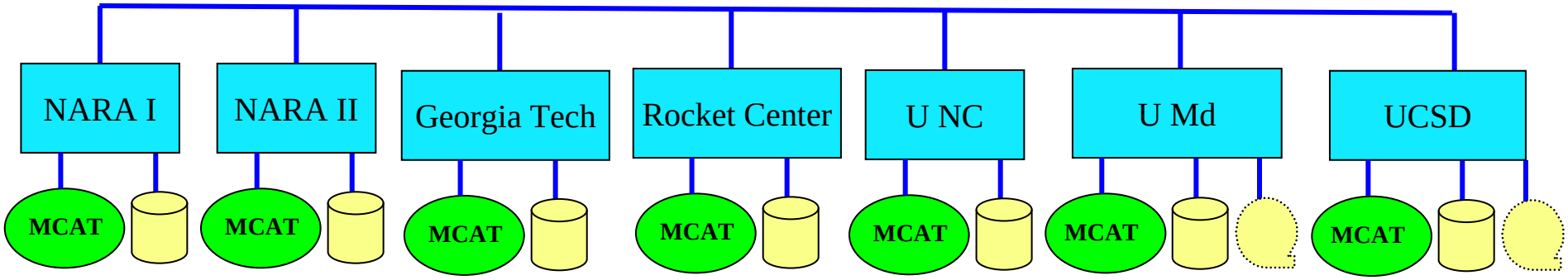

# Federation of Data Grids

- Federation policies govern interactions between data grids
  - Remote data grid forwards request to the federated data grid
  - Local policies always enforced
  - Multiple types of federation
    - Master-slave data grids
    - Central archive data grids
    - Chained data grids
    - Peer-to-peer data grids


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL
UCSD


# 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.

D·I·C·E i·R·O·D·S THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL UCSD NSF THE NATIONAL ARCHIVES ARCHIVES.GOV

# Challenges - Social Consensus

- Building a consensus on management policies for the shared collection
- Translating service level agreements for shared use of resources into computer actionable rules
- Translating assessment criteria into computer executable procedures
- Defining federation policies for sharing data between data grids / institutions


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Development Team

- DICE team
  - Arcot Rajasekar - iRODS development lead
  - Mike Wan - iRODS chief architect
  - Wayne Schroeder - iRODS developer
  - Bing Zhu - Fedora, Windows
  - Lucas Gilbert - Java (Jargon), DSpace
  - Paul Tooby - documentation, foundation
  - Sheau-Yen Chen - data grid administration
- Preservation
  - Richard Marciano - Preservation development lead
  - Chien-Yi Hou - preservation micro-services
  - Antoine de Torcy - preservation micro-services


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Foundation

- Data Intensive Cyber-environments
  - Non-profit open source software development
  - Promote use of iRODS technology
  - Support standards efforts
  - Coordinate international development efforts
    - IN2P3 - quota and monitoring system
    - King's College London - Shibboleth
    - Australian Research Collaboration Services - WebDAV
    - Academia Sinica - SRM interface


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL


# Prioritize Development

- Generic infrastructure
  - Turn specific requests into generic framework
- Assign importance
  - Bug fixes
  - Funded development
  - Multiple requests
  - Critical need to meet major demonstration
- Incorporate community supplied mods
  - Generic infrastructure
  - Compliance with iRODS modular design


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL
UCSD


# Features in Next Release

- Support for mySQL as the iCAT metadata catalog
- Support for Kerberos authentication
- Support for resource monitoring system
- Multi-tasking the batch server (irodsReServer) for more robust job execution.
- A new resource class - Compound Resource for a class of resources that support only put/get type functions
  - (e.g., ftp, HPSS parallel I/O, etc)
- Better support for writing micro-services - consolidation of data structures used by micro-services, more helper routines.
- Better Java interface for iRODS - parallel I/O, metadata support, etc.
- Multi-threading put/get of small files (if it can be done in time for the release)
- Better support for restricted listing of collections (ACLs).

iRODS is a "coordinated NSF/OCI-Nat'l Archives research activity" under the auspices of the President's NITRD Program and is identified as among the priorities underlying the President's 2009 Budget Supplement in the area of Human and Computer Interaction Information Management technology research

Reagan W. Moore

rwmoore@renci.org

http://irods.diceresearch.org

Current iRODS release 2.0.1


THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL