

# iRODS User Group Meeting 2010

*Policy-Based Data Management, Sharing, and Preservation*

March 24–26, 2010 • Chapel Hill, NC, USA



Data Intensive Cyber Environments Center

University of North Carolina at Chapel Hill

School of Information and Library Science

Renaissance Computing Institute

Data Intensive Cyberinfrastructure Foundation

[https://www.irods.org/index.php/iRODS\\_User\\_Meetings](https://www.irods.org/index.php/iRODS_User_Meetings)

Report to the National Science Foundation



THE UNIVERSITY  
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Any opinions, findings, conclusions or recommendations expressed in this Report are those of the authors and do not necessarily reflect the views of the authors' institutions or the NSF.

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We would also like to acknowledge support from Data Intensive Cyber Environments Center at the University of North Carolina at Chapel Hill; the Renaissance Computing Institute; the School of Information and Library Science (SILS) at UNC Chapel Hill; and the Data Intensive Cyberinfrastructure Foundation.

The meeting organizers were Reagan Moore, Chair (UNC) and Arcot Rajasekar (UNC). Report prepared by Paul Tooby.



## iRODS User Group Meeting Summary

### **iRODS**

iRODS, the Integrated Rule-Oriented Data System, is an open source data grid software system developed by the Data Intensive Cyber Environments research group (developers of the SRB, Storage Resource Broker), and collaborators.

The iRODS system, currently at version 2.3, is based on expertise gained through nearly a decade of user-driven applications in support of data grids, digital libraries, persistent archives, and real-time data systems.

iRODS management policies (sets of assertions these communities make about their digital collections) are characterized in iRODS as computer actionable Rules that control the execution of procedures. The procedures are composed from basic functions (micro-services) that are written in the C language. The state information generated by application of the procedures is stored in a central metadata catalog.

At the iRODS core, a Rule Engine interprets the Rules to decide how the system is to respond to actions initiated by all clients, as well as administrative operations. iRODS is distributed as open source software under a BSD license.

### **2010 iRODS User Group Meeting**

The second annual iRODS user group meeting was held from March 24-26, 2010 in Chapel Hill, North Carolina. The first meeting was held in Nice, France in February 2009. The meeting attracted a wide range of attendees from experienced software developers who are contributing code to the open source iRODS software, to users with installations of varying sizes, to potential users wanting to learn more about iRODS. Users from academia, international and business organizations, and federal and state agencies were represented at the meeting.

With its advanced design and highly configurable and extensible architecture, iRODS is gaining increasing attention and users. The meeting attendance exceeded capacity with over 50 attendees from across the United States and as far away as France, Australia, and Taiwan, and participation from Japan by teleconference.

The meeting began with sessions on an introduction to release 2.3 of iRODS, descriptions of how to create new micro-services and policies, a review of the unix shell command capabilities (icommands), and descriptions of the interactions (queries) on the iCAT metadata catalog.

A majority of the meeting was devoted to sessions for papers and presentations on user applications. The papers demonstrated the wide range of ways that communities have applied the iRODS framework. More than a dozen presentations and posters described use of iRODS in national data grids (e.g. Australian Research Collaboration Service), large-scale scientific research projects (e.g. KEK high energy physics data grid, French national computing center CC-IN2P3), institutional repositories (e.g. Carolina Digital Repository), and preservation environments (e.g. Taiwan National Archives).



Additional sessions were devoted to the development of new iRODS clients and integration of new capabilities into the iRODS framework. In particular, the JARGON Java I/O library was presented along with plans for integration with web services, development of a dropbox interface (iDrop), and support for digital library interfaces such as Islandora.

The final day of the meeting was dedicated to seeking community input into prioritizing new feature development, and identifying new types of interoperability mechanisms that are needed. A list was compiled of the current clients used to interact with an iRODS data grid. More than 35 existing clients were identified, ranging from Grid clients (GridFTP, JSAGA), file system interfaces (FUSE, PetaFS, webDAV), web browser interfaces (iExplore), digital library interfaces (Fedora, DSpace, Drupal, Islandora), workflow systems (Kepler, Taverna) and specialized interfaces such as URSpace for synchronizing local resources with iRODS. Interactions between collaborators are being supported through the Data Intensive Cyberinfrastructure Foundation, which supports the iRODS open source community.

A proceedings of the meeting with the collected papers, poster abstracts, and other products is forthcoming.

### **Benefits to the iRODS Community and Wider Cyberinfrastructure Community**

- Interchange among users accelerated leveraging each other's applications of iRODS.
- Interchange among users and iRODS developers provided direct user guidance for development of useful real-world features.
- Publication of use cases and other meeting products in the Proceedings for the wider community will disseminate the collective iRODS community expertise.
- Strengthening collaborations with other projects widens interoperability, leveraging the iRODS development investment (see list of 36 current iRODS clients in Appendix).

### **Appendices – User Meeting Documents**

- List of papers and posters with brief descriptions
- iRODS User Meeting Agenda
- Author List – see Agenda
- List of iRODS Feature Requests
- List of iRODS Clients
- Meeting Webpage with downloadable papers  
[https://www.irods.org/index.php/iRODS\\_User\\_Meetings](https://www.irods.org/index.php/iRODS_User_Meetings)

### **Links**

- iRODS Integrated Rule-Oriented Data System wiki <https://www.irods.org/>
- Data Intensive Cyber Environments Center at UNC <http://dice.unc.edu>
- Data Intensive Cyberinfrastructure Foundation <http://dicersearch.org>
- Renaissance Computing Institute (RENCI) <http://www.renci.org>
- UCSD Institute for Neural Computation (INC) <http://inc.ucsd.edu>
- NSF Office of Cyberinfrastructure (OCI) <http://www.nsf.gov/dir/index.jsp?org=OCI>
- NARA Center for Advanced Systems and Technologies <http://www.archives.gov/ncast>



## Appendices

### Papers and Posters Presented at the 2010 iRODS User Group Meeting

#### User Applications: How Communities Have Applied iRODS

##### *Papers*

- **High Availability iRODS System (HAIRS)** Yutaka Kawai (KEK, Japan), Adil Hasan (University of Liverpool). Describes a High Availability load-balanced iRODS System (HAIRS) developed for use in the KEK high energy physics data grid, with potential applications in similar large-scale scientific research projects.
- **iRODS at CC-IN2P3** Jean-Yves Nief, Pascal Calvat, Yonny Cardenas, Pierre-Yves Jallud, Thomas Kachelhoffer (CC-IN2P3, Lyon, France). Describes large scale production use of SRB (2 PB) and iRODS (100s TB) in multiple communities and applications, including data grids in biology and biomedicine; physics; Adonis large-scale humanities community (with Fedora integration); etc. as well as iRODS code development at the French national CC-IN2P3 supercomputing center.
- **Using iRODS to Preserve and Publish a Dataverse Archive**, Mason Chua (Odum Institute, UNC), Antoine de Torcy (DICE Center, UNC), Jewel H. Ward (SILS, UNC), Jonathan Crabtree (Odum Institute, UNC). Describes interoperation with social science Dataverse Archive allowing publication of the archive into iRODS to enable search through the iRODS Metadata Catalog (iCAT) and the ability to apply iRODS preservation capabilities to the archive.
- **Conceptualizing Policy-Driven Repository Interoperability (PoDRI) Using iRODS and Fedora**, David Pcolar (CDR, UNC), Daniel W. Davis (Cornell, DuraSpace), Bing Zhu (DICE, UCSD), Alexandra Chassanoff (SILS, UNC), Chien-Yi Hou, Richard Marciano (SALT, UNC). Describes work integrate and interoperate between the iRODS and Fedora digital repositories, providing policy-aware object models, including policy expressions, and a distributed architecture for policy-driven management. Combining iRODS and its Rules engine with Fedora's rich semantic object model for digital objects will leverage the best features of both products. Funded by IMLS.
- **Community-Driven Development of Preservation Services**, Richard Marciano (SALT, UNC), Chien-Yi Hou (SALT, UNC), Jennifer Ricker (NC State Library), Glen McAninch (KY Dept. Lib. & Archives), David Pcolar (CDR, UNC) et al. Describes lessons learned in the DCAPE project to articulate a community-based development approach for preservation services that will support institution-specific preservation policies (including business models) while providing required economy of scale for a cost-effective service. Funded by NHPRC.

##### *Posters*

- **Distributed Data Sharing with PetaShare for Collaborative Research**, PetaShare Team @LSU (poster). Describes use of iRODS in the PetaShare data grid to enable transparent handling of data sharing, archival, and retrieval mechanisms, making data easily available to scientists for analysis and visualization on demand. Used in 25 research projects in five state universities and two health sciences centers across Louisiana. Describes the PetaFs virtual filesystem.



- **University of North Carolina Information Technology Services**, William Schultz (UNC) (poster). Describes use of iRODS in multiple data grids in the context of UNC HPC infrastructure.
- **The ARCS Data Fabric**, Shunde Zhang, Florian Goessmann, Pauline Mak (ARCS) (poster). Describes use of iRODS in the ARCS Data Fabric which lets researchers easily store and share research data across institutional boundaries in a generic service not tied to any specific kinds of data or research disciplines and available to every Australian researcher and international collaborators. Describes access through WebDAV clients.
- **Building a Trusted Distributed Archival Preservation Service with iRODS**, Jewel H. Ward, Terrell G. Russell, and Alexandra Chassanoff (SILS, UNC) (poster). Describes the design and development of generic iRODS Rules to 1) validate the trustworthiness of a repository through the enactment of ISO-MOIMS compliant policies; and 2) enable the distributed auditable administration of the repository through the invocation of iRODS Rules.

## Clients for iRODS

### Papers

- **A Service-Oriented Interface to the iRODS Data Grid**, Nicola Venuti, Francesco Locunto (NICE), Michael Conway, Leesa Brieger (UNC RENCI and DICE). Describes an open source iRODS plugin that gives iRODS users access to the Nice EnginFrame cloud interface framework through an easy-to-use GUI that can be easily customized for community use, offering multiple views for users, administrators, etc.
- **iExplore for iRODS Distributed Data Management**, Bing Zhu (DICE group, UCSD). Describes the iExplore GUI client tool for navigation and manipulation of data within the iRODS distributed data system. Designed and implemented in the Windows platform, it offers a rich set of functions and excellent performance.
- **The Development of Digital Archives Management Tools for iRODS**, Tsung-Tai Yeh, Hsin-Wen Wei, Shin-Hao Liu (Academia Sinica, Taiwan), Pei-Chi Huang (Tsing Hua University, Taiwan), Tsan-sheng Hsu (Academia Sinica, Taiwan), Yen-Chiu Chen (Tsing Hua University, Taiwan). Describes development for use in the TELDAP program in Taiwan of the UrSpace user interface and corresponding Sync Package and monitoring system (SIMS) that can check iRODS for errors and monitor the system independently.

### Posters

- **A GridFTP Interface for iRODS**, Shunde Zhang (ARCS). Describes the design and implementation of a GridFTP interface for iRODS. Written as a plugin on Globus GridFTP for iRODS, it provides an OS-independent standalone solution that doesn't rely on Globus but is compatible with existing Globus clients.

## iRODS Integration

- **Enhancing iRODS Integration: Jargon and an Evolving iRODS Service Model**, Mike Conway (DICE Center, UNC). Describes the JARGON Java I/O library and plans for integration with web services, development of a dropbox interface (iDrop), and support for digital library interfaces such as Islandora.



# iRODS User Meeting Agenda

March 24 – 26, 2010 at Renaissance Computing Institute, UNC, Chapel Hill NC

## *Wednesday, March 24*

### **Session I (9:00- 10:30)**

- **Introduction to iRODS** (30 min) Moore
- **iRODS Version 2.3** (30 min) Schroeder
- **Introduction to Micro-services** (30 min) Moore

Break (30 min)

### **Session II (11:00-12:30)**

- **Intro to Policies** (30 min) Moore
- **Policy session**, how to build a set of policies for your collection (1 hour) Rajasekar

Lunch (12:30 – 1:30)

### **Session III (1:30- 3:00)**

- **Micro-service session**, how to write a micro-service (1 hour) Wan
- **Advanced iCommands** (30 min) Wan

Break (30 min)

### **Session IV (3:30-5:00)**

- **iCAT interactions** (1 hour) Schroeder / Rajasekar
- **Questions** (30 min)

## *Thursday, March 25*

### **Session V (9:00-10:30)**

- **User Application Sessions, How Communities Have Applied iRODS**
  - **High Availability iRODS System (HAIRS)** Yutaka Kawa (KEK, Japan), Adil Hasan (University of Liverpool) (teleconference)
  - **iRODS at CC-IN2P3** Jean-Yves Nief, Pascal Calvat, Yonny Cardenas, Pierre-Yves Jallud, Thomas Kachelhoffer (CC-IN2P3, Lyon, France)
  - **Using iRODS to Preserve and Publish a Dataverse Archive**, Mason Chua (Odum Institute, UNC), Antoine de Torcy (DICE, UNC), Jewel H. Ward (SILS, UNC), Jonathan Crabtree (Odum Institute, UNC)
  - **Distributed Data Sharing with PetaShare for Collaborative Research**, PetaShare Team @LSU (poster)
  - **University of North Carolina Information Technology Services**, William Schultz (UNC) (poster)

Break (30 Min)





## Thursday (cont.)

### Session VI (11:00-12:30)

- *The ARCS Data Fabric*, Shunde Zhang, Florian Goessmann, Pauline Mak (ARCS) (poster)
- *A Service-Oriented Interface to the iRODS Data Grid*, Nicola Venuti, Francesco Locunto (NICE), Michael Conway, Leesa Brieger (DICE RENC UNC)
- *iExplore for iRODS Distributed Data Management*, Bing Zhu (DICE UCSD)
- *A GridFTP Interface for iRODS*, Shunde Zhang (ARCS)

Lunch (12:30-1:30)

### Session VII (1:30-3:00)

#### • Clients for iRODS

- *The Development of Digital Archives Management Tools for iRODS*, Tsung-Tai Yeh, Hsin-Wen Wei, Shin-Hao Liu (Academia Sinica, Taiwan), Pei-Chi Huang (Tsing Hua University, Taiwan), Tsan-sheng Hsu (Academia Sinica, Taiwan), Yen-Chiu Chen (Tsing Hua University, Taiwan)
- *Building a Trusted Distributed Archival Preservation Service with iRODS*, Jewel H. Ward, Terrell G. Russell, and Alexandra Chassanoff (SILS, UNC) (poster)
- *Conceptualizing Policy-Driven Repository Interoperability (PoDRI) Using iRODS and Fedora*, David Pcolar (CDR, UNC), Daniel W. Davis (Cornell, DuraSpace), Bing Zhu (DICE UCSD), Alexandra Chassanoff (SILS, UNC), Chien-Yi Hou, Richard Marciano (SALT, UNC)
- *Community-Driven Development of Preservation Services*, Richard Marciano (SALT, UNC), Chien-Yi Hou (SALT, UNC), Jennifer Ricker (NC State Library), Glen McAninch (KY Dept. Lib. & Archives), David Pcolar (CDR, UNC) et al.

Break (30 min)

### Session VIII (3:30-5:00)

- *Enhancing iRODS Integration: Jargon and an Evolving iRODS Service Model* Mike Conway (DICE, UNC)
- Questions on user porting of clients

## Friday, March 26

### Session IX (9:00-10:30)

- **Prioritization of tasks** (1 1/2 hour) Moore

Break (30 min)

### Session X (11:00-12:30)

- **Question and Answers** (1 1/2 hours) Moore

Lunch (12:30 – 1:30)

### Session XI (1:30 – 3:00)

- **Integration Session**, how to integrate your favorite workflow/client with iRODS (60 min) Conway
- **Data Intensive Cyberinfrastructure Foundation session**, coordinating development across interested communities. (30 minutes) Tooby





### iRODS Requested Features

Key: B = Bug A = Completed Number = No. of user group requests  
(0 indicates requests by users not present, etc.)

B	Add a Doxygen indexed version of iRODS source on the wiki for micro-services and helper functions.
B	Add object type to audit trail
B	Allow GSI authentication to non-ICAT-Enabled-Server without irodsUserName being set.
	Automate Dicom metadata extraction from binary files. Find misextractdicom
B	Fix UDP on Solaris.
B	Implement FITS header parsing and metadata loading. Find msiextractfits
B	Issues with symbolic links on FUSE mounted directory - copy symbolic links when directory structure is ignored
B	Post link to VBrowser, links to Taverna and EGEE grid
B	Post on Wiki a list of the planned developments for Jargon.
B	Publish the complete iRODS network protocol.
18	Admin interface to list all current connections and the associated irods users. (keep with record of IP addresses)
16	Set access controls on rules and micro-services. Currently on users, collections, resources, metadata.
15	Editorial review of documentation
15	Document all APIs
15	icommand for checking ports (health check). Jargon admin will do this
15	icommands with tab completion
15	Installation - check for firewall interaction (notification of presence, like a ping on each port).
15	Links to Petashare, Urspace, Jux, 43 clients
15	Script for checking/updating IP address (5 locations).
15	Support transfer of multiple files using multiple I/O streams. Virtual ibun
12	Add regular expressions to i-commands (wild cards).
12	Use external identity management and external authentication
11	Management of rules within iCAT to enable versioning. Distribution of rules to core.irb file at each server.
11	Request for Shibboleth based authentication for new users (UNC) credential mapping / assign privilege according to Shibboleth role - TUCASI
10	A more general mechanism to access external databases. Admin will define location and specify SQL, client will be able to provide arguments. Independent of ICAT. Need a way for the information provided, or saved, to be integrated into the iRODS framework.
10	Add -P to irsync
10	Support for accented letters (metadata and filenames) - Taiwan
10	Support for dynamic IP address.
9	Export audit trails from iCAT and truncate
9	Have second notification list about upgrades that address vulnerabilities. Set up an iRODS admin mailing list.
9	irsync across physical resources to repair corruption - similar to irepl
9	Support for Java-based micro-services.



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(0 indicates requests by users not present, etc.)

8	Multi-thread connection.
8	Policy consensus development
8	SHA-256 checksum, CRC checksum
8	Support checksums in Jargon (before transfer), <code>iput -k</code>
7	Add ability for a project PI to create rodsuser accounts for project members. Create accounts under groupadmin
7	Control number of connections on servers (batch jobs) - connection pool
7	Provide transaction based interaction with external workflow
7	Restrict ability of ASSIGN to change user name, user role, user permissions.
7	Support read-only view on selected columns in database
7	Use defined SQL commands that can be invoked through a micro-service.
7	Virtual ibun that concatenates files for transmission
7	Automatic failover to a secondary iCAT
6	Document the scheduling of rules in parallel, and use of delayed rules
6	Restart rule engine
6	Reload option for irodsctl script to behave like Apache reload
6	Active directory integration with Kerberos, documentation - Chris Jordan
6	Add ways to handle the comment fields for data, resources, users, metadata (icommand and micro-service)
6	Collaborator analysis tool for iRODS community
6	Create script for automating module creation. Provide default template for creating new Micro-service. Documentation
6	iDisk for iRODS - iDrop. The iDisk area is on your computer, and reliably synchs to a remote storage system periodically.
6	Implement queuing/client-backoff within Jargon
6	Manage list of connecting IP addresses to track denial of service
6	Manage queue of requests. Want to control maximum number of executing requests.
6	Metadata analysis tools for federated data grids
6	National dropbox. This is similar to iDisk, and provides a way to back up or share your files through a drag and drop interface.
6	Project analysis tools for domains using iRODS
5	Add AVU metadata to resource groups.
5	Create a Windows only environment, using SqlServer
5	Integration of logging into Jargon
5	Want to disable triggering of rules from a client by selected users
4	Ensure end-to-end audit of data sharing policy for pulling data into a secure environment
4	Federation of independent databases: NC B-prepared / EPA / structured information resource drivers
4	Integration with local metadata (schema), for remote database access
4	Integration with VCL policies - policy engine controlled by metadata, which constructs environment



### iRODS Requested Features

Key: B = Bug A = Completed Number = No. of user group requests  
(0 indicates requests by users not present, etc.)

4	Need drivers for a wide variety of databases for resources
4	Provide mechanism to synchronize rule bases across servers within a data grid.
4	Provide versioning support for rules.
4	Support a session shell in iRODS for iRODS commands, isession. Authenticate once.
4	Support adaptable security policies (change level of access based on situation).
4	Support local policy enforcement on database access (de-identification)
4	Support Perl-based Micro-services by including Perl interpreter in the Micro-service.
3	Create a Windows only environment, using Postgres and GSI (both now run on Windows)
3	List system generated metadata in iEXP
2	Admin interface to rename a resource.
2	Configure port numbers for data transfer. Support alternate IP address.
2	Driver for other types of databases for use by iCAT (DB2, SQLServer)
2	Native encryption of files, probably through remote execution. Transforms on data.
1	Add core.irb rule to check policy on iget. May want to return alternate version (redacted copy) of file.
1	Are there CIM common information models for accessing databases?
1	Automate creation of an account for new users. Example is GSI based access. Extend to LDAP/Kerberos
1	Create a VM build for use of iRODS in tutorials.
1	Decompress on the fly.
1	iRODS server for memory cache, RAM disk
1	Mechanism to test whether a community's client is compatible with iRODS protocol and version numbers
1	Modify icommands to use the zoneID:internal ID instead of the file name or add GUID
1	Provide a library of script-based micro-services
1	Support compressed files on disk for minimizing space. Could be done through a preProcForPut core.irb hook.
1	Support ticket-based access to iRODS.
1	When fail over to an alternate server, verify that the Rule engine will not have a conflict for a queued Micro-service. Related to versioning of rules and micro-services.
0	Create a VDT (Virtual Data Toolkit) version of iRODS.
0	Create digital signing registration to be able to track origin of files. Given signature, find original copy. Related to definition of an AIP
0	Create RDA interface to Sybase.
0	Develop Fortran API.
0	Develop Perl API.
0	Extensions to Jargon for UDP transport.
0	Improve webDAV caching of a working copy of a file correctly
0	Improve webDAV caching of a working copy of a file correctly (external)
0	Manage locks for collaborative editing (either on storage system, in metadata, or portal) - expensive



### iRODS Requested Features

Key: B = Bug A = Completed Number = No. of user group requests  
(0 indicates requests by users not present, etc.)

0	Port iCAT to Sybase.
0	Port SRB APIs on top of iRODS, will avoid having to rewrite many application scripts.
0	Port SRB scommands onto iRODS (remap options)
0	Support logical registration into iRODS. Ability to associate metadata with a name without requiring a file. Add an info file.
0	Support token-based identification such as SecureID. One-time passwords - offload to external authentication management
0	Which types of databases need to be supported?

### Completed Tasks

A	Add links to WebDav environment on iRODS wiki, provides drag and drop access to files across windows.
A	Command to force execution on another server. msiremoteexec
A	Consider use of Google Code repository and other shareware sites. Automate. GitHub (Russell)
A	Create a collaboration environment for promoting development of iRODS. (done through DICF)
A	Create a Condor interface / port for iRODS (Stork)
A	For SRB to iRODS metadata migration, handle migration of SRB zones. How can multiple SRB zones be re-federated within iRODS easily? Limited scripts.
A	Hook for preProcForPut for medical applications.
A	icp between data grids (bug fixed)
A	Jargon parallel I/O
A	Mount a flash drive. Treat as a mounted collection.
A	Option to restrict irods admin access to specific hostnames/IP addresses.
A	Provide mechanism to add rule base extensions to a remote rule base.
A	Recursive upload of directories - icommands
A	Save RDA request results for use in a session, want to pass result list to another Micro-service. Put in a file.
A	Support mounting of a Webdav directory into iRODS. (done through DAVIS)
A	Support Python-based Micro-services by including Python interpreter in the Micro-service. Documentation
A	Support sequential transfers as one-hop, similar to parallel. Done for iput.
A	Support Soft Links in iRODS (supported in 2.3)
A	When compile, verify that only changed files are recompiled.



<b>iRODS Clients</b> Extending Interoperability			
	<b>Client</b>	<b>Developer</b>	<b>Language</b>
1.	Akubra/iRODS	DICE	Jargon
2.	Archive tools-NOAO	Eric – NOAO	
3.	Big Board visualization / FUSE	RENCI	
4.	C API	Mike Wan DICE	C
5.	C I/O library	Wayne Schroeder DICE	C
6.	Davis - WebDAV	ARCS Australia	Jargon
7.	DCAPE	UNC	
8.	Dropbox / iDisk / iDrop	Mike Conway	Jargon
9.	EnginFrame - Jargon	NICE / RENCi	Jargon
10.	Fedora on Fuse	IN2P3 France	FUSE
11.	Fedora/iRODS module	ITS - UNC-CH, DICE	Jargon
12.	File-format-identifier	GA Tech	
13.	FUSE	IN2P3, DICE	FUSE
14.	FUSE optimization	PetaShare LSU	FUSE
15.	GridFTP - Griffin	ARCS Australia	
16.	iExplore	Bing Zhu DICE	C++
17.	Islandora	DICE	Jargon
18.	Jargon	DICE	Jargon
19.	Jsaga	IN2P3 France	Jargon
20.	JUX	IN2P3 France	Jargon
21.	Kepler	DICE	Jargon
22.	OpenDAP	ARCS, Australia	
23.	Parrot	Doug Thain	
24.	Pcommands	PetaShare LSU	
25.	Peta Web browser	PetaShare LSU	
26.	PetaFS (Fuse)	PetaShare team LSU	
27.	Petashell (Parrot)	PetaShare LSU	
28.	PHP - DICE	Bing Zhu, DICE	
29.	Pyrods - Python	Jerome Fusillier	Python
30.	Resource Monitoring	IN2P3	
31.	Saga	KEK	
32.	Shibboleth	King's College, London UK	
33.	Sync-package	Academica Sinica, Taiwan	
34.	Taverna	RENCI	
35.	URSpace	Teldap - Academia Sinica	
36.	VOSpace	IVOA	



<b>Client Requests</b>		
Admin interface		Jargon
Chronopolis status interface	NCAR	
Earth System Grid publisher	NCAR	
icommands with tab completion		C
iRULE designer	Jerome Fusillier	
Perl load library		
Ruby		
WSDL web service		Jargon
<b>iRODS Micro-services</b>		
Cheshire3	SHAMAN EU	Python
GridFTP	Dresden	
Kepler		
MakeFlow		C