Provisioning Flexible and High Available iRODS-based Data Services at Euro-Mediterranean Center on Climate Change

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Motivations & Objectives

iRODS-based Data Portal Application

Data Service Components for netCDF files: iRODS, Solr, Thredds

CLIMA Architecture for provisioning Data Services

Future works
Motivations

- CMCC scientific datasets: **multidisciplinary** data related to climate change scenarios and impacts: climate, ocean, agriculture, hydrology, atmosphere, socio-economic, forest, ecosystems, climate indicators, risk assessment
- Some scientific datasets can be **critical**, used by different divisions and **accessed in different (spatial/temporal) ways**
- CMCC operational data services can have **different needs and requirements**:
  - *data formats* (such as netCDF, csv, grib,…)
  - *schemas*
  - *data policies*
  - *storage characteristics*
  - *software components* (Thredds Data Servers (OpenDAP, WMS, NCSS), OGC-WPS, FTP, Science Gateway, Custom Operational Chains, …)
Examples of Operational Data Services @ CMCC

Copernicus Marine Environment and Monitoring Services

Copernicus Climate Services C3S

Mediterranean Sea Med-MFC

Black Sea BS-MFC

CMIP5
Objectives

- Providing users with a unique global namespace for their scientific datasets to ease the management of scientific datasets (retrieve & archiving)
- Optimal storage usage from admin perspectives
- Ease the implementation of operational chains (netCDF post-processing - adding global attributes, schema compliant verification (CF), file naming rules, validation, product quality)
- Improve collaboration productivity between internal and external users by sharing CMCC scientific datasets
- Development of a data portal for CMCC products (datasets publishing, search & discovery, data subsetting, ...)
- Flexible setup of operational data services
iRODS-based Data Portal for netCDF Files

DATA PORTAL

Search & Discovery Rest API Engine (Dataset&Files Abstraction)

iRODS Rest API

Thredds Data Server

iRODS Fuse

IPCC CMIP5 CMCC ESGF Node
~ 170K files, 100TB data

• Data Ingestion with ireg
• netCDF microservices for AVUs generation (global attributes and variables)
Issues

- iRODS Query Engine performance
- iRODS Query Engine expressivity limitations (i.e., spatial and time queries, faceting, ...)
- Performance and cache issues of iRODS fuse with Thredds
- One iRODS Zone is not a feasible solution for CMCC needs:
  - a unique metadata DB for any CMCC file/operational service difficult to define and maintain
  - possible side effects for the ingestion rules of different operational services datasets
  - admin operations needed for updating rules
How to solve issues?

- Tight integration of iRODS with Thredds
- Solr search platform for indexing netCDF header
- Multiple iRODS Zones: one for each “data service”
How to integrate iRODS with Thredds?

• Parrot Virtual Filesystem ([http://ccl.cse.nd.edu/software/parrot](http://ccl.cse.nd.edu/software/parrot))
• NFSRods ([https://github.com/modcs/NFSRODS](https://github.com/modcs/NFSRODS))
• Thredds servers configured for iRODS POSIX-compliant resource
  – Issue for compound resources: the file is in the archive and not in the cache
• Leveraging Jargon library ([https://github.com/DICE-UNC/jargon](https://github.com/DICE-UNC/jargon)) for
  – provide Thredds `ucar.unidata.io.RandomAccessFile` ([https://www.unidata.ucar.edu/support/help/MailArchives/netcdf/msg09388.html](https://www.unidata.ucar.edu/support/help/MailArchives/netcdf/msg09388.html))
Thredds Dataset Source Plugin for iRODS

```java
public class IrodsDataSource implements thredds.servlet.DatasetSource {
    public boolean isMine( HttpServletRequest req) {
        ...
    }
    public NetcdfFile getNetcdfFile (HttpServletRequest req, HttpServletResponse res) throws IOException {
        ...
    }
}
```

Dataset Source class into `${tomcat_home}/webapps/thredds/WEB-INF/lib` or `classes` directory

Add a line to `${tomcat_home}/content/thredds/threddsConfig.xml` file

```xml
<datasetSource>clima.thredds.IrodsDataSource</datasetSource>
```
Automated Solr Indexing of netCDF files

- Rules for `acPostProcForPut/acPostProcForDelete/acPostProcForObjRename`
- `msiExecCmd` microservice to execute a ruby script for indexing netCDF header (query the Thredds NCML (netCDF Markup Language) Service and transform the xml doc for Solr)

- Solr document id = iRODS data_object id
- A single value field for iRODS data object
- A single value field for each global attribute
- A multi-value field for variable/dataset names
- Spatial and time coverage fields
CLIMA Architecture (Vision)

APPS LAYER

DATA SERVICE INFORMATION ACCESS LAYER

CLOUD-BASED BACKEND FOR LIFECYCLE MANAGEMENT OF CONTAINERIZED DATA SERVICES
CLIMA Backend

DATA SERVICE COMPONENTS
- Data Service Rest API
- Science Gateway

CONTAINER MANAGEMENT PLATFORM
- Rancher

COMPUTER & NETWORKING SERVICE
- Open Nebula
- VLAN

STORAGE SERVICE
- S3 Rados Gateway
- Ceph

VIRTUALIZATION
- KVM

NETWORKING
- VD

STORAGE
- Rados

AUTHENTICATION
- freelpa

RESOURCES
VIRTUALIZATION

LIGHT & SIMPLE
Lightweight and easy to install, maintain, operate, upgrade and use

FLEXIBLE
Fully open-source and customizable to fit into any data center and policies

ROBUST
Production-ready, highly-scalable, reliable and supported

POWERFUL
Innovative functionality for private/hybrid clouds and DC virtualization

ORCHESTRATION

Cloud Management
- VDC multi-tenancy
- Simple cloud GUI and interfaces
- Service elasticity/provisioning
- Federation/hybrid

Virtual Infra Management
- Capacity management
- Multi-VM management
- Resource optimization
- HA and business continuity

OpenNebula

vCenter

KVM
Xen
VMware
A complete container management platform that makes it easy to...

Production ready
- 20 million+ downloads
- Open platform for innovating
- Easy to use interface
- Multi-tenant
- Role based access
- 24X7 support
- And more....

RUN CONTAINERS
with the most complete set of container and infrastructure management capabilities

MANAGE APPLICATIONS
by simplifying day to day application lifecycle management

INNOVATE WITH CONTAINERS
without compromising flexibility by empowering developers with fast access to the latest tools

Credits: Shannon Williams, Rancher Co-Founder/VP Sales, @smw355
Complete Container Management Platform

Application Catalog

User Mgmt
RBAC
AD/LDAP
SAML

Container Orchestration and Scheduling

Ops Mgmt
CI/CD
Registries
Monitoring

Infrastructure Services

Storage
Networking
Security
DNS/LB

Multi-tenant Environments

Environment 1

Environment 2

.......... ..

Environment N

Credits: Shannon Williams, Rancher Co-Founder/VP Sales, @smw355
OpenNebula and Rancher Integration

- OpenNebula docker-machine plugin

- PR #315 to the Rancher community catalog
  ([https://github.com/rancher/community-catalog/pull/315](https://github.com/rancher/community-catalog/pull/315))
CLIMA Catalog in Rancher

Catalog: CLIMA

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**iRODS**

- **iRODS ICAT**
  (Experimental) iRODS ICAT Server
  - View Details

- **iRODS Resource server**
  (Experimental) iRODS Resource Server
  - View Details

- **iRODS Rest API Server**
  (Experimental) iRODS Rest API Server
  - View Details

**MariaDB Galera Cluster**

- (Experimental) Synchronous multi-master cluster for MariaDB
  - View Details

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**PostgreSQL**

- PostgreSQL — an object-relational database (ORDBMS)
  - View Details

**Solr**

- Solr
  - View Details

**Thredds**

- Thredds
  - View Details

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### iRODS iCAT Stack Configuration Options

<table>
<thead>
<tr>
<th>iRODS Zone Name*</th>
<th>iRODS Port*</th>
</tr>
</thead>
<tbody>
<tr>
<td>tempZone</td>
<td>1247</td>
</tr>
</tbody>
</table>

**Name of the iRODS Zone**

<table>
<thead>
<tr>
<th>iRODS Control-Plane Port*</th>
<th>iRODS Zone Key*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1248</td>
<td>TEMPORARY_zone_key</td>
</tr>
</tbody>
</table>

**Port of the iRODS ICAT Server**

<table>
<thead>
<tr>
<th>iRODS Negotiation Key*</th>
<th>iRODS Control Plane Key*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMPORARY_32byte_negotiation_key</td>
<td>TEMPORARY_32byte_ctrl_plane_key</td>
</tr>
</tbody>
</table>

**iRODS Negotiation Key**

<table>
<thead>
<tr>
<th>iRODS Administrator Username*</th>
<th>iRODS Administrator Password*</th>
</tr>
</thead>
<tbody>
<tr>
<td>rods</td>
<td>****</td>
</tr>
</tbody>
</table>

**iRODS Administrator Username**

<table>
<thead>
<tr>
<th>iRODS Default Resource Name*</th>
<th>Postgres Database Service*</th>
</tr>
</thead>
<tbody>
<tr>
<td>repository</td>
<td>postgres</td>
</tr>
</tbody>
</table>

**iRODS Default Resource Name**

Start services after creating
CLIMA Data Service deployment with Rancher

- Rancher Environment -> CLIMA Data Service -> iRODS Zone
- External DNS for DNS Update (RFC2136) -> FQDN of iRODS iCAT and Resource Servers
- Rancher NFS as a storage service for container volumes
- Rancher Load Balancer and Health Checking for iRODS iCAT High Availability
- Rancher metadata service to share iRODS setup information such as Zone name, Zone key, iCAT db, …
- Rancher sidekick services to setup volumes and read metadata information
Ongoing & Future Works

- Federation of Data Services with Hybrid cloud setup (OpenNebula + AWS)
- Indexing netCDF Files (... Looking forward for QueryArrow Database plugin and GQv2)
- iRODS & Thredds Integration
- iRODS & netCDF integration (iRODS-based netCDF library?)
- CLIMA Data Service Integration with Ophidia (CMCC Big Data Analytics Platform - http://ophidia.cmcc.it)
- Automated Scaling of CLIMA Data services with Rancher webhooks and Prometheus
Thanks! Questions?