DREAM: Distributed Resources for the Earth System Grid Federation (ESGF) Advanced Management

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(IN52A) Exploiting Big Earth Data: Computation, Testing, and CyberGIS III

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Overview

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Distributed Resources for the Earth System Grid Federation (ESGF) Advanced Management (DREAM) provides a new way to access large data sets across multiple DOE, NASA, and NOAA compute facilities.

DREAM is focused on providing services for dynamic management of resources held at diverse and scattered U.S. sites. Some of the present issues that we seek to address include how to:

- **Publish** dynamic resources into a virtual organization;
- **Discover** distributed resources and services through an intuitive, yet powerful query syntax;
- **Link** together various phases of a scientific execution;
- **Monitor and expose** the dynamic storage and computational resources, throughout the federation;
- **Execute** parallel distributed analytics across DOE, NASA, and NOAA data centers; and
- **Explore, analyze, and visualize** large-scale data remotely using commodity hardware.
Our approach generalizes the current operational infrastructure used by the ESGF into a template architecture that hides each implementation layer behind a well-defined Application Programming Interface (API), so that different communities may decide to adopt or swap any single part. The deployable software stack will include the following modules:

- **Publishing services** (reference implementation based on ESGF publishing software);
- **Search services** (reference implementation based on Solr-Cloud and ESGF Search API);
- **Transfer services** (reference implementation based on Globus/GridFTP);
- **Computation services** (reference implementation based on Ultrascale Visualization Climate Data Analysis Tools (UV-CDAT) and ESGF Computing API);
- **Resource monitoring and allocation** (to be developed from scratch);
- **Security services** (reference implementation based on open standards and ESGF security infrastructure);
- **User interface** (reference implementation based on CoG web knowledge environment);
- and
- **Exploration services** (remote analysis and visualization based on streaming, multi-resolution data)
The two basic principles behind the DREAM design are “modularity” and “abstraction”. Modularity means that DREAM will be structured not as a single monolithic system, but rather as a composition of interacting software services, which are packaged and can be installed individually and independently.

The functionality of each service will be abstracted in a well-defined API, so that each service can be easily invoked by other services and clients without worrying about the underlying implementation details. All service APIs will be defined to conform to the Representational State Transfer (REST) web service paradigm, which will allow simple invocation by standard web-enabled clients.

In general, software systems that are both modular and abstract have an intrinsic longer longevity, because each service can be evolved or replaced individually, without affecting the backward compatibility with other parts of the systems, or its clients.
Architecture

DREAM Software Modules – REST APIs

- Publishing Services
- Search Services
- Transfer Services
- Computing Services
- Analytics Services
- Visualization Services
- Exploration Services
- Monitoring Services
- Resource Services
- Network Services
- Workflow Services
- Security Services

Virtual Organization

- Node 1
  - Metadata Catalogues
  - Data Storage

- Node 2
  - Metadata Catalogues
  - Data Storage

- Node 3
  - Metadata Catalogues
  - Data Storage

- Node N
  - Metadata Catalogues
  - Data Storage

Site 1

Site 2

Site 3

Site N
Requirements

- **Distributed**: DREAM will support a system composed of geographically distributed nodes, each with its own set of data resources, metadata catalogs, and software services. The DREAM protocols and services will unite all nodes in a single federation, so that a client will be able to discover, search, download and execute resources independent of their physical location, as if they were held and run on a single server.

- **Dynamic**: the DREAM architecture will be designed to support a highly dynamic system, which will expose with minimum delay all data and services that are available at that time throughout the federation. For example, data collections produced by a model run, data streams originating from the real-time processing of a field instrument, or new derived products produced by a scientist running their processing code, could all be published into the system and immediately returned as results of federation-wide searches. Additionally, the system will continually provide an up-to-date report on the state of its components and will be able to automatically direct client requests where resources are available.

- **Scalable**: the DREAM architecture will be able to scale to the “Big Data” volumes that are expected in several scientific fields (climate, astronomy, genomics, etc.) in the next 5-10 years. Scalability will be achieved through a two-fold approach. First, each service will be implemented through a high-performance technology that is inherently able to handle large volumes of data, in a distributed environment. Second, the DREAM modular architecture will allow each service to be instantiate multiple times.
Requirements

- **Resiliency and Fault Tolerance**: The DREAM architecture will be designed to include redundant components for all critical services (such as search, authentication, authorization, data download and visualization), and to execute automatic failover in case any component becomes unavailable. When backup services are not available, we will ensure that DREAM produces meaningful error responses to human and machine clients.

- **Secure**: DREAM will support a distributed and federated security model, whereby each node will maintain complete control over the policies for accessing its local data and computational resources, while federation-wide authentication and authorization services will be responsible for enforcing these policies homogenously through the system. Single-sign-on and federated access control will allow users to register and authenticate only once, and then propagate their identity.
Requirements

DREAM Infrastructure

An integrated cyber-infrastructure leveraging core Office of Science and external resources to enable discovery, analytics, simulation, and knowledge innovation.
We recognize that data management, stewardship and curation is an ongoing and long-lived function that requires a strategy that is resilient to continuing evolution in hardware and software.
Motivating Use Case

Science Input

- Configuration UI + Rule engine to guide valid configs

DOE Accelerated Climate Modeling for Energy (ACME) Testbed

Run Model

- Retrieve required datasets
- Store manually provided files
- ESM run status

Output Data

- Store history files
- Store diagnostic data
- Analysis

Data Management

Rapid, reliable, secure data transport and synchronization: Globus Online

ACME Database
Enables search/discovery, automated reproducibility, workflow status, monitoring dashboard, data archive and sharing

System Monitoring UI
- Simulation Manager & Provenance
- AKUNA + Provenance
- Data Archive
- ESGF

Diagnostics & Analysis

UV-CDAT & Dakota
- Uncertainty Quantification
- Exploratory Analysis
- Explanatory Analysis
- Diagnostics Generation

Analysis (UV-CDAT)
- Diagnostics Output

Legend
- Monitoring & Provenance
- Dataset Dataflow ESGF
- User Driven Interaction
- Automated Workflow Process Control
- Process level Dataflow

Single sign on and group management: Globus Nexus

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