HDFCloud

HDF5 in the Cloud
(and NetCDF4…)

The HDF Group

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My Background

The HDF Group

Sr. Architect at The HDF Group

Started in 2014

Have been exploring remote interfaces to HDF

Previously: Dev Manager at Amazon/AWS

amazon web services

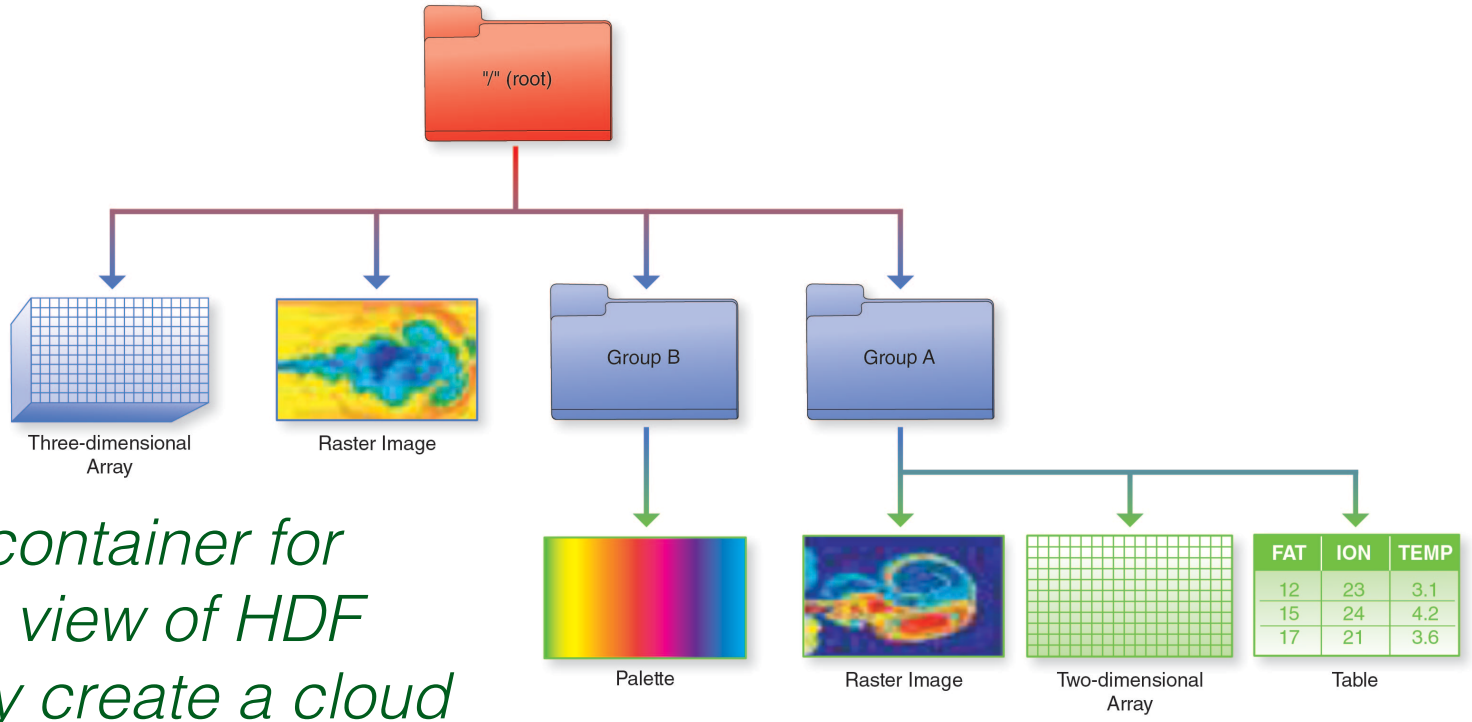
More previously: Used HDF5 while a developer at Intel

intel inside

What is HDF5?

Depends on your point of view:

- a C-API
- a File Format
- a data model



The File format is just a container for The data. Dropping this view of HDF allows us to more flexibly create a cloud version of HDF.

Why HDF in the Cloud

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- It can provide a cost-effective infrastructure
  - Pay for what you use vs pay for what you may need
  - Lower overhead: no hardware setup/network configuration, etc.
- Potentially can benefit from cloud-based technologies:
  - Elastic compute – scale compute resources dynamically
  - Object based storage – low cost/built in redundancy
- Community platform
  - Enables interested users to bring their applications to the data
  - Share data among many users

Cost Factors

- **Most public clouds bill per usage**
- **For HDF in the cloud, there are three big cost drivers:**
  - **Storage – What storage system will be used? (see next slide)**
  - **Compute – Elastic compute on demand better than fixed cost**
    - Scale compute to usage not size of data
  - **Egress charges**
    - Ingress is free but getting data out will cost you ($0.09/GB)
    - Enabling users to get just the data they need will tend to lower egress charges

Introducing Highly Scalable Data Service (HSDS)

- RESTful interface to HDF5 using object storage
- Storage using AWS S3 (portable to most other object storage systems)
  - Built in redundancy
  - Cost effective
  - Scalable throughput
- Runs as a cluster of Docker containers
  - Elastically scale compute with usage
- Feature compatible with HDF5 library
- Implemented in Python using asyncio
  - Task oriented parallelism

HSDS Features

- Clients can interact with service using REST API
- SDKs provide language specific interface (e.g. h5pyd for Python)
- Can read/write just the data they need (as opposed to transferring entire files)
- No limit to the amount of data that can be stored by the service
- Multiple clients can read/write to same data source
- Scalable performance:
  - Can cache recently accessed data in RAM
  - Can parallelize requests across multiple nodes
  - More nodes -> better performance

Object Storage Challenges for HDF

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- Not POSIX!
- High latency (>0.1s) per request
- Not write/read consistent
- High throughput needs some tricks
  - (use many async requests)
- Request charges can add up (public cloud)

For HDF5, using the HDF5 library directly on an object storage system is a non-starter. Will need an alternative solution…

HSDS S3 Schema

Big Idea: Map individual HDF5 objects (datasets, groups, chunks) as Object Storage Objects

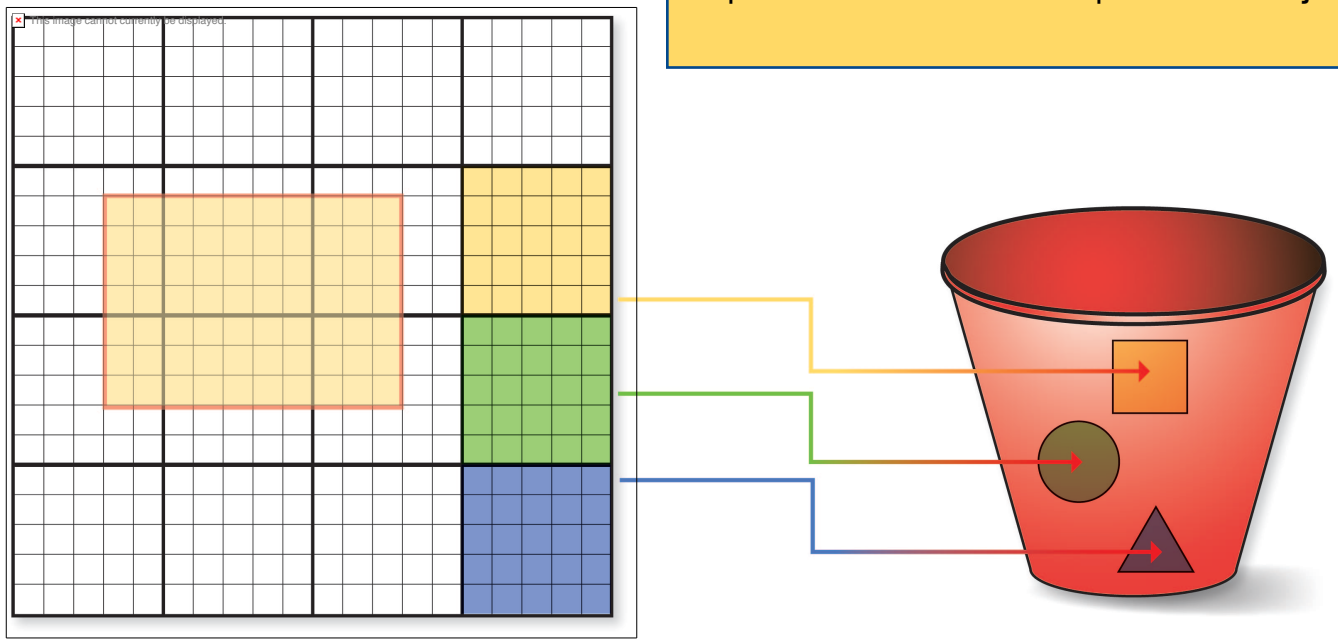
How to store HDF5 content in S3?

- Limit maximum storage object size
- Support parallelism for read/write
- Only data that is modified needs to be updated
- (Potentially) Multiple clients can be reading/updating the same “file”

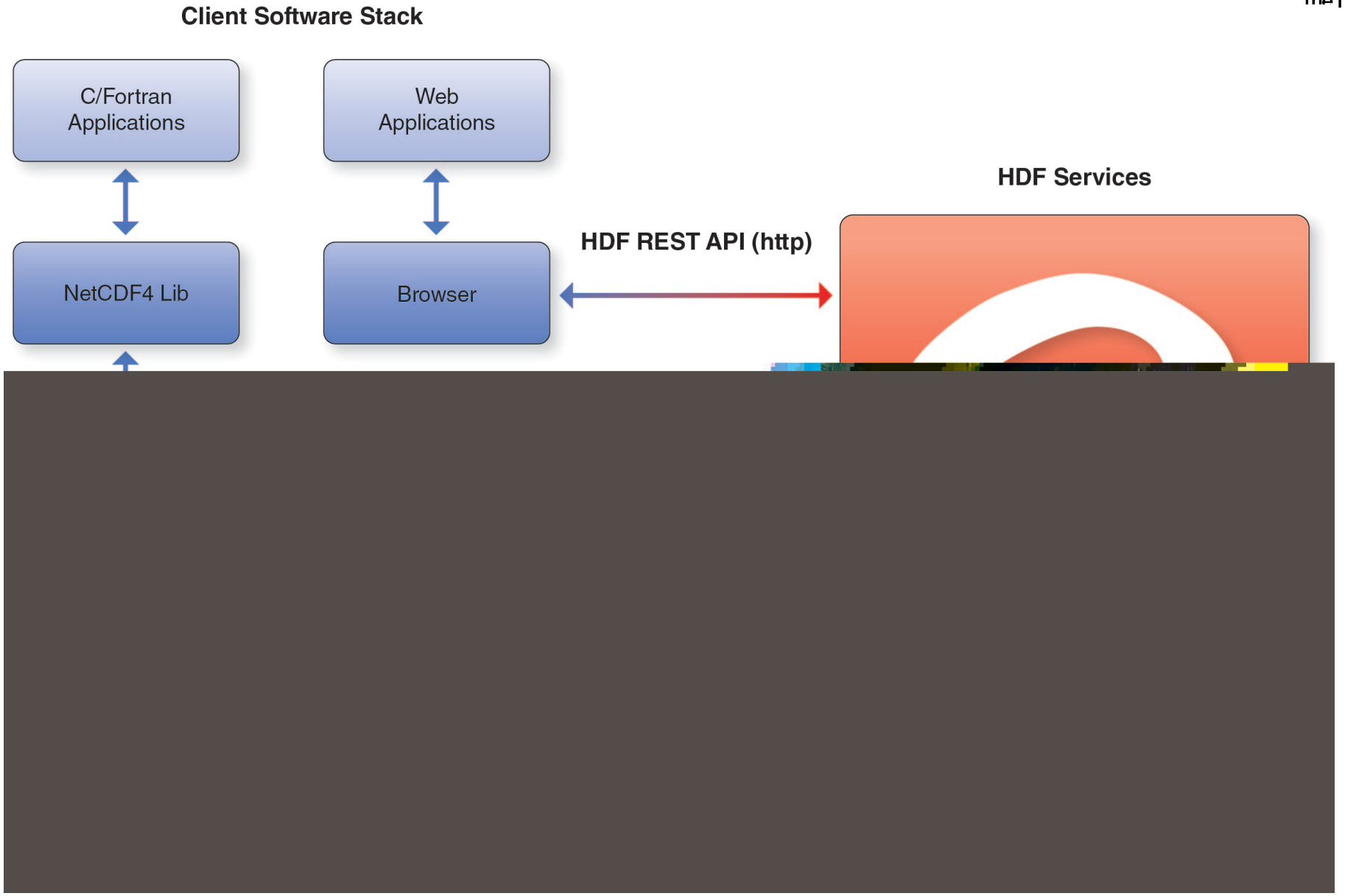
Each chunk (heavy outlines) get persisted as a separate object

Legend:

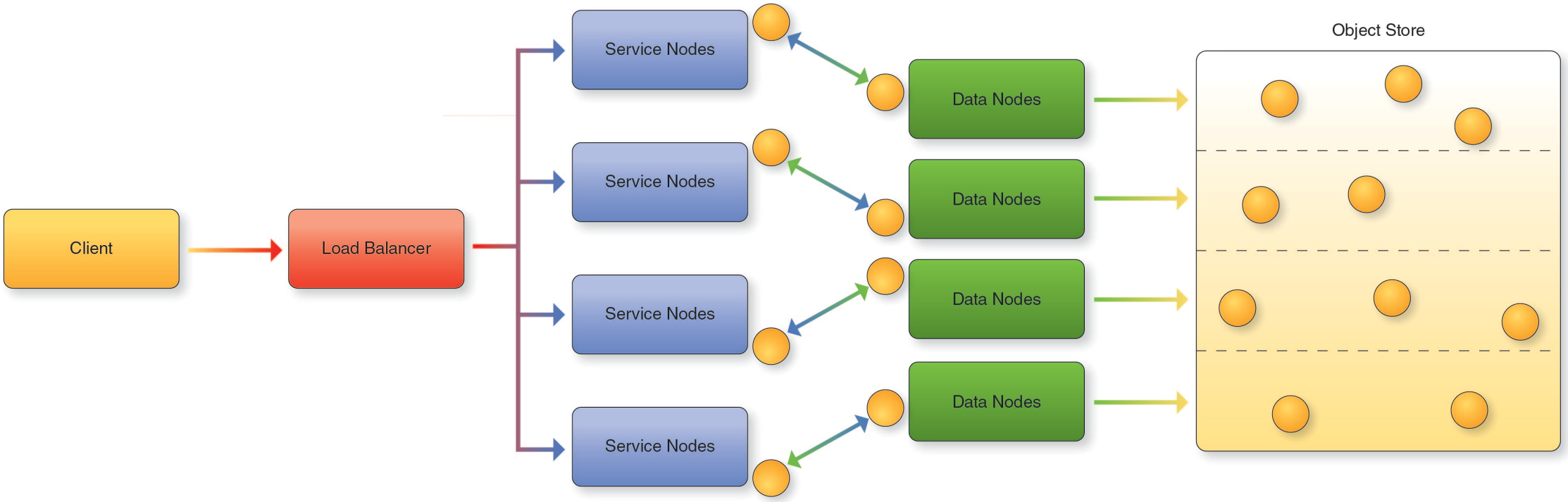
- *Dataset is partitioned into chunks*
- *Each chunk stored as an S3 object*
- *Dataset meta data (type, shape, attributes, etc.) stored in a separate object (as JSON text)*



Client/Server Architecture



Architecture for HSDS



Legend:

- Client: Any user of the service
- Load balancer – distributes requests to Service nodes
- Service Nodes – processes requests from clients (with help from Data Nodes)
- Data Nodes – responsible for partition of Object Store
- Object Store: Base storage service (e.g. AWS S3)

H5pyd – Python client for HDF Server

- H5py is a popular Python package that provide a Pythonic interface to the HDF5 library
- H5pyd (for h5py distributed) provides a h5py compatible h5py for accessing the server
- Pure Python – uses requests package to make http calls to server
- Compatible with h5serv (the reference implementation of the HDF REST API)
- Include several extensions to h5py:
  - List content in folders
  - Get/Set ACLs (access control list)
  - Pytables-like query interface

HDF REST VOL

- The HDF5 VOL architecture is a plugin layer for HDF5
- Public API stays the same, but different backends can be implemented
- REST VOL substitutes REST API requests for file i/o actions
- C/Fortran applications should be able to run as is
- Still in development – Beta expected this year

HSDS CLI (Command Line Interface)

- Accessing HDF via a service means one can't utilize usual shell commands: ls, rm, chmod, etc.
- Command line tools are a set of simple apps to use instead:
  - hsinfo: display server version, connect info
  - hsls: list content of folder or file
  - hstouch: create folder or file
  - hsdel: delete a file
  - hsload: upload an HDF5 file
  - hsget: download content from server to an HDF5 file
  - hsacl: create/list/update ACLs (Access Control Lists)
- Implemented in Python & uses h5pyd

Future Work

- Work planned for the next year
  - Compression
  - Variable length datatypes
  - NetCDF support
  - Auto Scaling
  - Scalability and performance testing
- Special thanks to NASA who is supporting this work under ACCESS grant 15-0031

To Find out More:

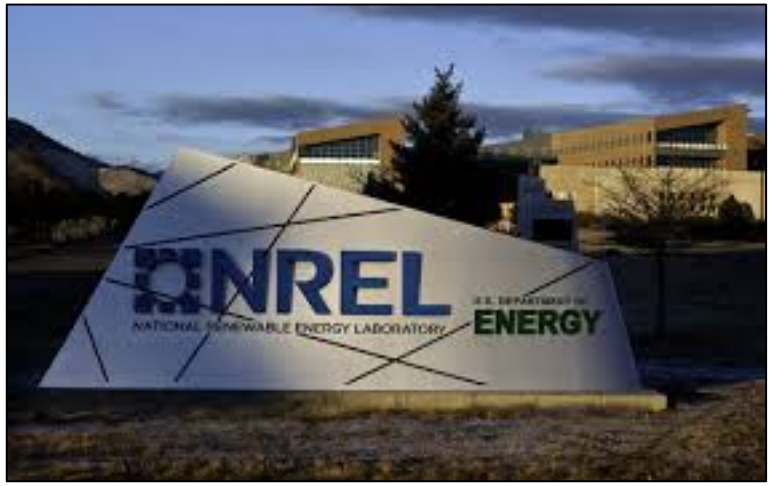
- H5serv: https://github.com/HDFGroup/h5serv
- Documentation: http://h5serv.readthedocs.io/
- H5pyd: https://github.com/HDFGroup/h5pyd
- RESTful HDF5 White Paper: https://www.hdfgroup.org/pubs/papers/RESTful_HDF5.pdf
- Blog articles:
  - https://hdfgroup.org/wp/2015/04/hdf5-for-the-web-hdf-server/
  - https://hdfgroup.org/wp/2015/12/serve-protect-web-security-hdf5/
  - https://www.hdfgroup.org/2017/04/the-gfed-analysis-tool-an-hdf-server-implementation/

HDF5 Community Support

- Documentation - https://support.hdfgroup.org/documentation/
  - Tutorials, FAQs, examples
- HDF-Forum – mailing list and archive
  - Great for specific questions
- Helpdesk Email – help@hdfgroup.org
  - Issues with software and documentation

https://support.hdfgroup.org/services/community_support.html

Demo Time!



NREL (National Renewable Energy Laboratory) is using HSDS to make 7TB of wind simulation data accessible to the public.

Datasets are three-dimensional covering the continental US:

- Time (one slice/hour)
- Lon (~2k resolution)
- Lat (~2k resolution)

Initial data covers one year (8760 slices), but will be soon be extended to 5 years (35 TBs).

Rather than downloading TB's of files, interested users can now use the HSDS client libraries to explore the datasets.

Questions? Comments?

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