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DATA AND INFORMATION SYSTEM

Intro & Recent Advances

Remote Data Access via OpenDAP Web Services

ESDIS Presentation & Demonstration for the
CEOS Working Group on Information Systems & Services (WGISS)
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subcontractor to Raytheon for NASA/ESDIS

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OpenDAP

Part I

Introduction to OpenDAP* Web Services

*OpenDAP is an organization and an acronym:

"Open-source Project for a Network Data Access Protocol"

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OpenDAP Concepts

originally from Distributed Ocean Data System (DODS) circa 1994

- **URL ≈ dataset*** | **URL with constraint ≈ subset**
- **Retrieve**
  - *dataset descriptions (metadata)*
  - *dataset content (typed/structured)*
- **Retrieval protocol built in to multiple libraries**
  - → **flexible data typing**
    - *arrays (~coverages)*
    - *tables (~features)*
  - → **many, diverse clients**

*dataset ≈ granule

URL ≈ Granule*

per OpenDap's Data Access protocol (DAP)

http://laboratory.edu/device/experiment/granule.dmr

Domain name often is an organization's web server.	Servers often have hierarchical collections.	Each URL references a distinct DAP "dataset."	Suffixes specify return types.
Depending on suffix, DAP returns metadata or content, with options for human- or machine-readable forms (XML, NetCDF4...). Suffix "dmr" ➛ metadata only.			

*dataset ≈ granule

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OpenDAP

Datatype Philosophy

- Internal data model has few data types
  - For simplicity…
- Types are domain-neutral but flexible
  - Structures & attributes ➔ rich syntax & semantics
- These types support many domain-specific needs
  - A recent crawl* (23,000 domains in .gov, .edu, .org) found >1400 collections with DAP servers

*Performed by the National Snow & Ice Data Center in an NSF/EarthCube project

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OpenDAP services

Function as Middleware

- Data ingest via encoding-specific adapters
  - Handlers for a growing set of source-data types
- Multiple response encodings
  - Native DAP—useful in Python, Java, C++ ,Fortran…
  - netCDF (also GeoTIFF where possible)
  - XML (⇒ HTTP via style sheets)
  - Recently added: WMS, W10n (JSON), WCS (beta)

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Architectural Overview of Hyrax

a widely-used DAP server

OpenDAP

Data-User App (netCDF-based)

netCDF Libraries

Data-User App (python, java, c++)

Native-DAP Libraries

Data-User App (other standard)

OGC-Compliant

Data User, Browser-Only

XML or JSON

DAP(2|4), netCDF, XML, GeoTIFF, WMS, JSON…

Other Web Services

Core DAP Services (Hyrax Front-End)

DAP-Extending Services

Other Web Services

Apache Server Framework

Hyrax Back-End Server with Encoding-Specific Handlers

HDF files

netCDF files

text files

SQL database

extensible…

URL + Query ➔ Subset
& (future) results from other server functions

http:/.../granule.nc4?dap4.ce=constraints&dap4.func=functions

Dataset identifier as above, except return-type is NetCDF4 (= HDF)	DAP "constraint expressions" yield sub-arrays & other proper subsets	DAP4 "function expressions" enable extensions
Constraints specify subsets by variable names, by array indices & (for tables) by content. Likely extensions include statistics, UGRID subsetting, feature extraction...		

The query form **&dap4.func=...** enables DAP extensions ⇒ new server functions

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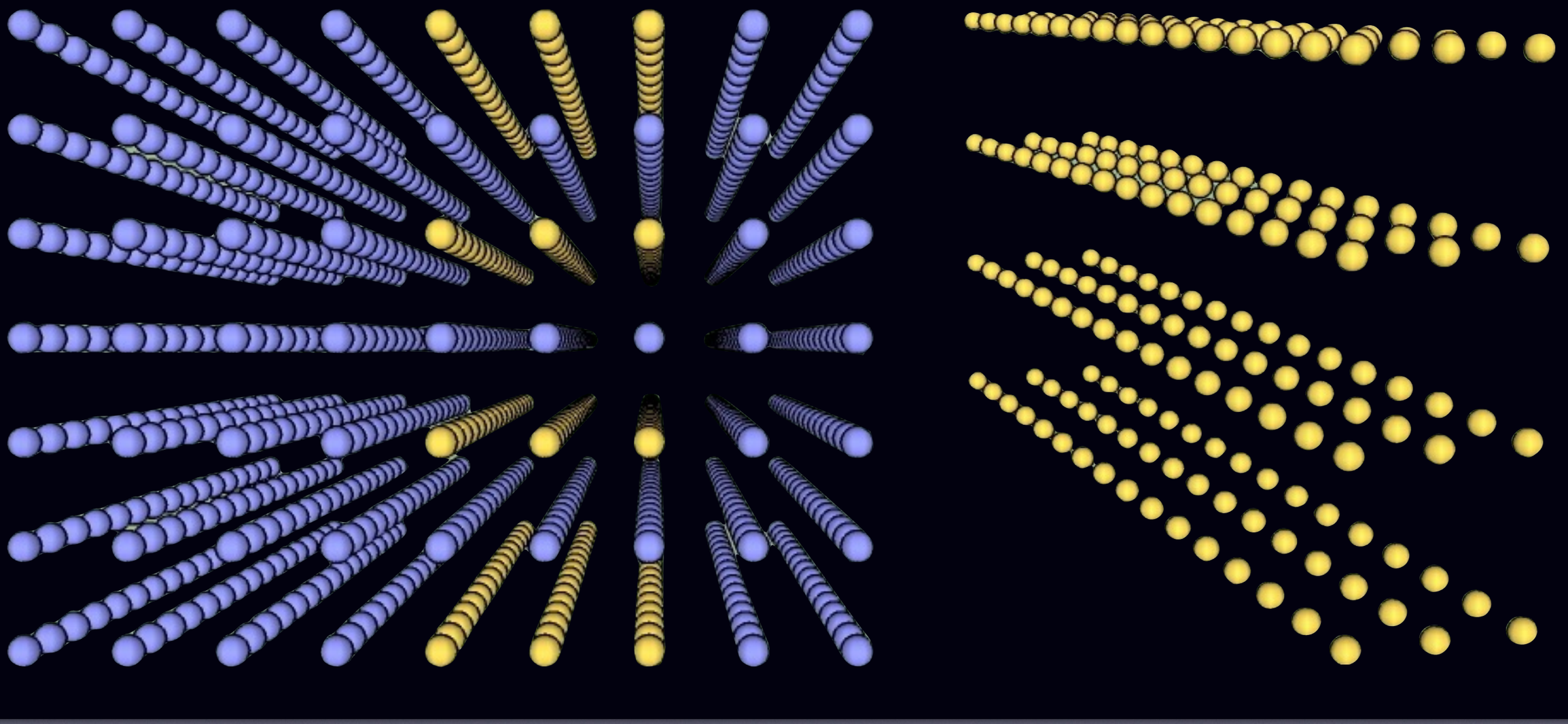
DAP-based
Subset Selection (from arrays | tables)

- Select variables by name
  - For tabular data, this means selecting columns
- Select rows of a table via column-specific value constraints
  - Allows both domain-based & range-based subsetting
- Select sub-arrays by constraining their indices

(array-style)

Index-Constrained Subsetting

OpenDAP



Source Array ➔ Sub-Array (response)

caveat —

Index-Based Subsetting

- Excellent if desired subset is a bounding box parallel to source array (indices ↔ coordinates)
- Less useful when
  - Subset selection not based on domain coordinates
  - Source is not organized as coordinate-mapped arrays
  - Desired subset is polygonal or is skewed (relative to source-array orientation)

OpenDAP

Part II

Recent Enhancements of OpenDAP Web Services

With Demonstrations

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This part of the presentation is drawn primarily from a project report on:

NASA Data Interoperability

An EOSDIS Presentation & Demo

Originally given March 27, 2015

Original Presenters: James Gallagher & Nathan Potter (OpenDAP)

This work was supported by NASA/GSFC under Raytheon Co. contract number NNG10HP02C

main NASA motivations for

OpenDAP Enhancements

- Easier software builds & better documentation
- Authentication of data users
- More response encodings
  - Open Geospatial Consortium (OGC) Web Services (WMS, WCS…)
  - JavaScript Object Notation (JSON) for Webification (w10n)
- Requesting DAP ops on many granules at once
  - Response = concatenated CSV (arrays ➛ tables) or
  - Response = zipped files

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progress on simplifying

OpenDAP Server Installation

- Context
  - Hyrax-install complexity was once a barrier to use
- Key Accomplishments
  - Adding modules does not increase the package count
  - Source build: now just 3 distinct packages
    - Previously 18 packages
  - Binary install: now just 2 RPMs + 1 WAR
    - Previously 15 RPMs + 1 WAR

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progress enhancing OpenDAP's

Website & Documentation

- Key Accomplishments
  - Various Website repairs
  - 760 fixed links (from automated before/after crawls)
  - Five documents added
    - Client configuration for authorization
    - Server configuration for authorization
    - Source-code build how-to
    - Summary of Winter-2015 ESIP-panel on Web-services performance
    - Server configuration for WMS provision

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progress on

User Authentication

(via EarthData login at NASA EOSDIS)

- Context/Things to Notice
  - Fine-grained access control for <u>individual</u> directories
  - Demo is Web-only, but cURL tests work as well
    - cURL—like most client applications—is built around libcurl, thus serving as a lowest common denominator
    - EarthData credentials are simply stored in a user's .netrc file
- Live Demo…

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prior context for enhancing

Multi-Granule Aggregation

- Many servers have allowed DAP *providers* to form (virtual) aggregations of (similar) granules
- But until now, end users could not choose
  - Granules to be aggregated
  - Forms of aggregation
- Furthermore, array- & table-style subsetting could not be mixed (with or without aggregation)

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progress on requester-specified

Multi-Granule Aggregation

- Context/Things to Notice
  - Request data from 1,000s of files with one operation

    N.B. Necessitates use of HTTP POST (to avoid huge URLs)
  - Two forms of aggregation response
    - Zipped netCDF files
    - Concatenated tables (CSV)

      N.B. Arrays may be aggregated as concatenated tables!
- Live Demo…

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DAP Output-Encoding Extensions

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OGC-Compliant

Data User, Browser, Curl, ...

XML or JSON

DAP(2|4), netCDF, XML, GeoTIFF, WMS, JSON...

Other Web Services

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HDF files | netCDF files | text files | SQL database | extensible...

OGC Protocol:

WMS Web Mapping Service

- WMS (Web Mapping Service)
  - Great for 2-dim geospatial data on ‘maps’ (but not for higher-dimensional data types)
  - A bridge to display tools, notably, Google Earth
- Live Demo…

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DAP Interoperability Leverage

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relevance:

OpenDAP & Interoperability

- We demonstrated
  - NASA (HDF5) files ➛ OpenDAP ➛ WMS ➛ Google Earth
- Notably, it seems unlikely that either
  - Google Earth engineers anticipated reading HDF5 or
  - NASA engineers planned to display data on Google Earth!
- This suggests* a definition for interoperability: "<u>supporting unanticipated uses</u>"

*Paraphrasing John Orcutt

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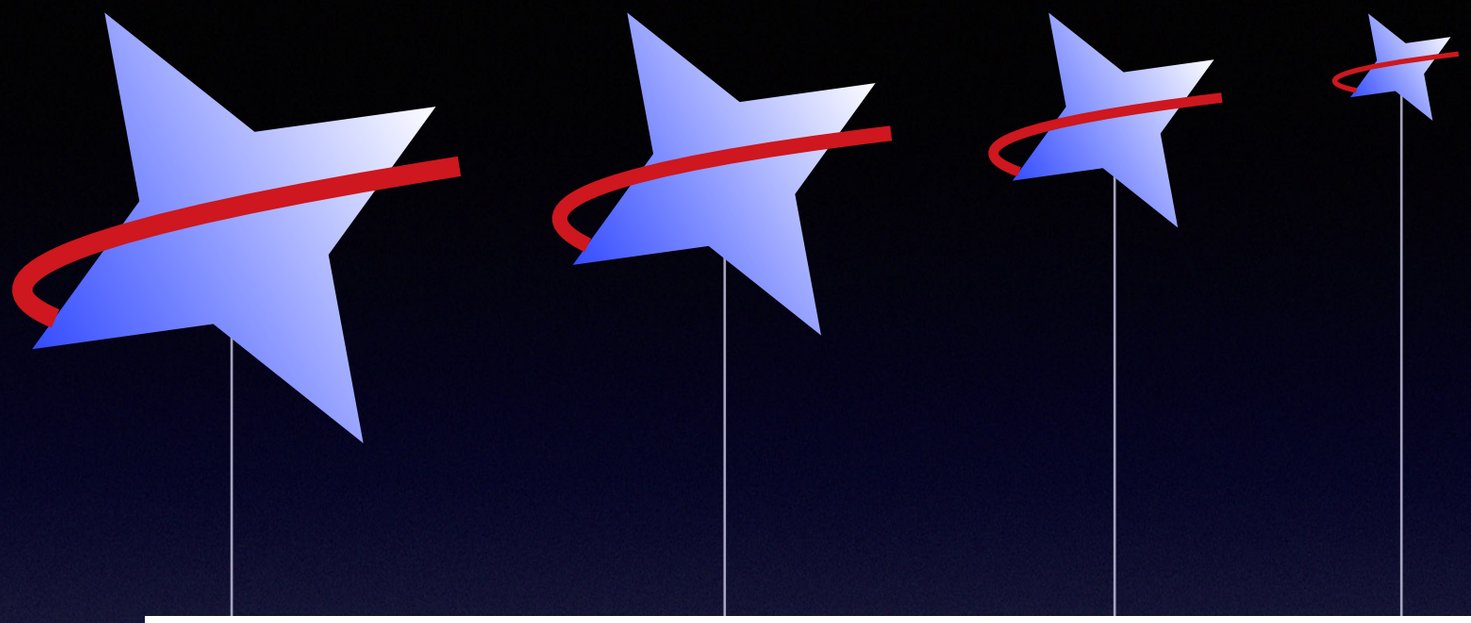

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