Seminar at UNIDATA

Boulder (CO) USA, 10 Dec 2010

Multi-disciplinary interoperability challenges

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and PIN -University of Florence

Outline

- System of Systems approach and principles
- Brokering SOA (B-SOA)
- EuroGEOSS Operating Capacity
  - multi-disciplinary discovery and access brokers – including semantic search;

- Related research topics
  - Harmonizing netCDF-CF and ISO models -from ncML to ncML-G+
  - Uncertainty-enabled data (and services)

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Rationale

- Contribution to the following Objectives
  - Formation and operation of an **Earth system science community**, based on **multidisciplinary knowledge integration**
  - Develop advanced digital earth infrastructures: **multi-disciplinary cyber(e)-Infrastructure**
- Interoperability across disciplines
  - **Semantic**
  - **Technical**
  - Organizational
- European and International Initiatives
  - EU **INSPIRE** (European SDI)
  - GEO **GEOSS**

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INSPIRE and GEOSS approach

- *Implement a "system of systems"*
  - *Consisting of existing and future information systems*
  - *Supplementing but not supplanting systems mandates and governance arrangements*
- Build on existing (autonomous) capacities
  - Mediate (standard and non-standard capacities)
  - Interconnect (capacities) and Adapt connecting protocols
- Recognized multi-disciplinary capacities should provide:
  - Metadata to describe available spatial resources
  - Network (Access) services to
    - discover, transform, view and download spatial resources
    - invoke advanced processing services to support decision making

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System of Systems principles

- Shift from technical interoperability towards conceptual composability
  - by recognizing and specifying *interoperability arrangements*
- Assure a low entry barrier for both resource Users and Producers
- Build incrementally on existing infrastructures (information systems) and incorporate heterogeneous resources
- Introduce distribution and mediation functionalities (i.e. brokering frameworks) for interconnect heterogeneous resources
    - Discovery, access, processing and chaining

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Flexibility: different Interoperability levels

- **Different interoperability levels -at different Infrastructures level**

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Flexibility: different Interoperability levels

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- **Four main infrastructure types**

1. **Distributed Computing** Infrastructure
   - Distributed Capacity provision functionalities

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Flexibility: different Interoperability levels

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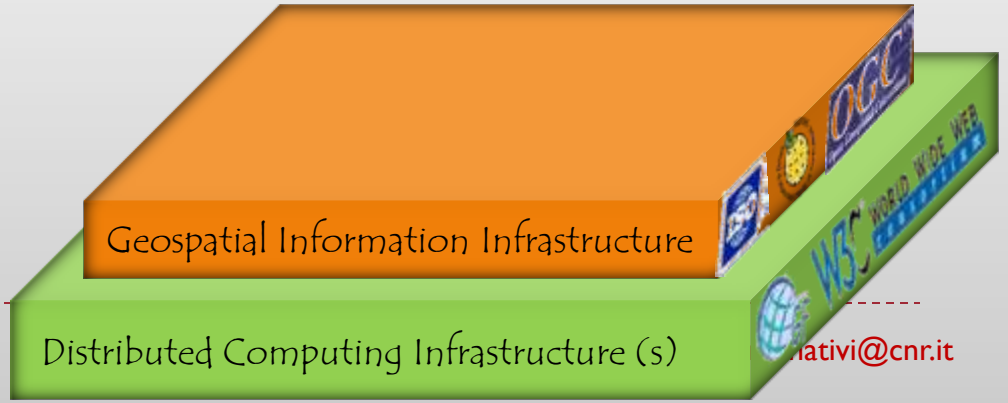
1. **Geospatial Information** Infrastructure
   - Geospatial resources core functionalities
2. **Distributed Computing** Infrastructure
   - Distributed Capacity provision functionalities



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Flexibility: different Interoperability levels

- **Different interoperability levels -at different Infrastructures level**
- **Four main infrastructure types**
  1. **Thematic/Community** Infrastructures
     - SBA/CoP resources core functionalities
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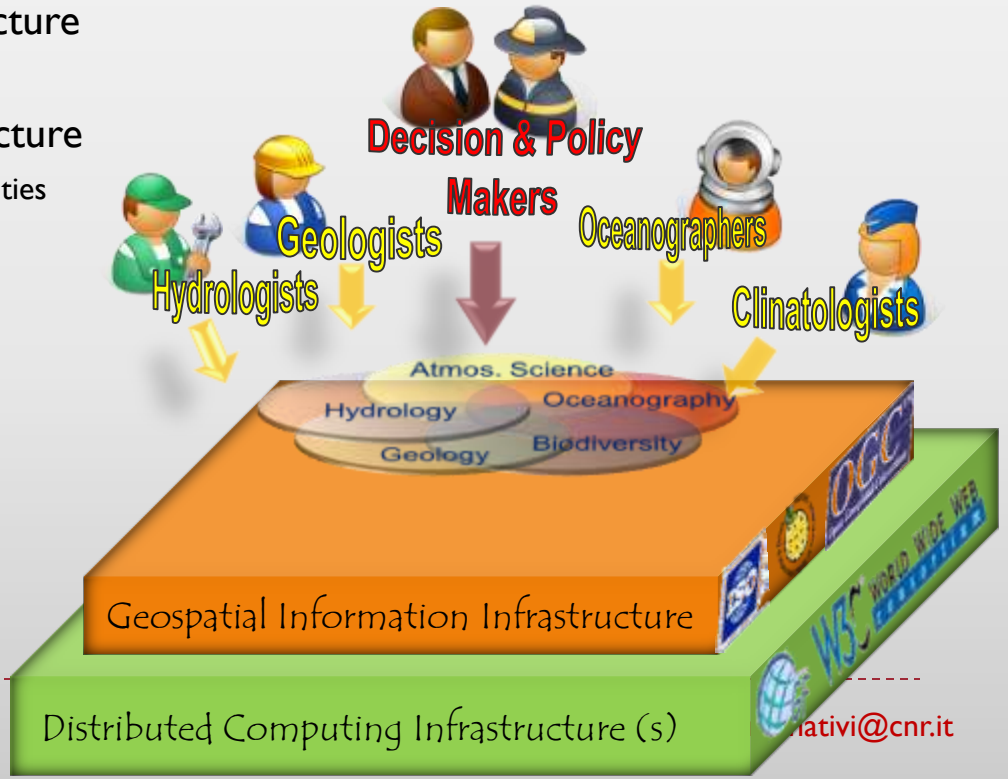

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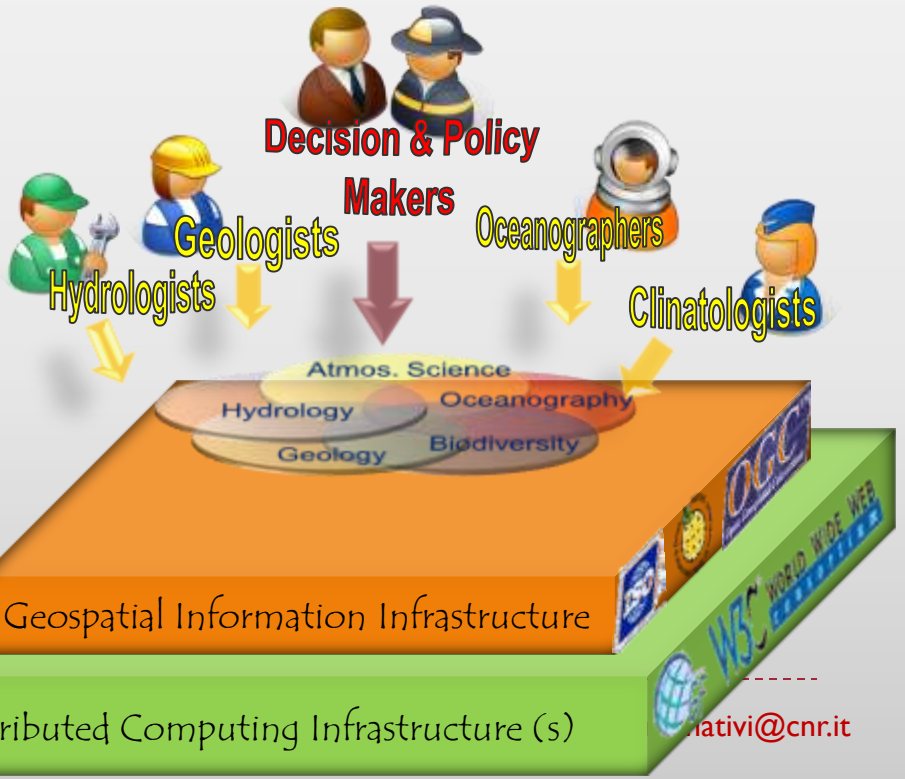
Domain Semantics



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Flexibility: different Interoperability levels

- **Different interoperability levels -at different Infrastructures level**
- **Four main infrastructure types**

1. **Thematic/Community** Infrastructures
   - SBA/CoP resources core functionalities
2. **Digital Earth (Earth System Science)** Infrastructure
   - Earth science resources core functionalities
3. **Geospatial Information** Infrastructure
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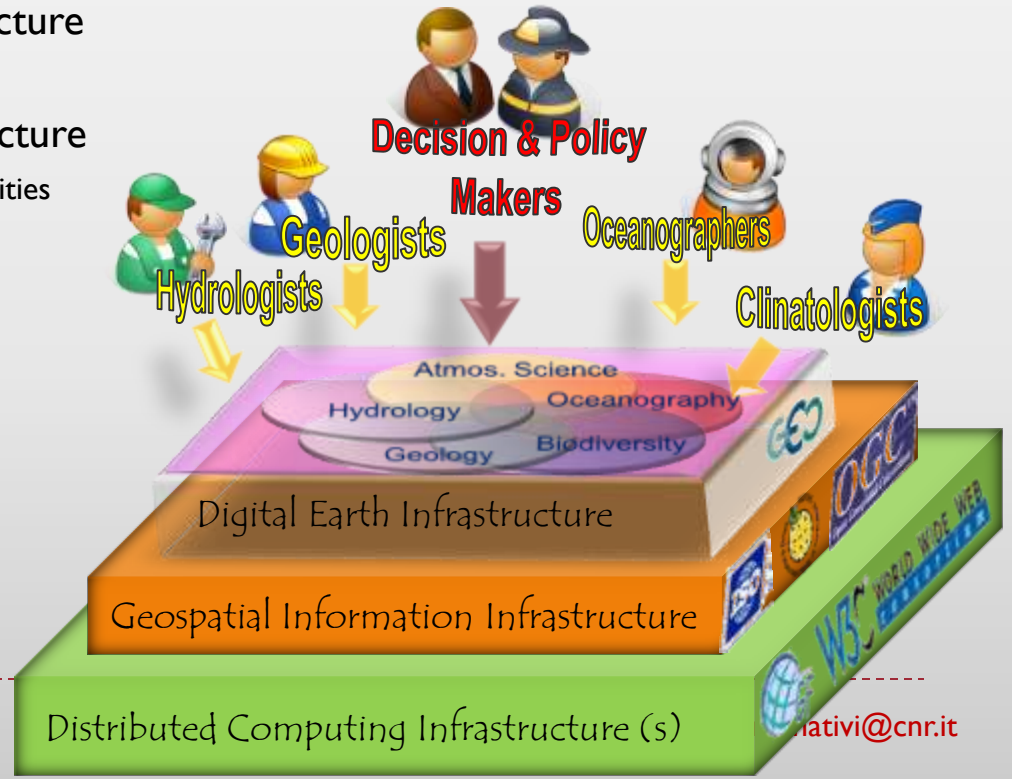
4. **Distributed Computing** Infrastructure
   - Distributed Capacity provision functionalities

Domain Semantics



Flexibility: Interoperability Arrangements

- Interoperability Arrangements:
  - to shift from technical interoperability towards conceptual composability

- They must be able to
  - align (and where necessary to harmonize) the heterogeneous system conceptual models.
  - connect autonomous systems at different infrastructural levels
  - avoid tight coupling or strong integrations -only define how system components interface with each other

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Interoperability Arrangements implementation

- Need:
  - to raise the level of abstraction and cope with systems complexity
- Solution:
  - Adapt SOA and MDA
  - Introduce brokering and mediation frameworks for managing resources
    - e.g. discovery, access, processing and chaining

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Brokering SOA (B-SOA)

- For complex (large and heterogeneous) infrastructures, SOA archetype does not scale and is not flexible

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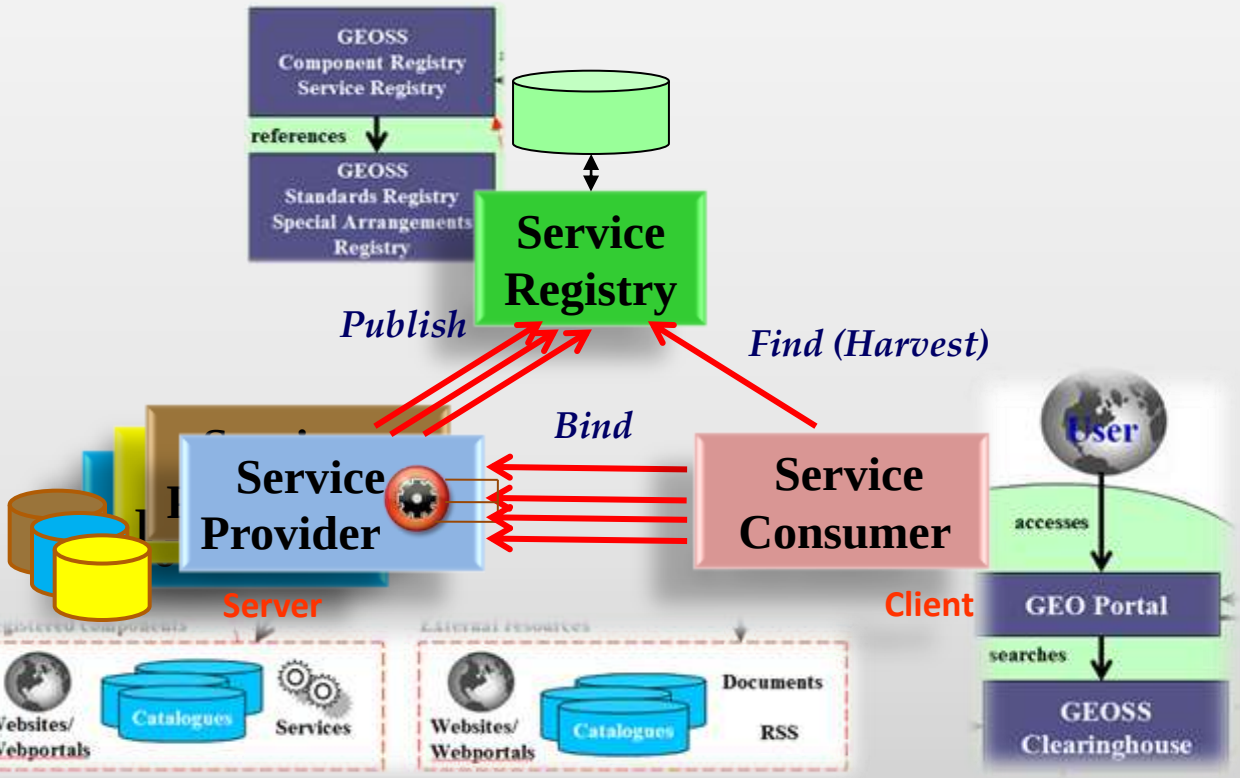
Present GCI framewok



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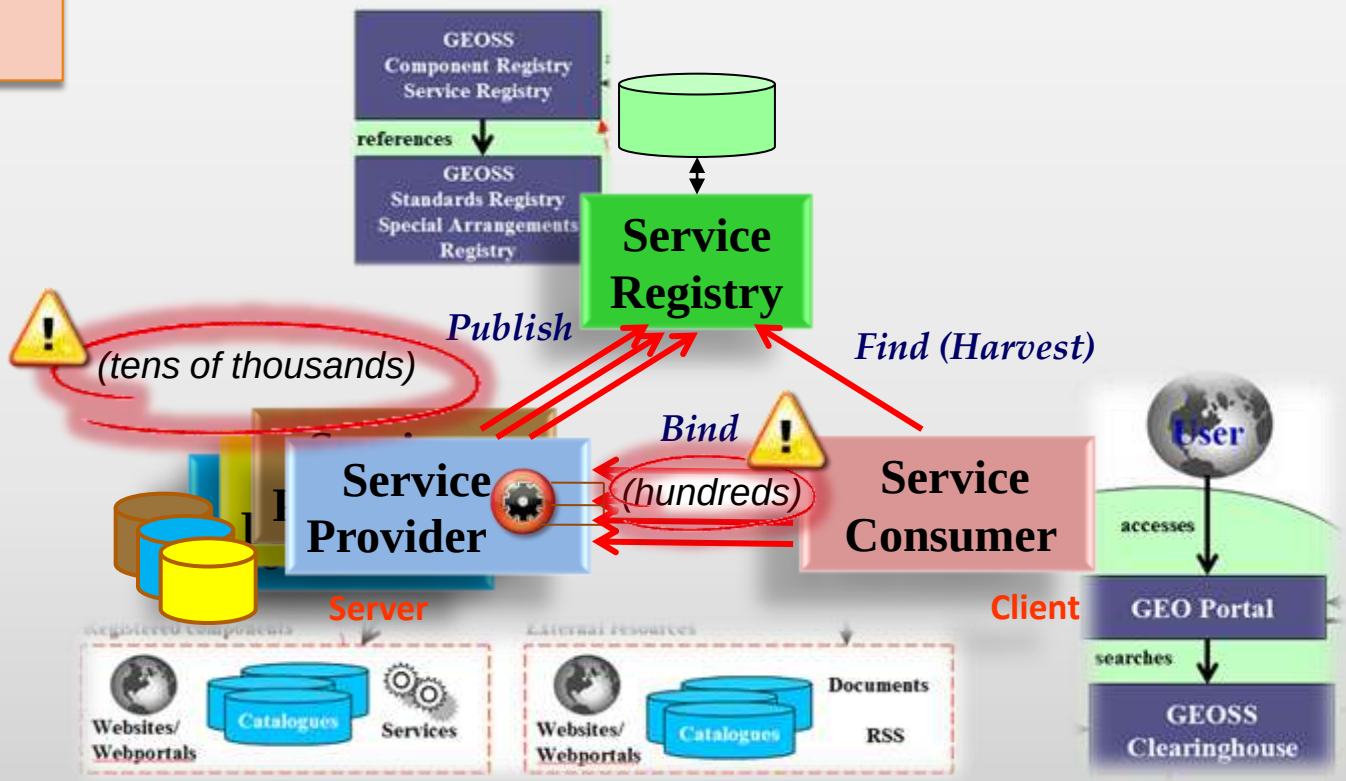

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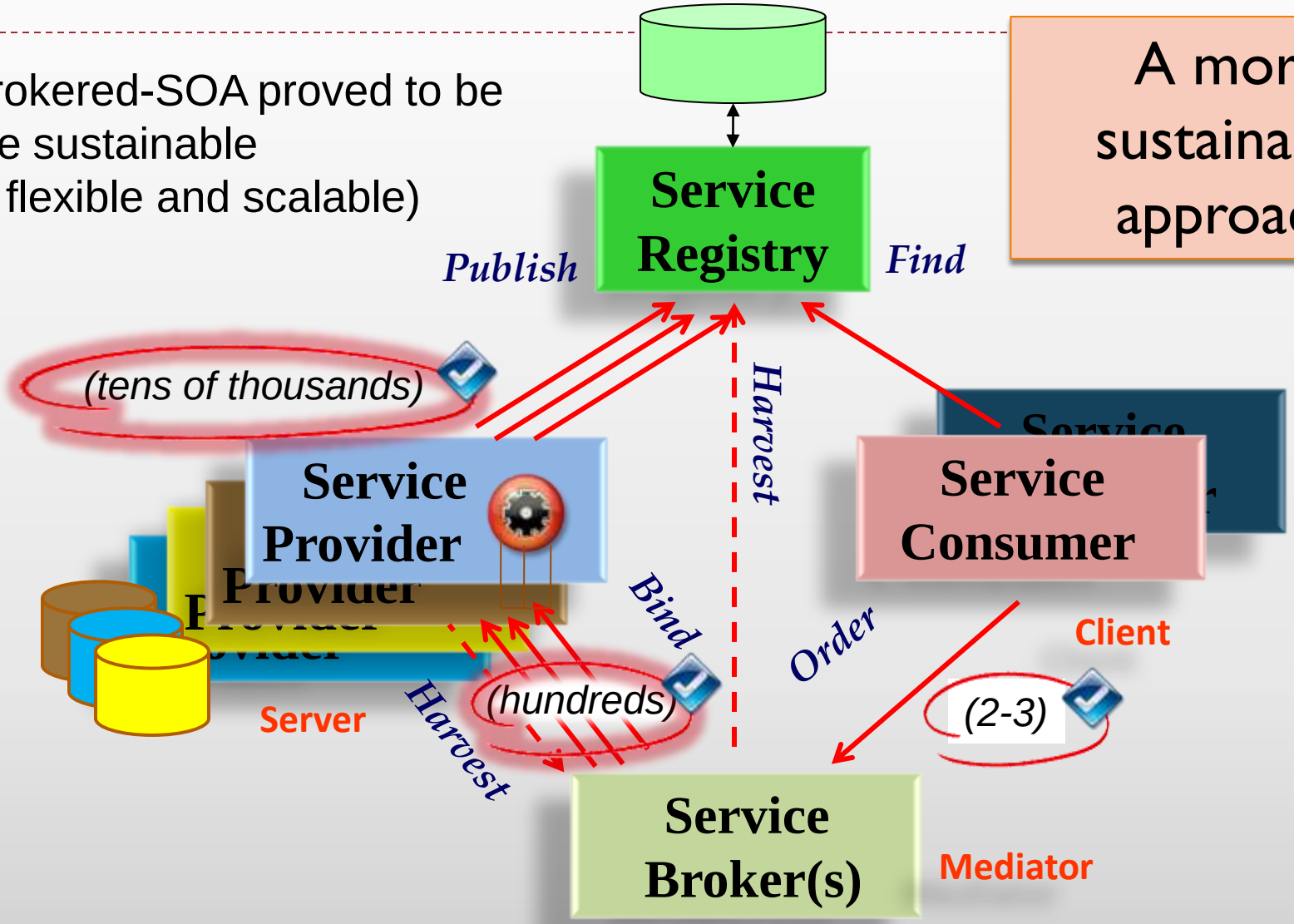
The Broker/Mediator component

A Brokered-SOA proved to be more sustainable (i.e. flexible and scalable)

A more sustainable approach



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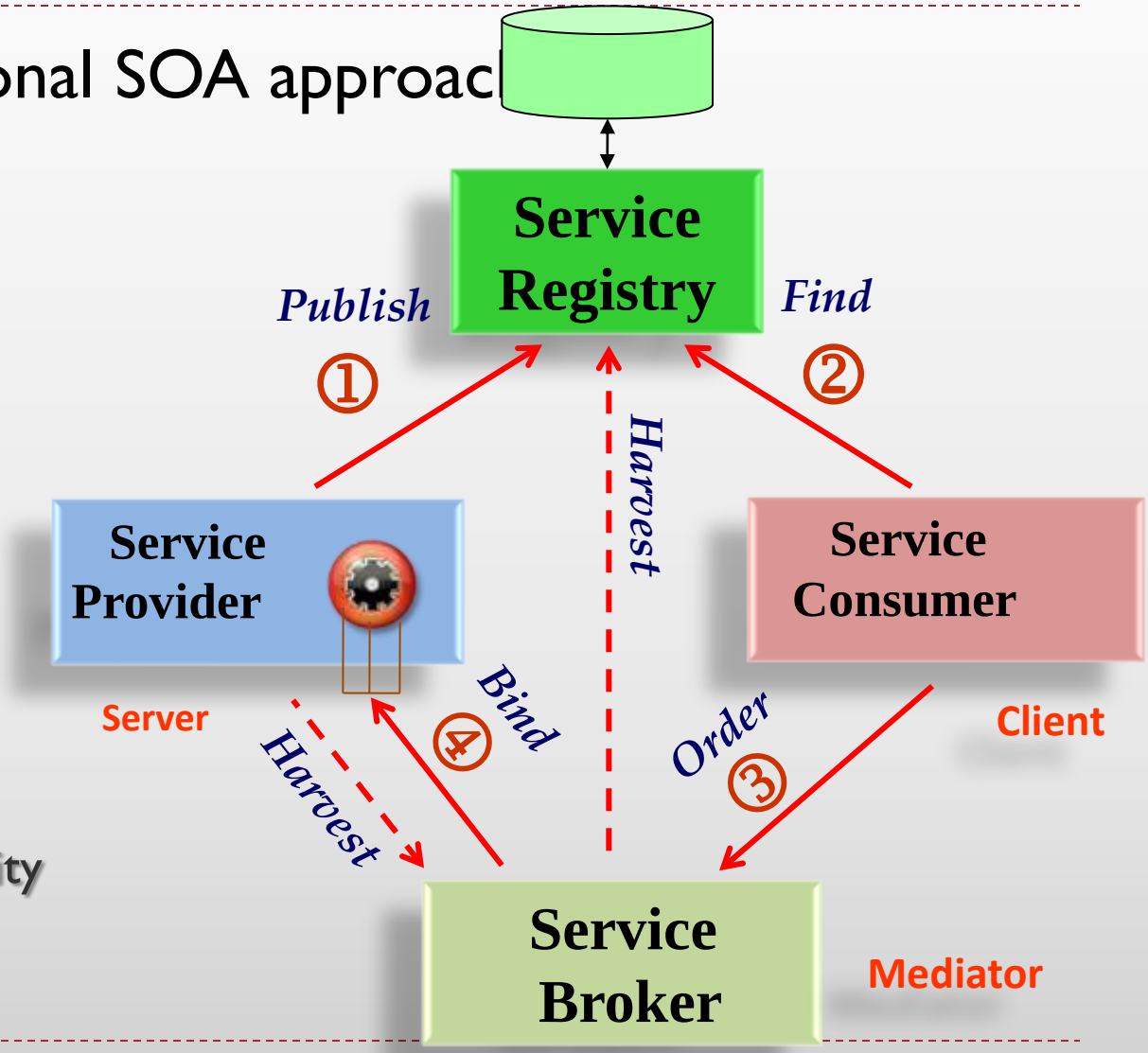
B-SOA framework

- Extend the traditional SOA approac
- Address SoS complexity
  - Many heterogeneous systems
  - Flexibility to support future systems
  - avoid tight coupling or strong integration
  - From technical interoperability to conceptual composability



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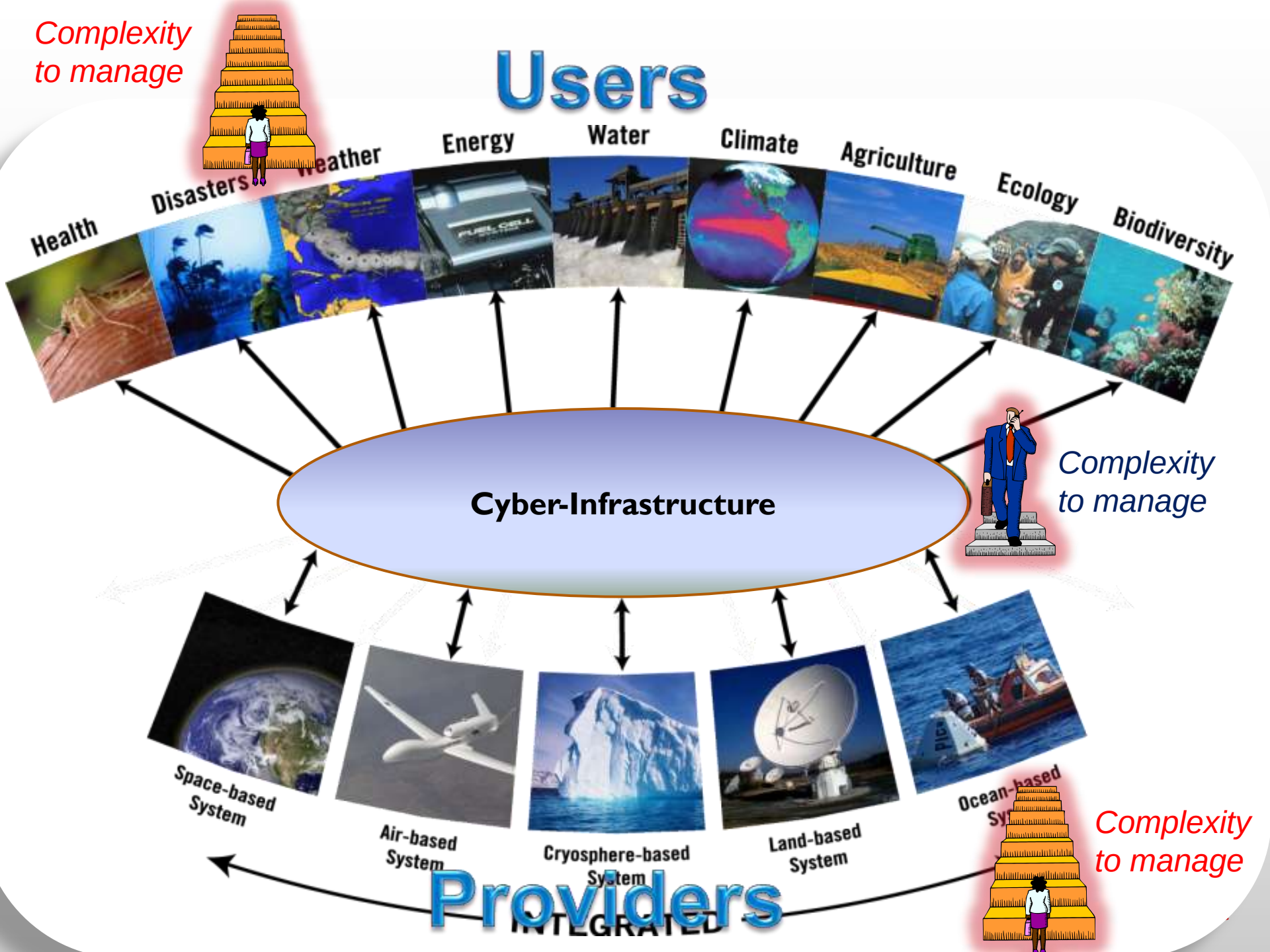
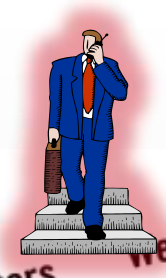

Complexity
to manage
Users
Health
Disasters
Weather
Energy
Water
Climate
Agriculture
Ecology
Biodiversity
Cyber-Infrastructure
Complexity
to manage
Space-based
System
Air-based
System
Cryosphere-based
System
Land-based
System
Ocean-based
Sy
Providers
INTEGRATED
Complexity
to manage

Low Entry Barrier



Users

Health

Disasters

Weather

Energy

Water

Climate

Agriculture

Ecology

Biodiversity

Brokering Framework

Complexity to manage

Space-based System

Air-based System

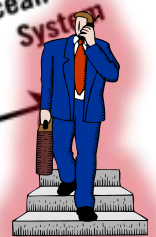
Cryosphere-based System

Land-based System

Ocean-based System

Providers

INTEGRATED



Low Entry Barrier

Low Entry Barrier for SBAs

- SBAs (and CoPs) systems
  - Remain autonomous
  - Remain unchanged –no new standard must be implemented, no new component or service must be implemented or deployed
- SBAs (and CoPs) may use their own standards to:
  - describe available spatial resources
  - publish accessible resources
- The multi-disciplinary infrastructure must
  - implement all the necessary mediation and brokering functionalities to interoperate with SBA systems avoiding strong integrations
  - Implement necessary semantic services to facilitate multi-disciplinary interoperability at the conceptual level

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Providers & Users

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Brokering System

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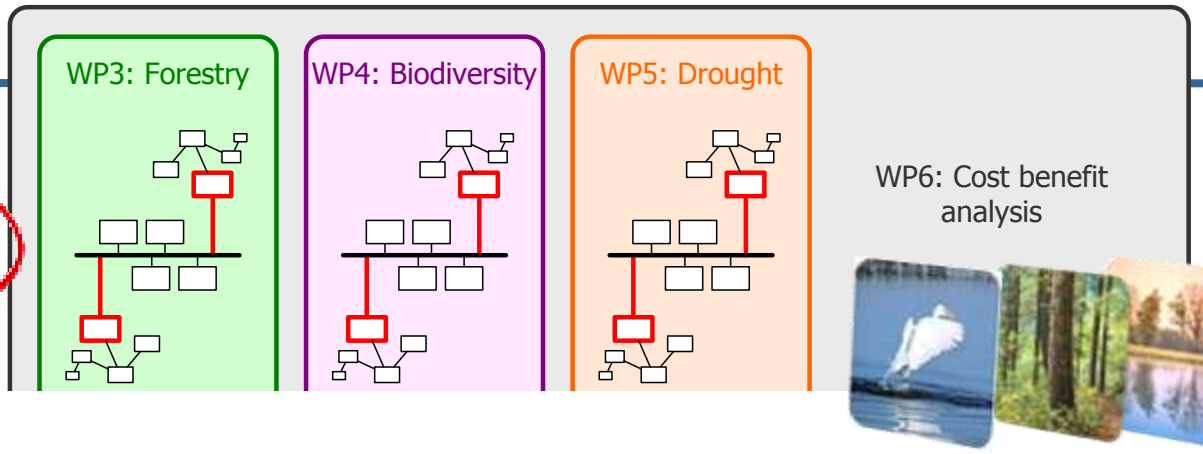
The EuroGEOSS experience

Three **Interoperability** phases

I. Enable thematic interoperability & connections local to global



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Three **Interoperability** phases

I. Enable thematic interoperability & connections local to global

WP3: Forestry

WP4: Biodiversity

WP5: Drought

WP6: Cost benefit analysis

II. Enable multi-disciplinary interoperability

WP2: Multi-disciplinary interoperability

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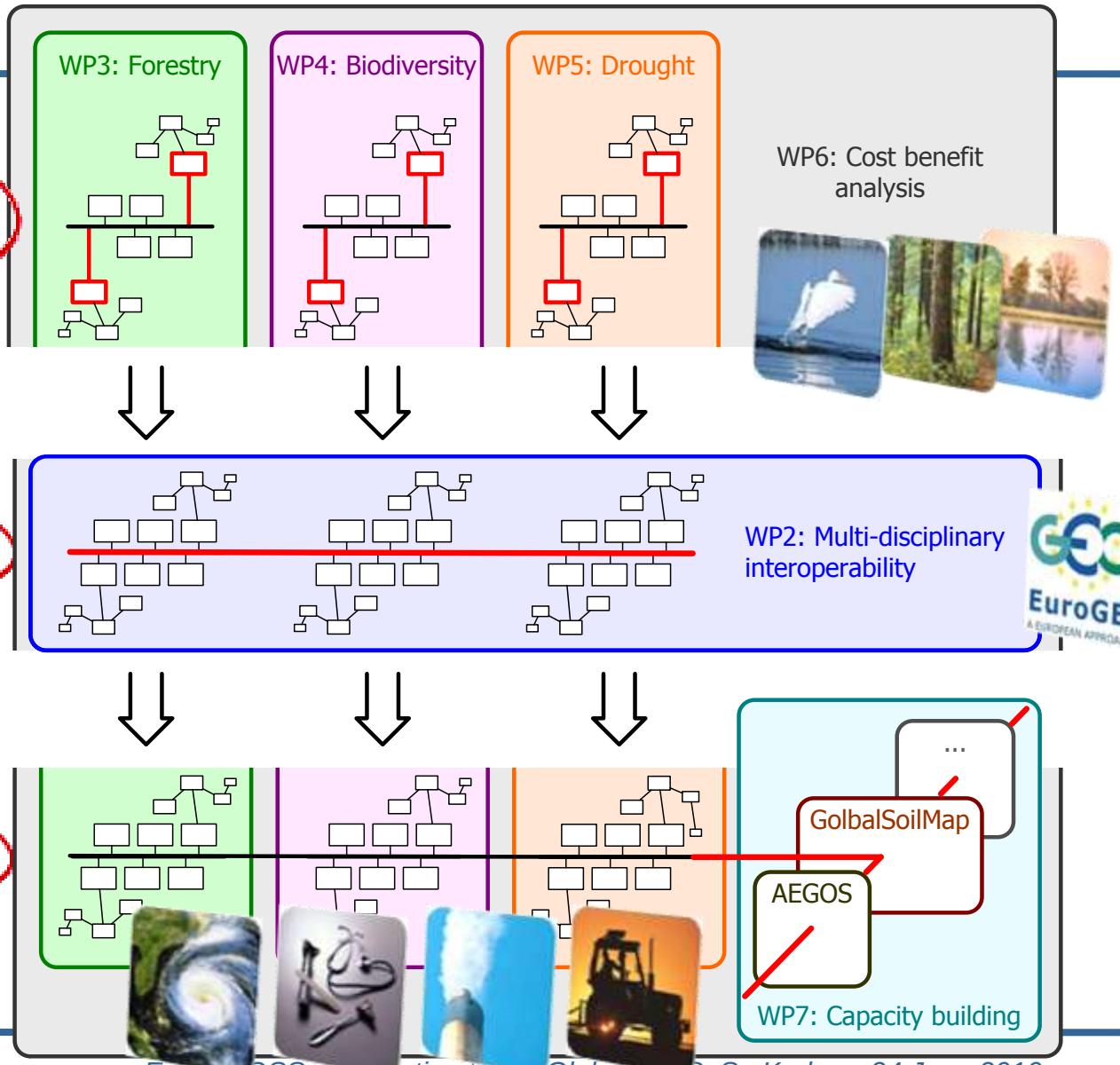
Three **Interoperability** phases

I. Enable thematic interoperability & connections local to global

II. Enable multi-disciplinary interoperability

III. Extend interoperability to other SBAs & systems



Multi-disciplinary Functionalities

USERS

MULTI-DISCIPLINARY RESOURCES

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Multi-disciplinary Functionalities

USERS

- Discovery broker
- Augmented (semantic) Discovery
- Web 2.0 resources discovery

MULTI-DISCIPLINARY RESOURCES

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Multi-disciplinary Functionalities

USERS

MULTI-DISCIPLINARY RESOURCES

- Discovery broker
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Support to multiple clients

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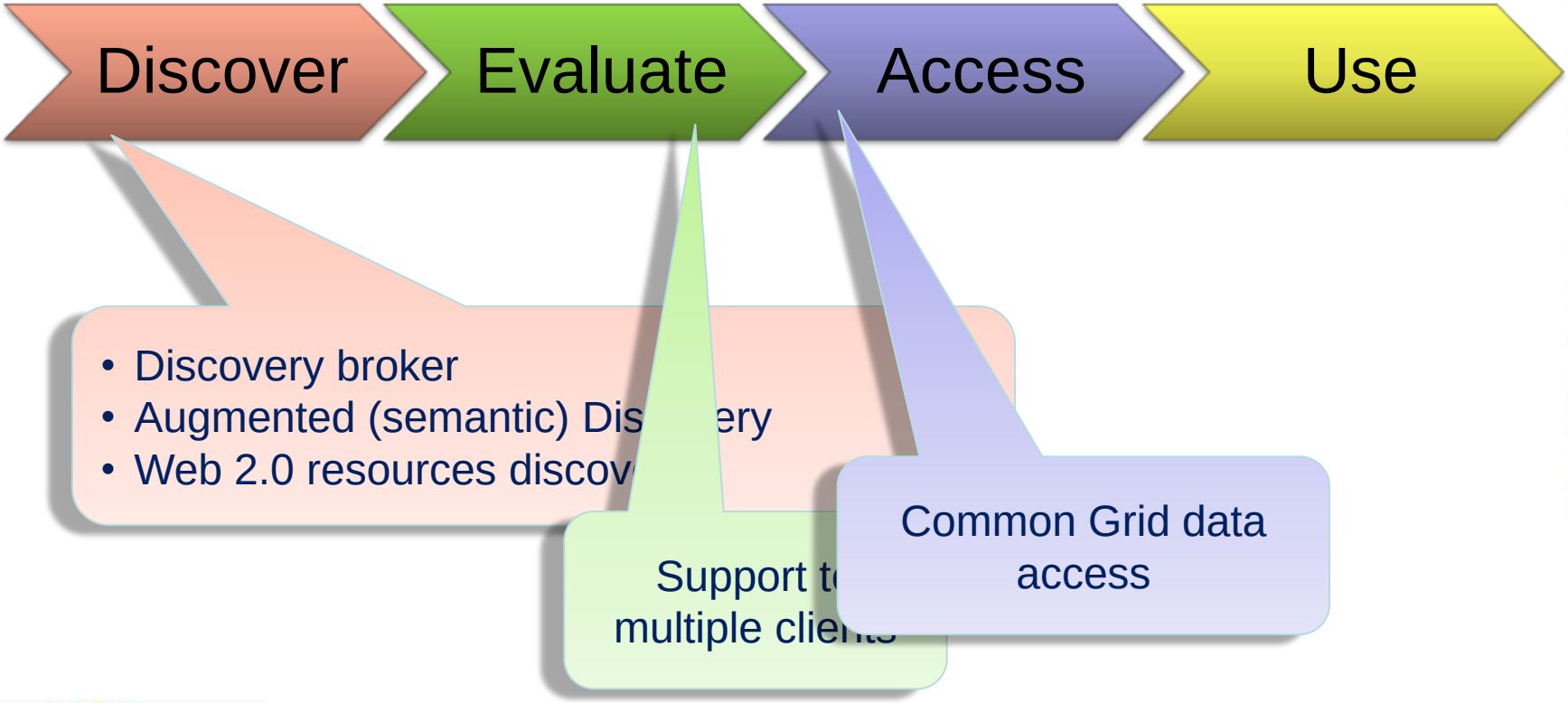
Multi-disciplinary Functionalities

USERS

MULTI-DISCIPLINARY RESOURCES



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Multi-disciplinary Functionalities

USERS

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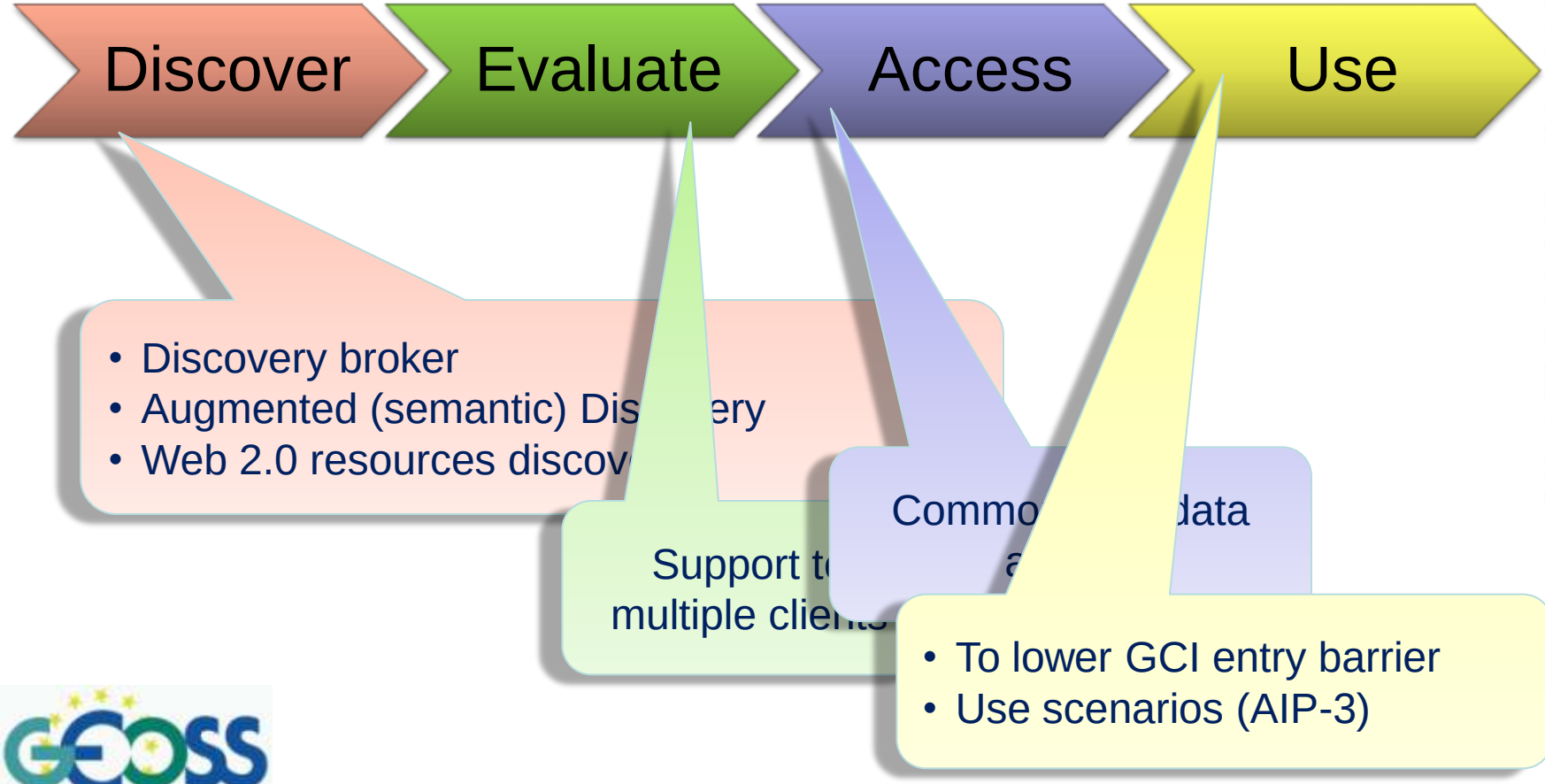

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TO LOWER ENTRY BARRIER FOR MULTI-DISCIPLINARY CAPACITY

Step 1: Discovery

«Service Providers»
Geospatial Resources

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Step 1: Discovery

Implement Interoperability Arrangements

«Service Providers»
Geospatial Resources

...

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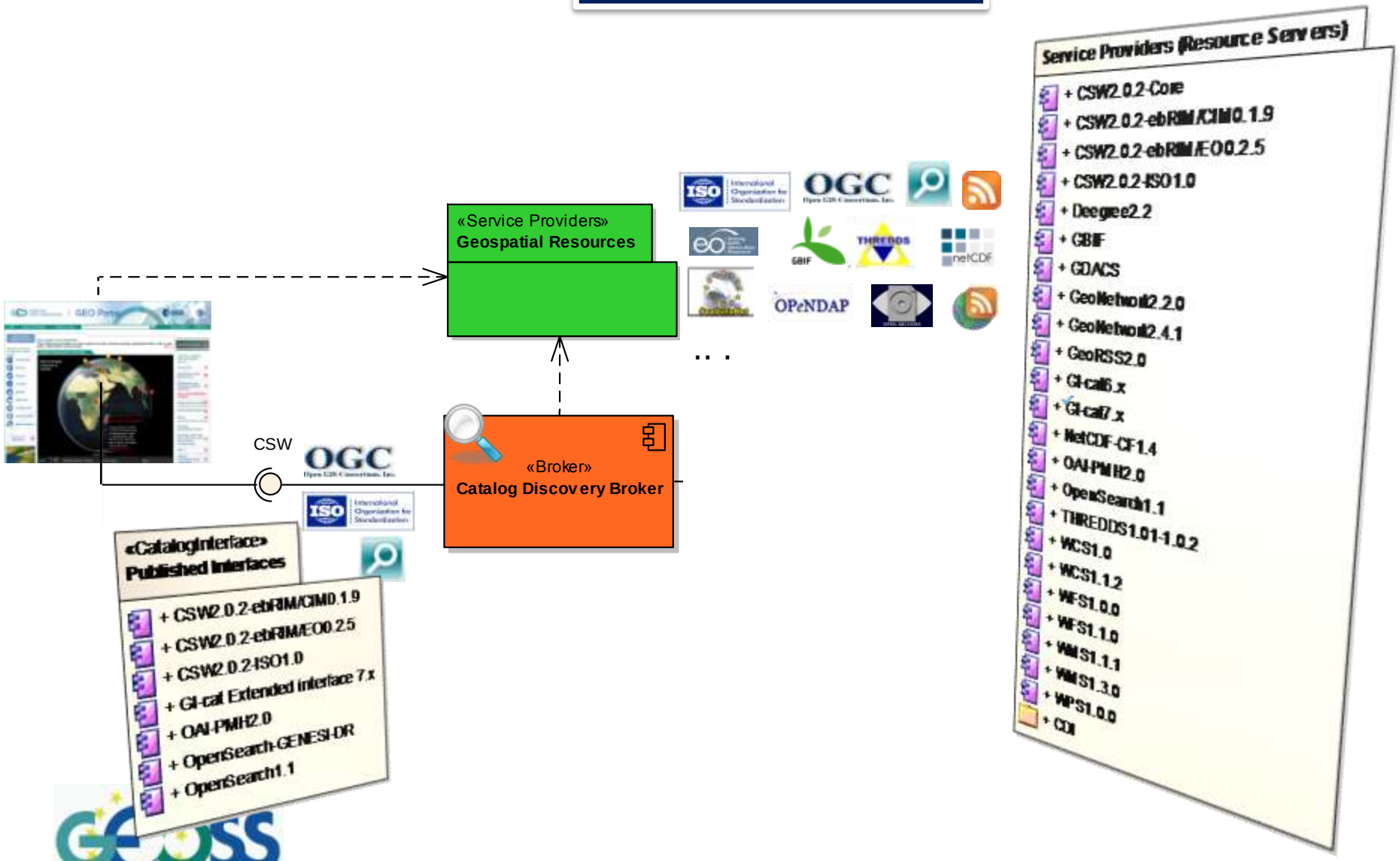
Step 1: Discovery



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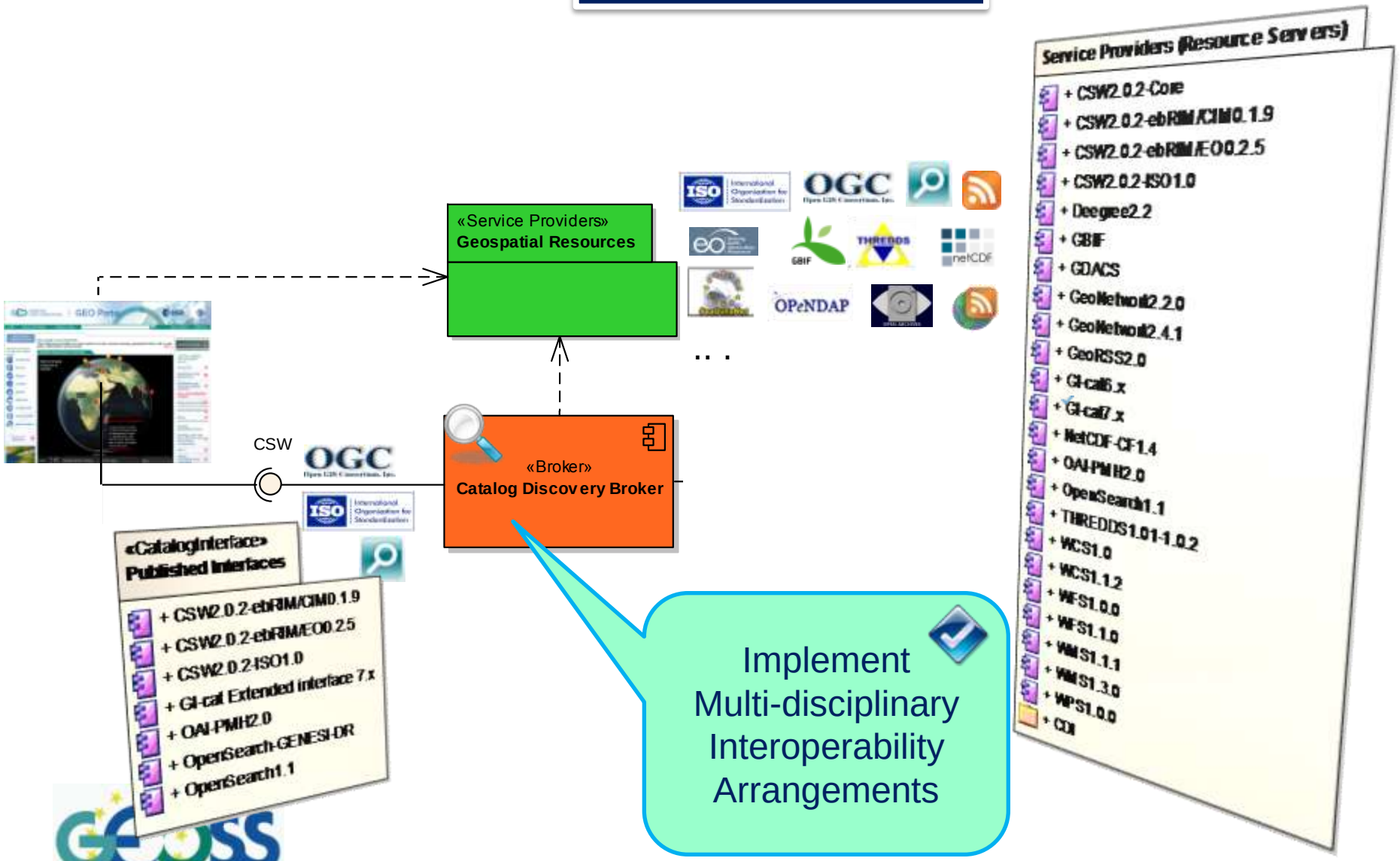

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Step 1: Discovery

Implement Subsetting & Transformation services

«Service Providers»
Geospatial Resources

...

CSW

«Broker»
Catalog Discovery Broker

«CatalogInterface»
Published Interfaces

- + CSW2.0.2-ebRIM/CIM0.1.9
- + CSW2.0.2-ebRIM/EO0.2.5
- + CSW2.0.2-ISO1.0
- + GI-cat Extended interface 7.x
- + OAI-PMH2.0
- + OpenSearch-GENESI-DR
- + OpenSearch1.1

Implement Multi-disciplinary Interoperability Arrangements

Service Providers (Resource Servers)

- + CSW2.0.2-Core
- + CSW2.0.2-ebRIM/CIM0.1.9
- + CSW2.0.2-ebRIM/EO0.2.5
- + CSW2.0.2-ISO1.0
- + Deegree2.2
- + GBIF
- + GDACS
- + GeoNetwork2.2.0
- + GeoNetwork2.4.1
- + GeoRSS2.0
- + GI-cat6.x
- + GI-cat7.x
- + NetCDF-CF1.4
- + OAI-PMH2.0
- + OpenSearch1.1
- + THREDDS1.01-1.0.2
- + WCS1.0
- + WCS1.1.2
- + WFS1.0.0
- + WFS1.1.0
- + WMS1.1.1
- + WMS1.3.0
- + WPS1.0.0
- + CDI

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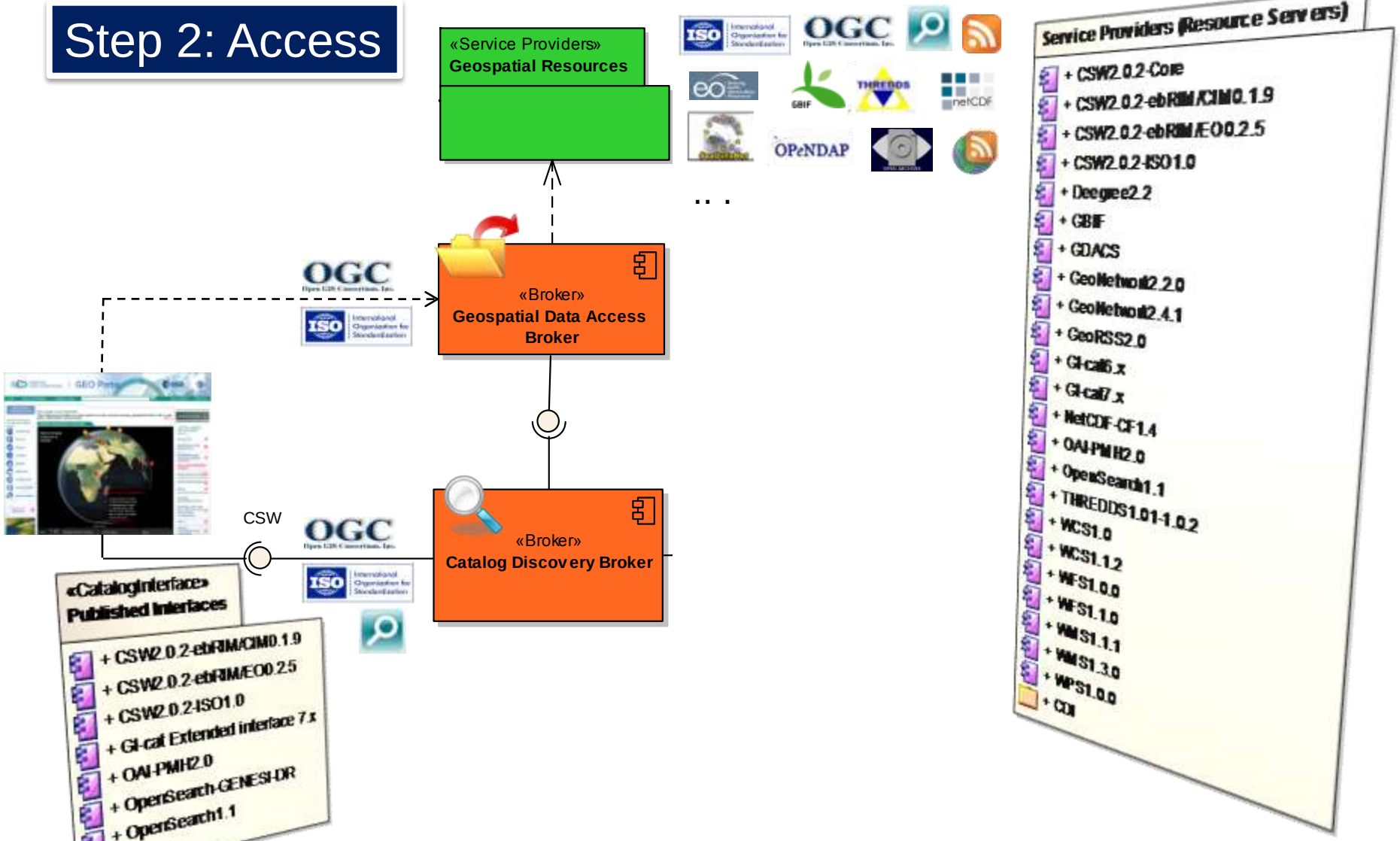
Step 2: Access



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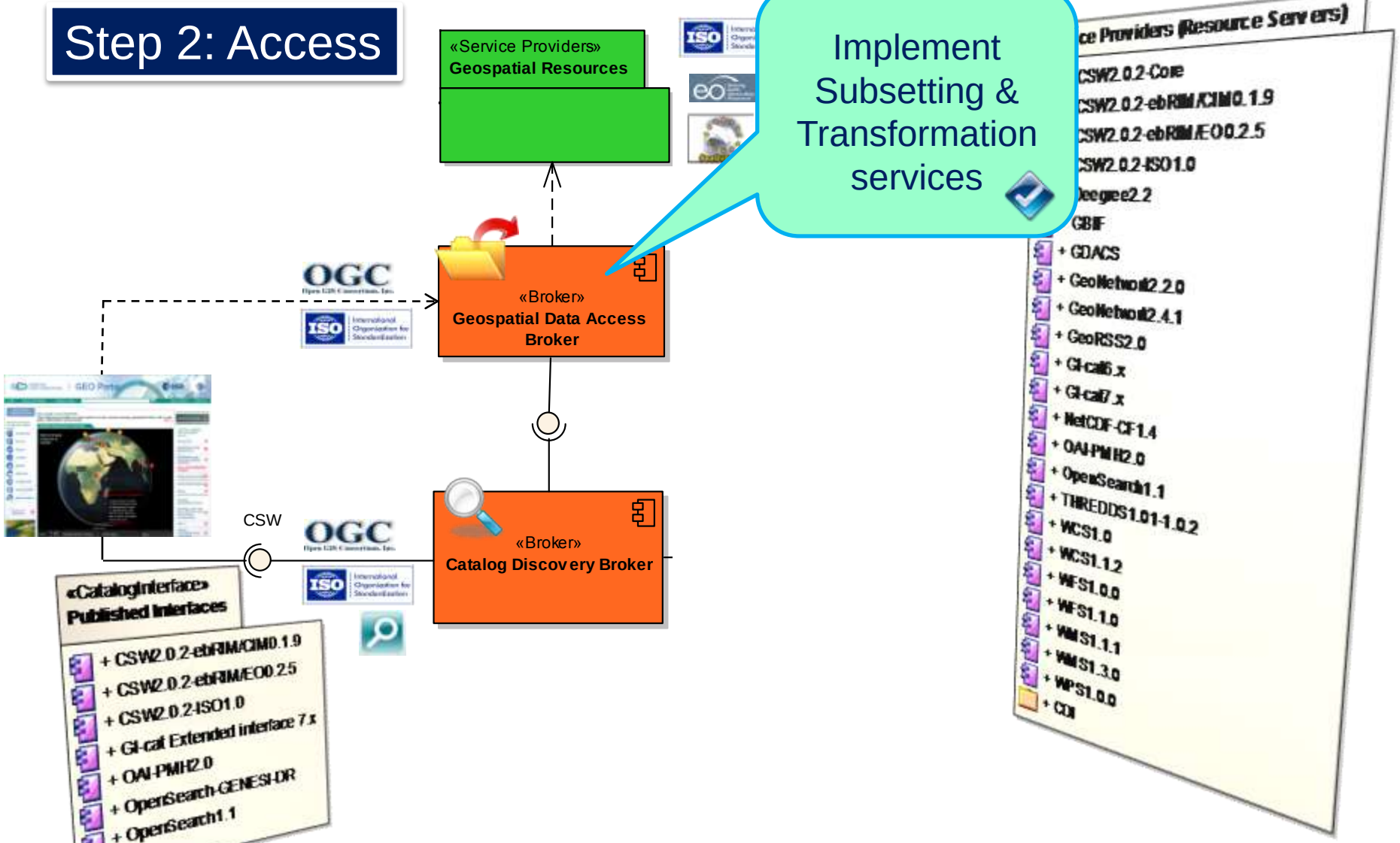

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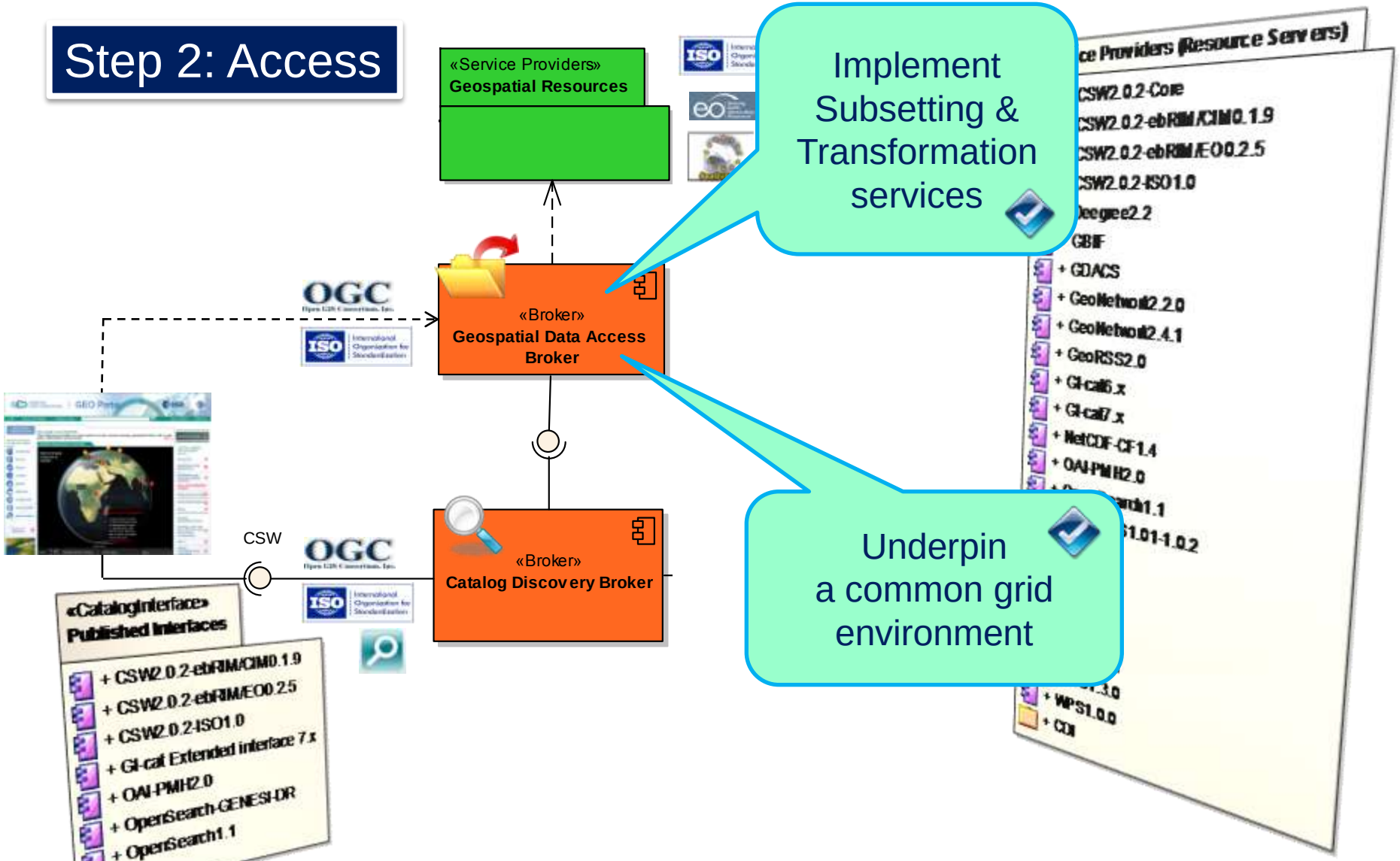

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Step 2: Access

Geospatial Web resources.

What about Web 2.0 resources ?

«Service Providers»
Geospatial Resources

«Broker»
Geospatial Data Access Broker

Implement Subsetting & Transformation services

Underpin a common grid environment

CSW

OGC

«Broker»
Catalog Discovery Broker

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Deegree2.2
GBIF
+ GDACS
+ GeoNetwork2.2.0
+ GeoNetwork2.4.1
+ GeoRSS2.0
+ GI-cat6.x
+ GI-cat7.x
+ NetCDF-CF1.4
+ OAI-PMH2.0
+ WPS1.0.0
+ CDI

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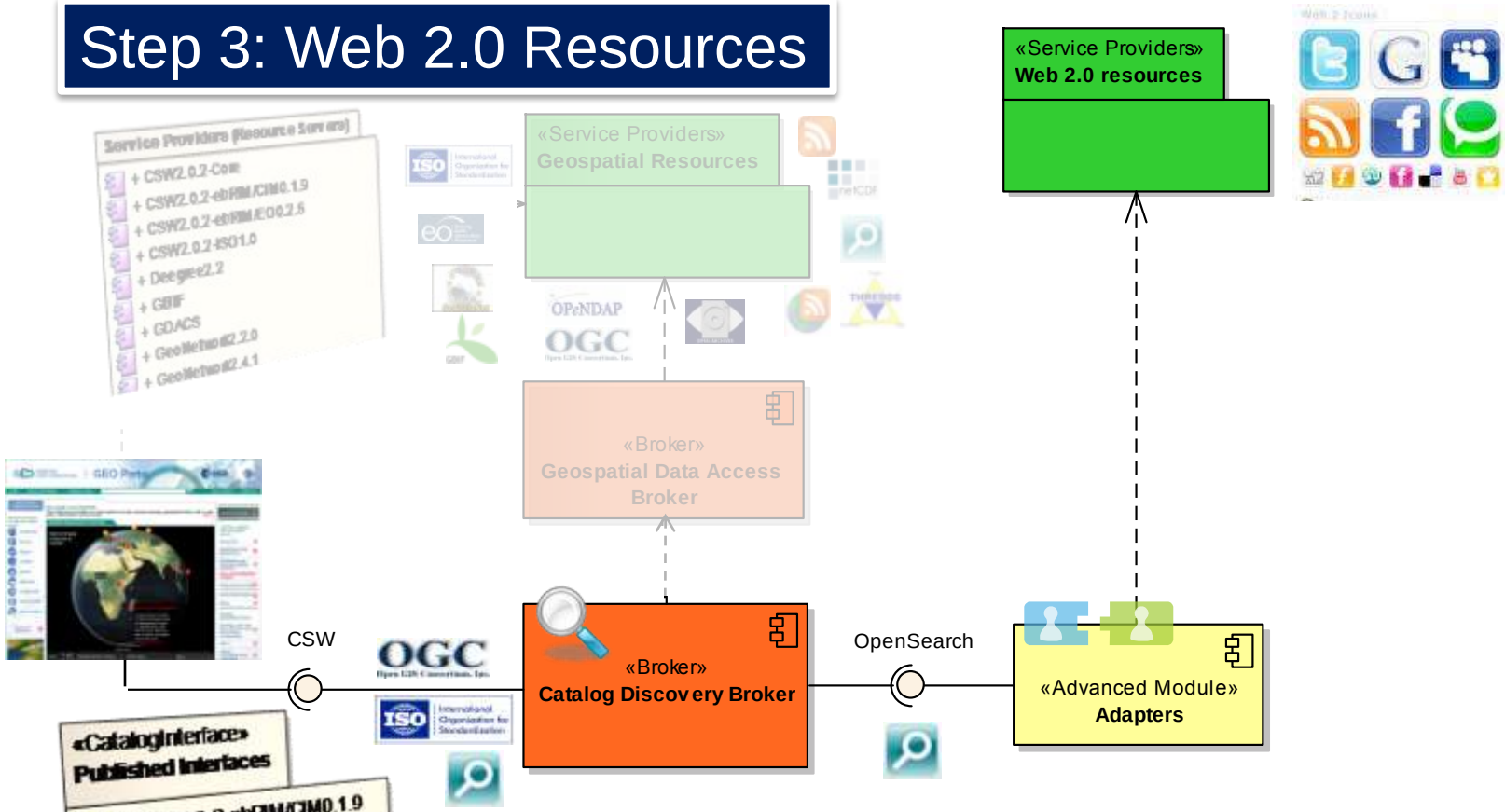
Step 3: Web 2.0 Resources



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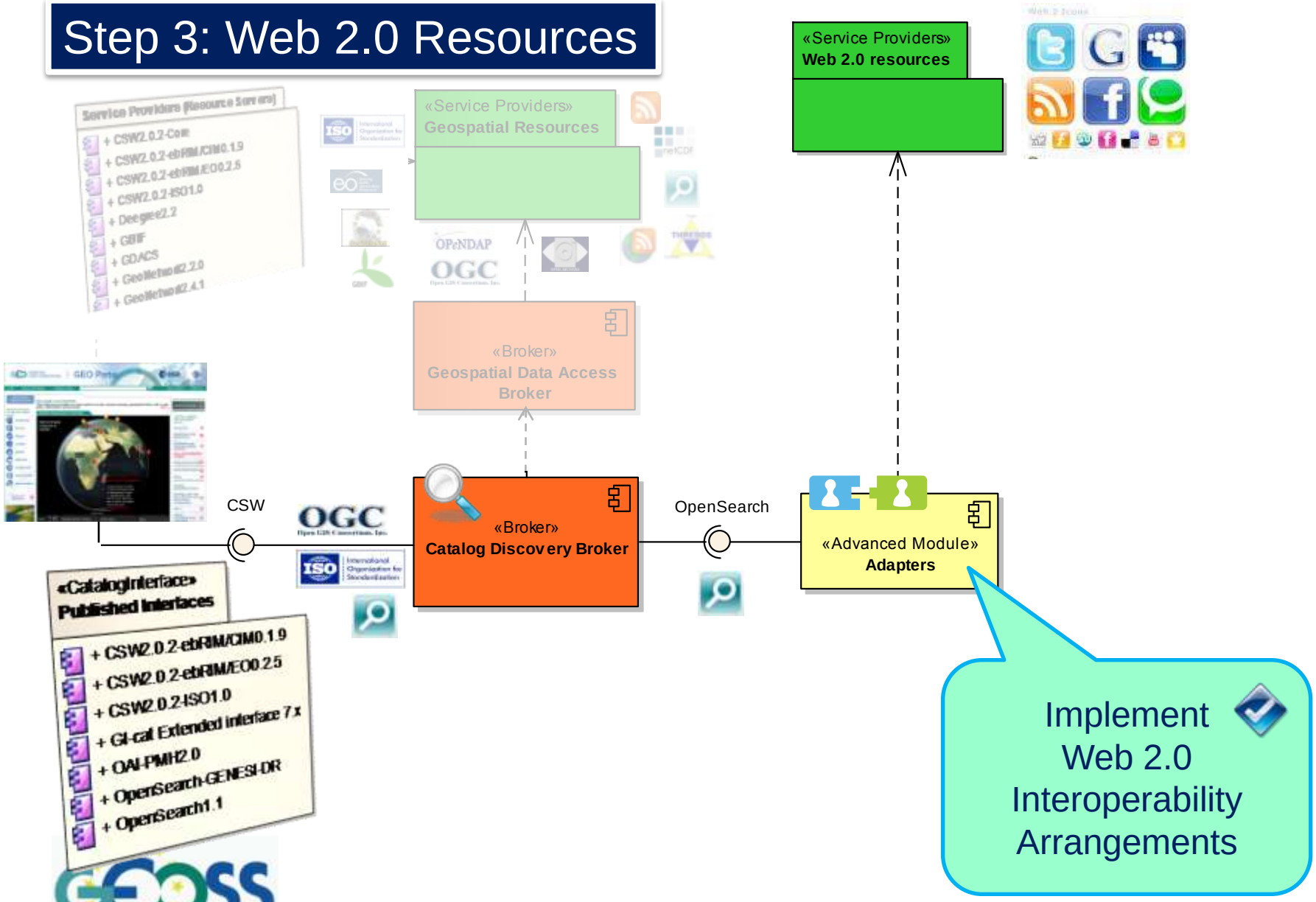

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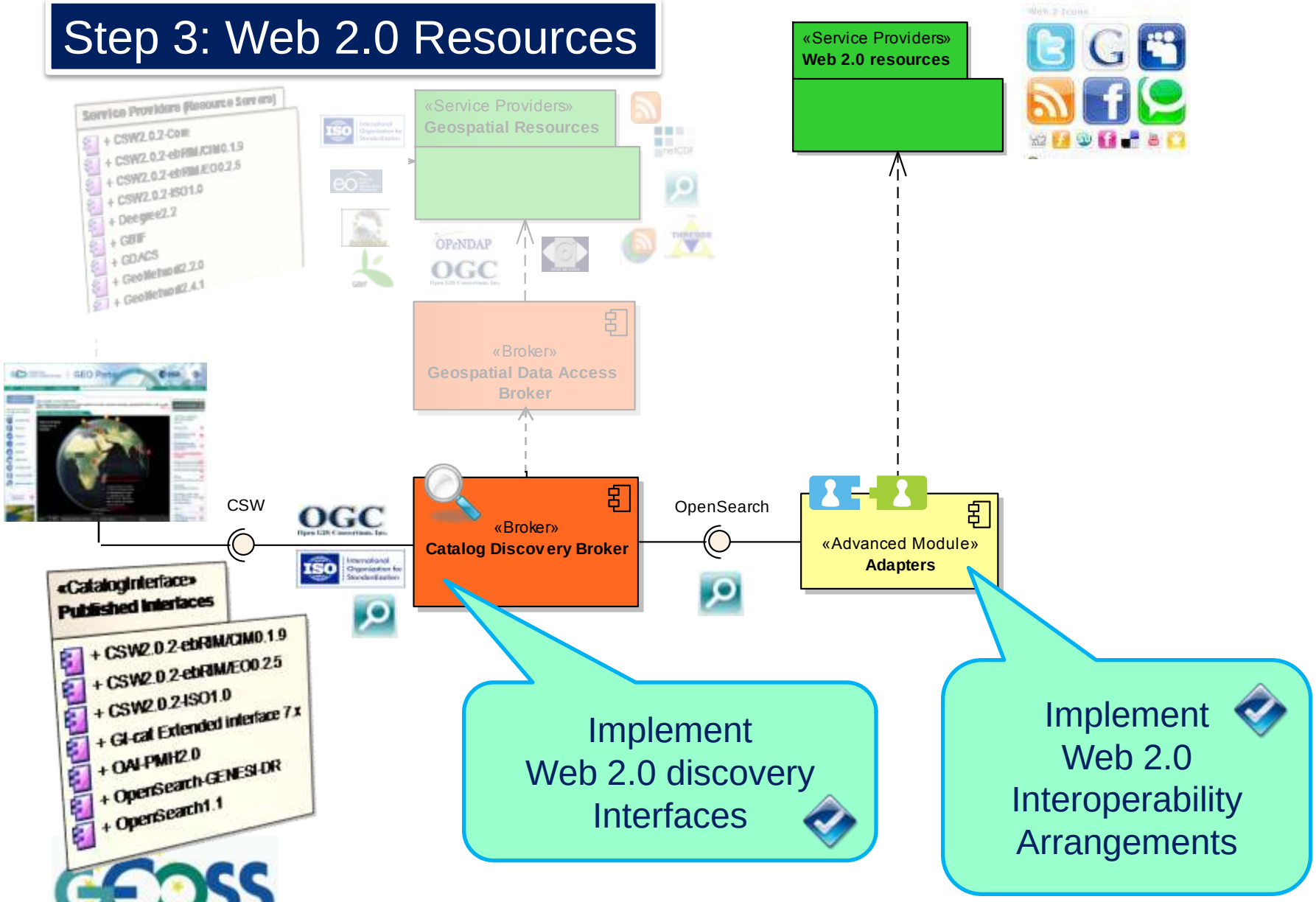

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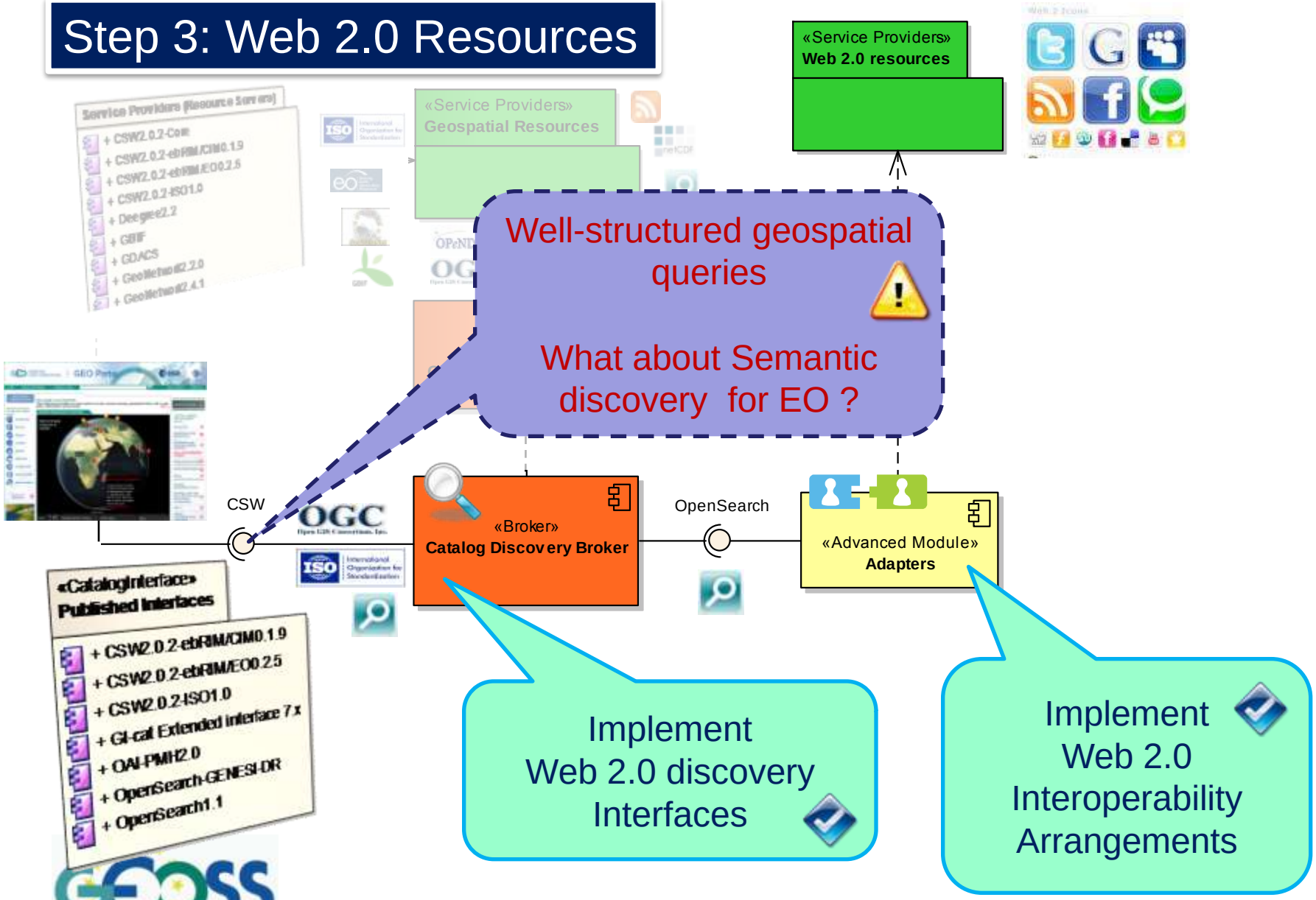
Step 3: Web 2.0 Resources



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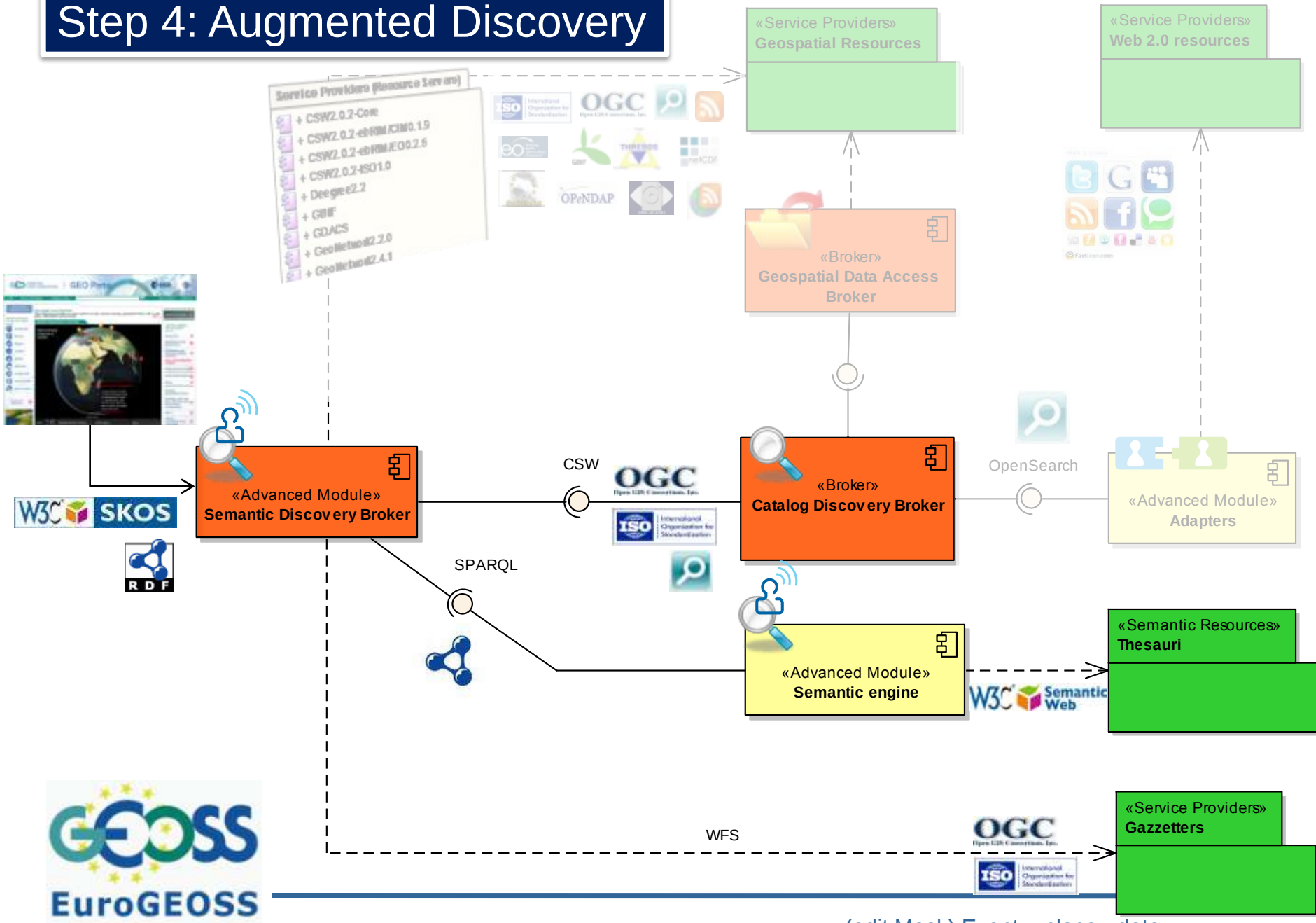
Step 4: Augmented Discovery



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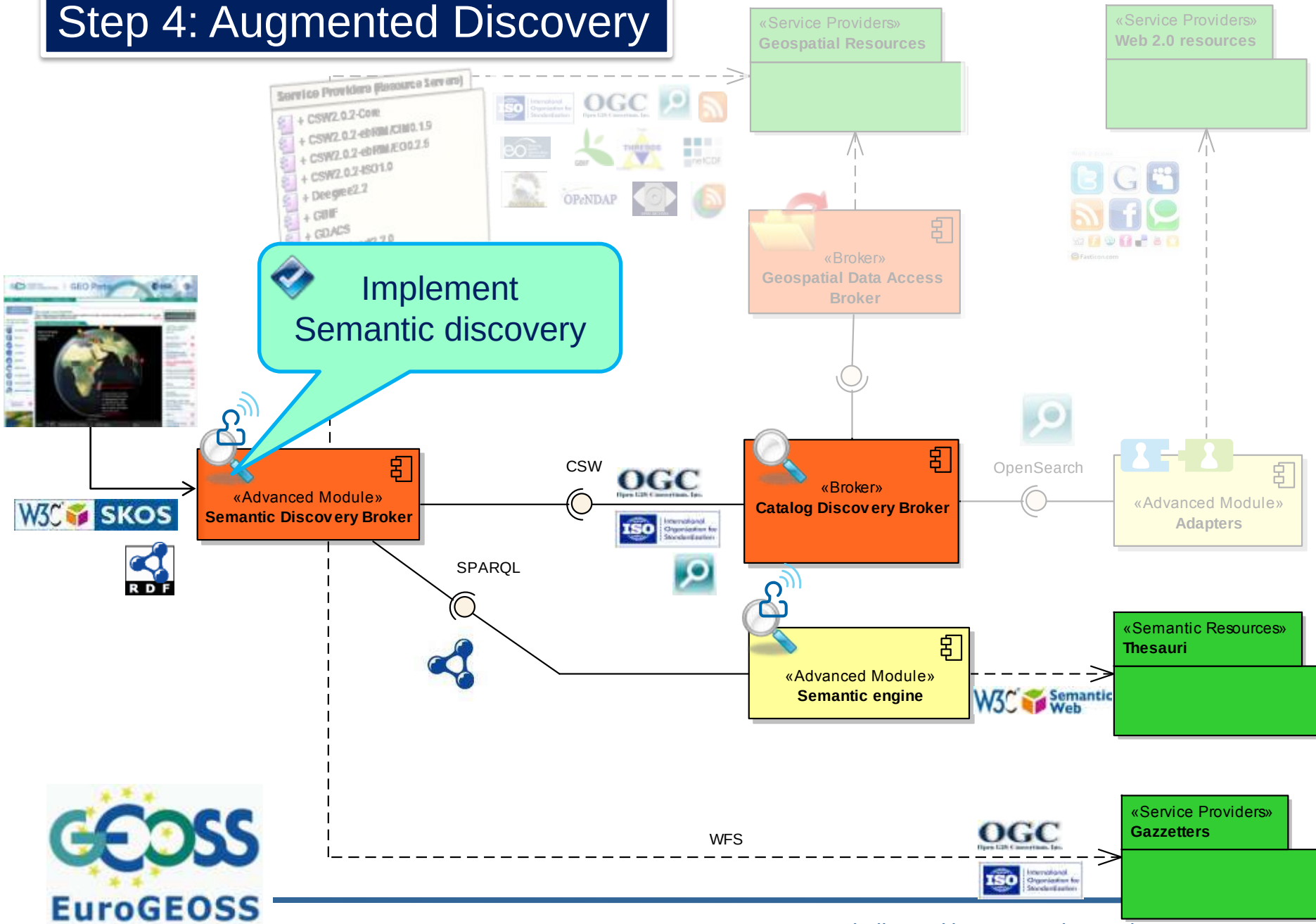

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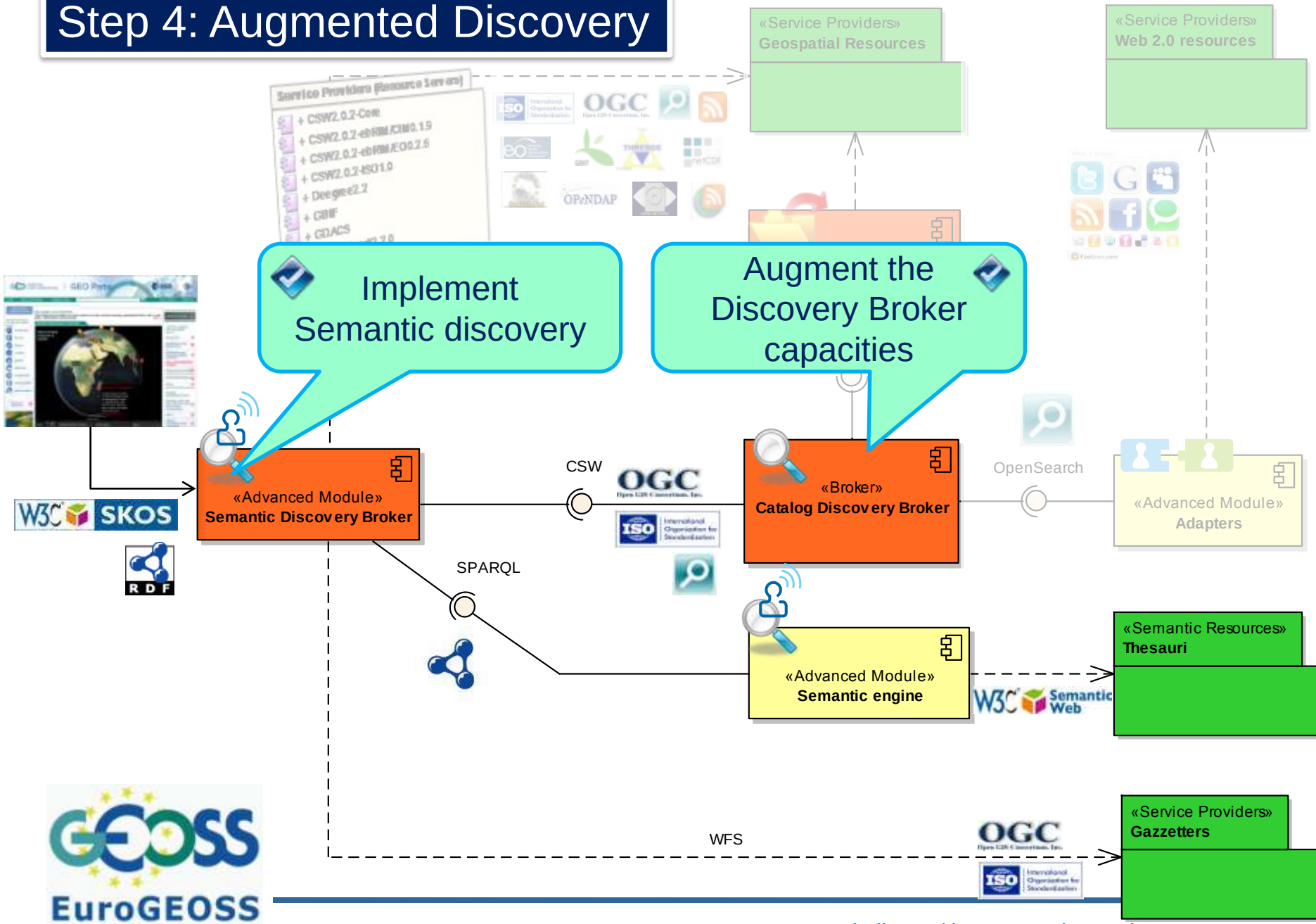

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Step 4: Augmented Discovery

Implement Semantic discovery

Augment the Discovery Broker capacities

«Service Providers» Geospatial Resources

«Service Providers» Web 2.0 resources

«Advanced Module» Semantic Discovery Broker

CSW

«Broker» Catalog Discovery Broker

OpenSearch

«Advanced Module» Adapters

SPARQL

«Advanced Module» Semantic engine

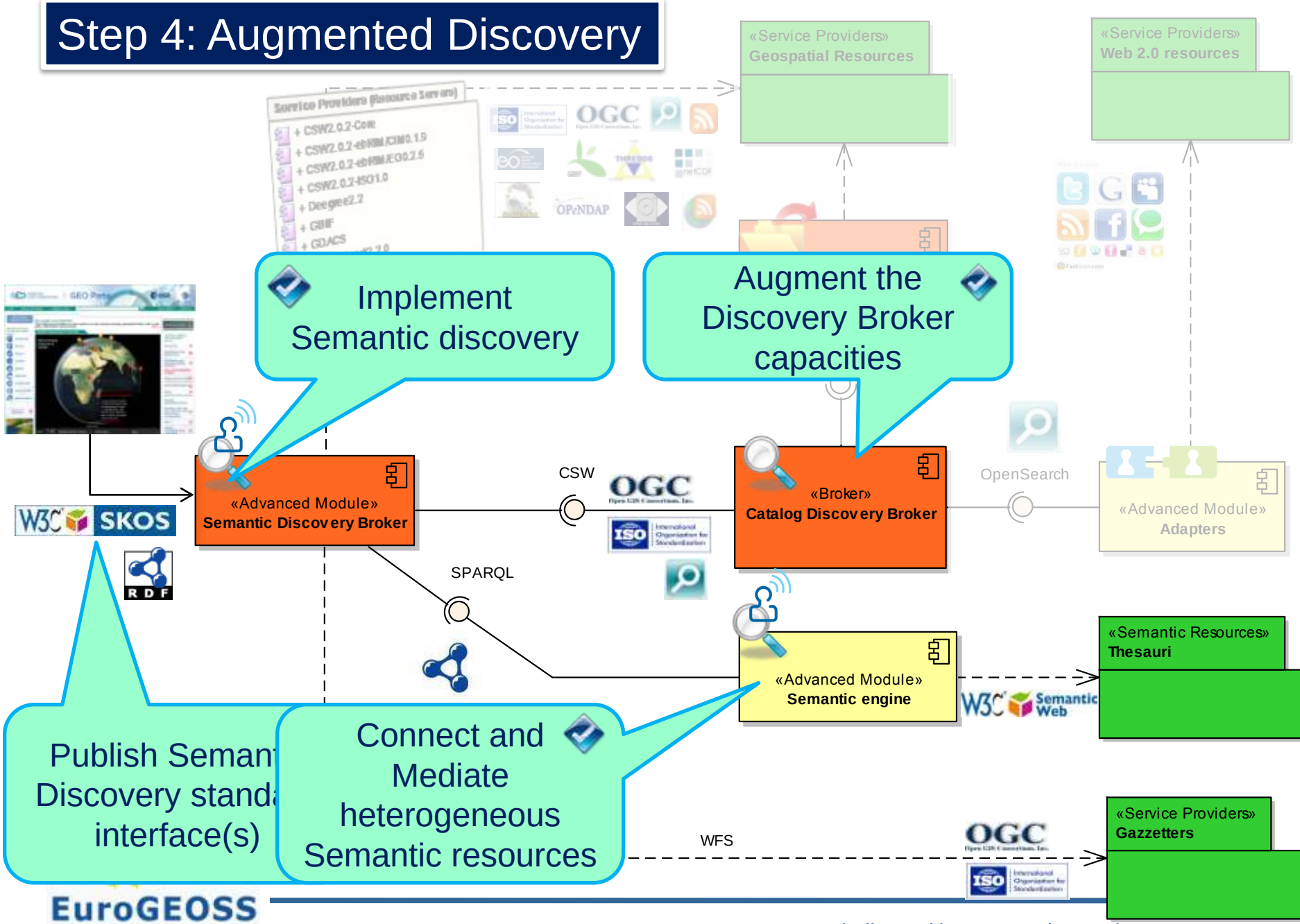
«Semantic Resources» Thesauri

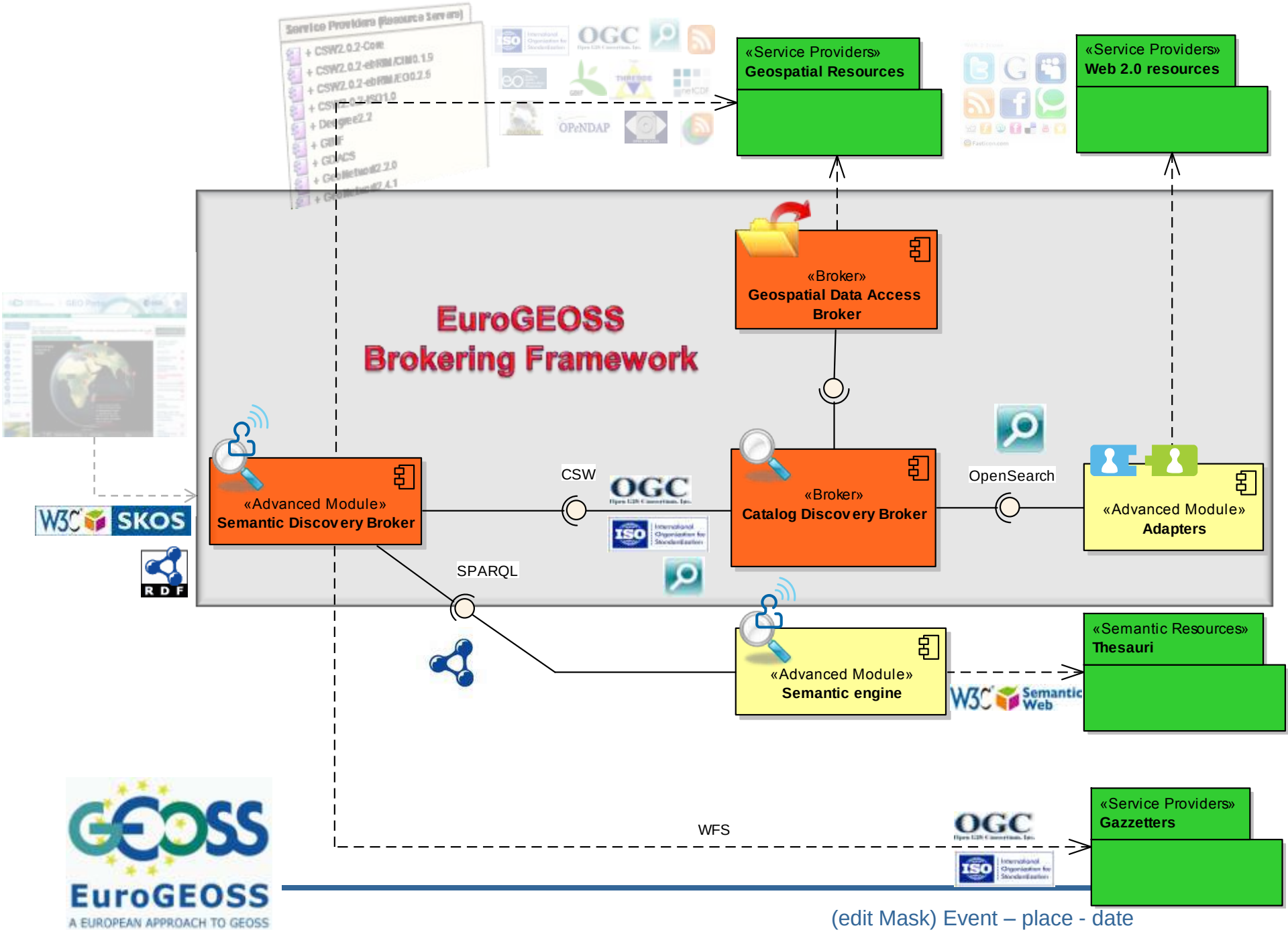
Publish Semantic Discovery standard interface(s)

WFS

«Service Providers» Gazzetters

Step 4: Augmented Discovery




«Service Providers»
Geospatial Resources
«Service Providers»
Web 2.0 resources
EuroGEOSS
Brokering Framework
«Broker»
Geospatial Data Access
Broker
«Advanced Module»
Semantic Discovery Broker
CSW
OGC
«Broker»
Catalog Discovery Broker
OpenSearch
«Advanced Module»
Adapters
SKOS
RDF
SPARQL
«Advanced Module»
Semantic engine
«Semantic Resources»
Thesauri
Semantic Web
WFS
«Service Providers»
Gazzetters
GEOSS
EuroGEOSS
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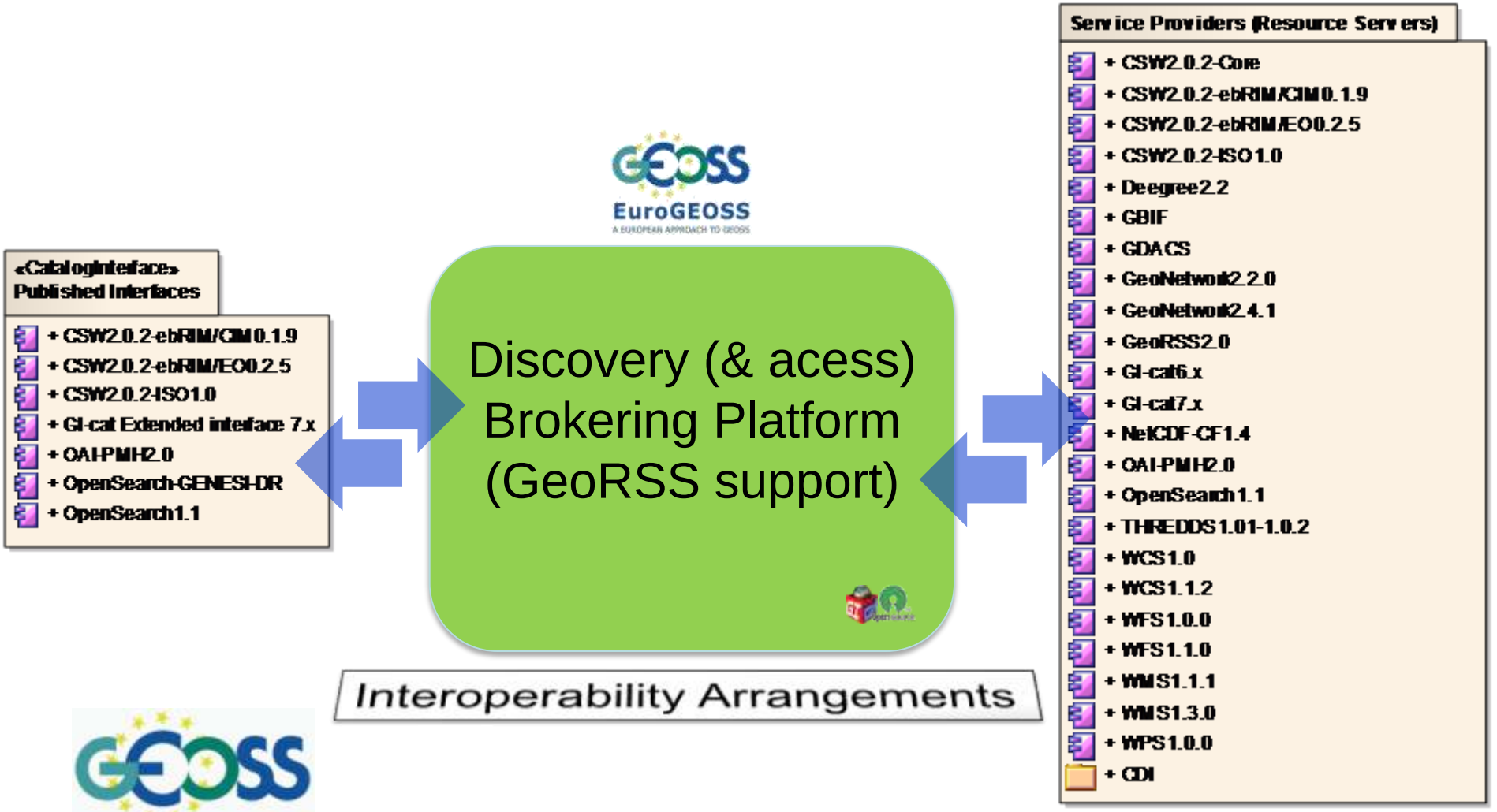
Empowered by 

DISCOVERY (& ACCESS) BROKER

Provided Interfaces & Supported Resource types



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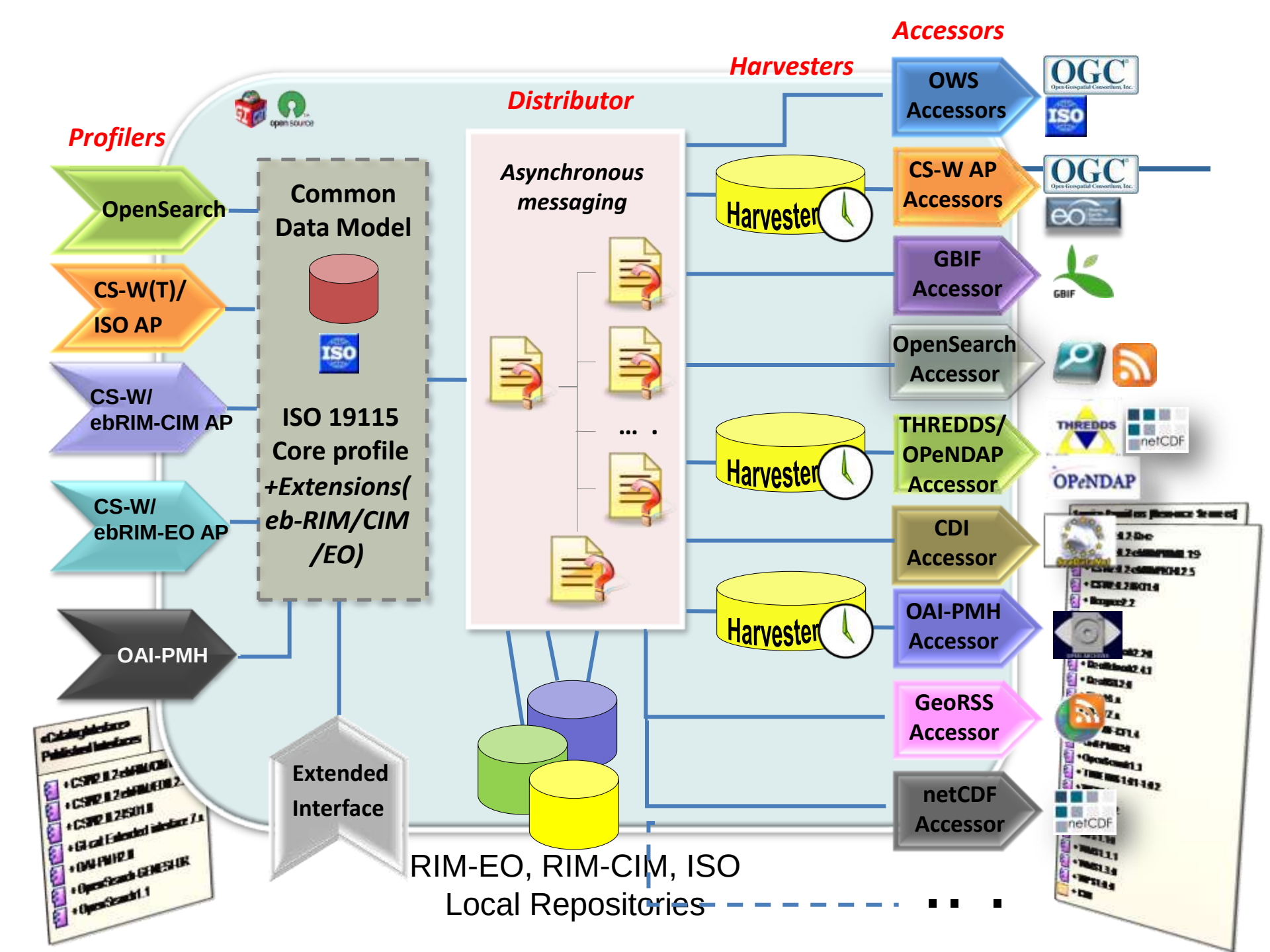
Accessors
Harvesters
Distributor
Profilers
OWS Accessors
CS-W AP Accessors
GBIF Accessor
OpenSearch Accessor
THREDDS/ OPeNDAP Accessor
CDI Accessor
OAI-PMH Accessor
GeoRSS Accessor
netCDF Accessor
Harvester
Harvester
Harvester
Asynchronous messaging
OpenSearch
CS-W(T)/ ISO AP
CS-W/ ebRIM-CIM AP
CS-W/ ebRIM-EO AP
OAI-PMH
Common Data Model
ISO 19115 Core profile +Extensions(eb-RIM/CIM /EO)
Extended Interface
RIM-EO, RIM-CIM, ISO
Local Repositories

Brokering framework: new Resource types supported

- OAI-PMH 2.0
- DublinCore
- ISO 19139
- DIF 9.7.1 (Data Interchange Format)
- netCDF-CF 1.4
- THREDDS (1.0.1, 1.0.2)
- GDACS
  (Global Disaster Alert and
  Coordination System)
- WAF (Web Application Firewalls/FTP)

. . .

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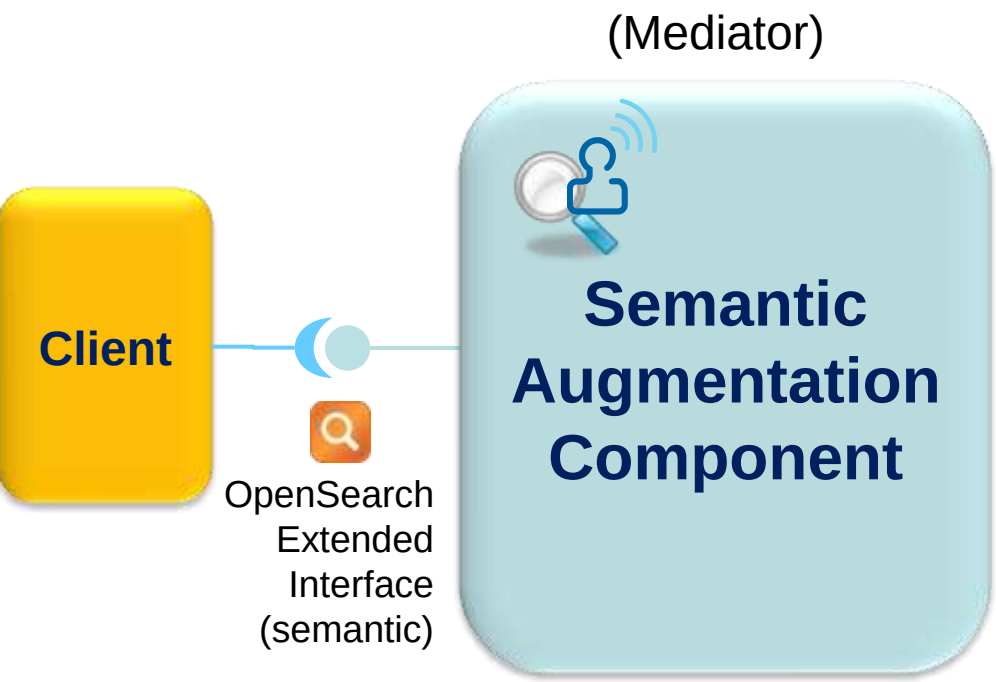
In collaboration with GENESIS

AUGMENTED (SEMANTIC) DISCOVERY

Semantic Augmentation



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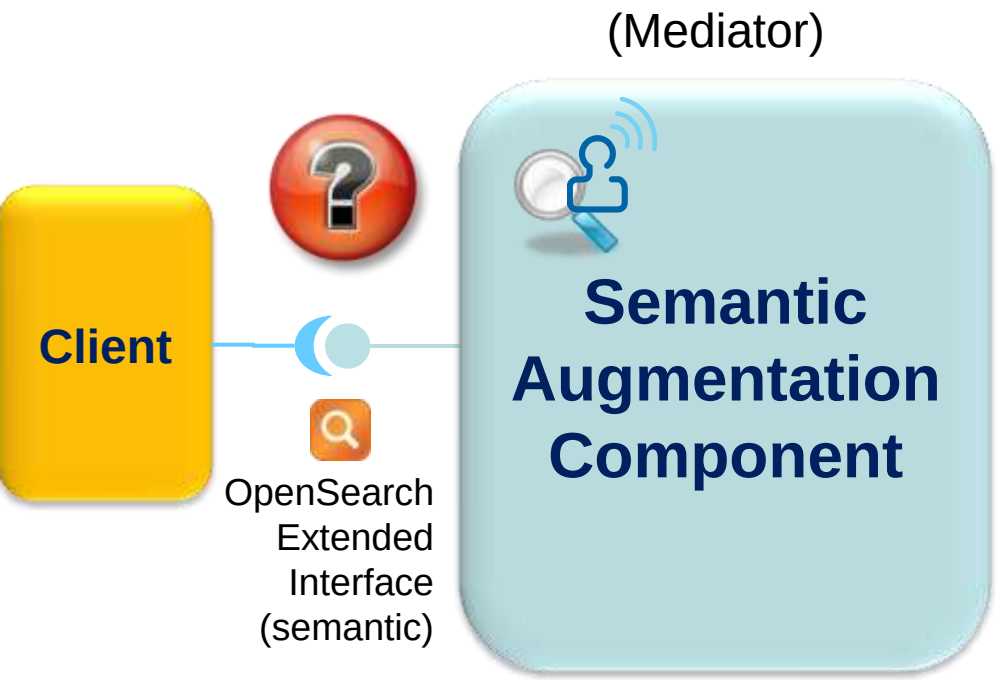
Semantic Augmentation



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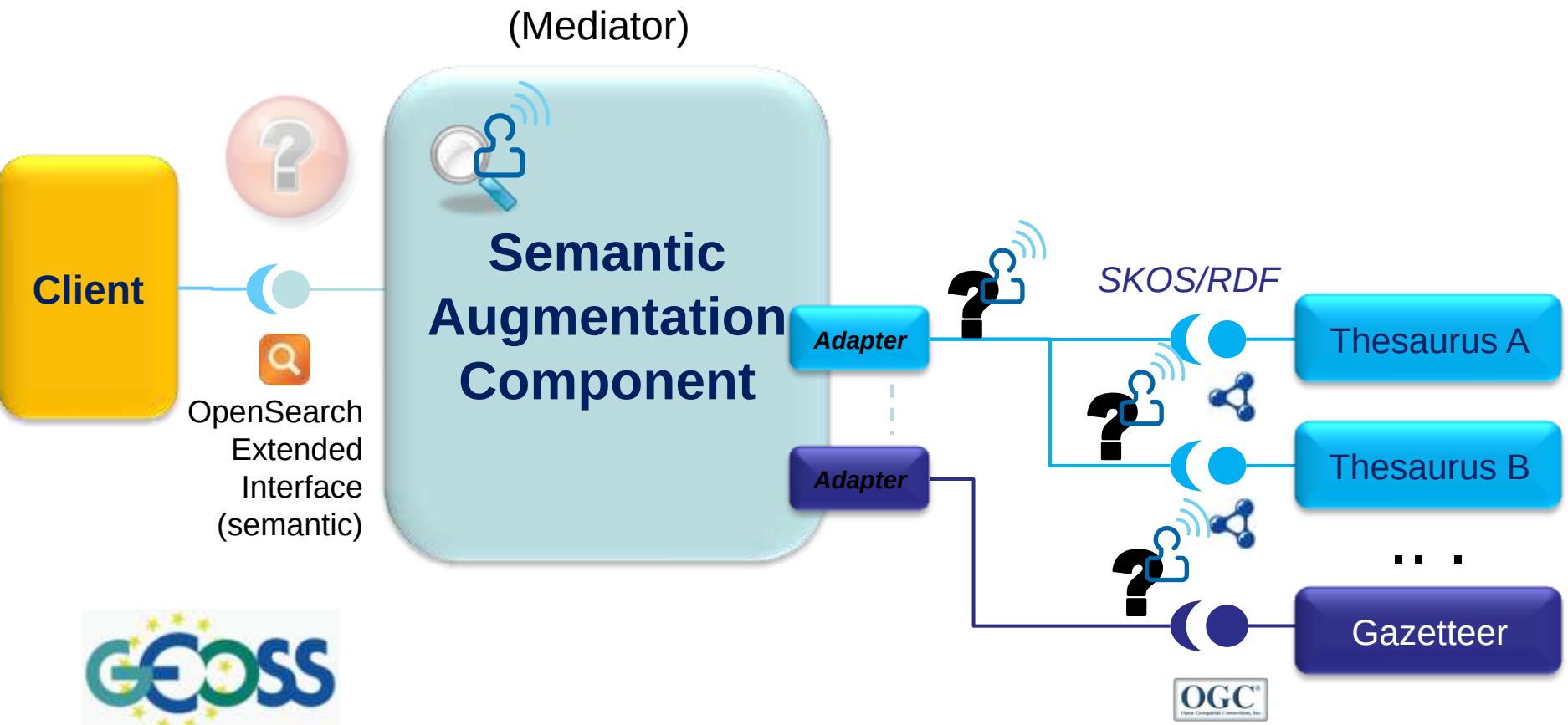
Semantic Augmentation



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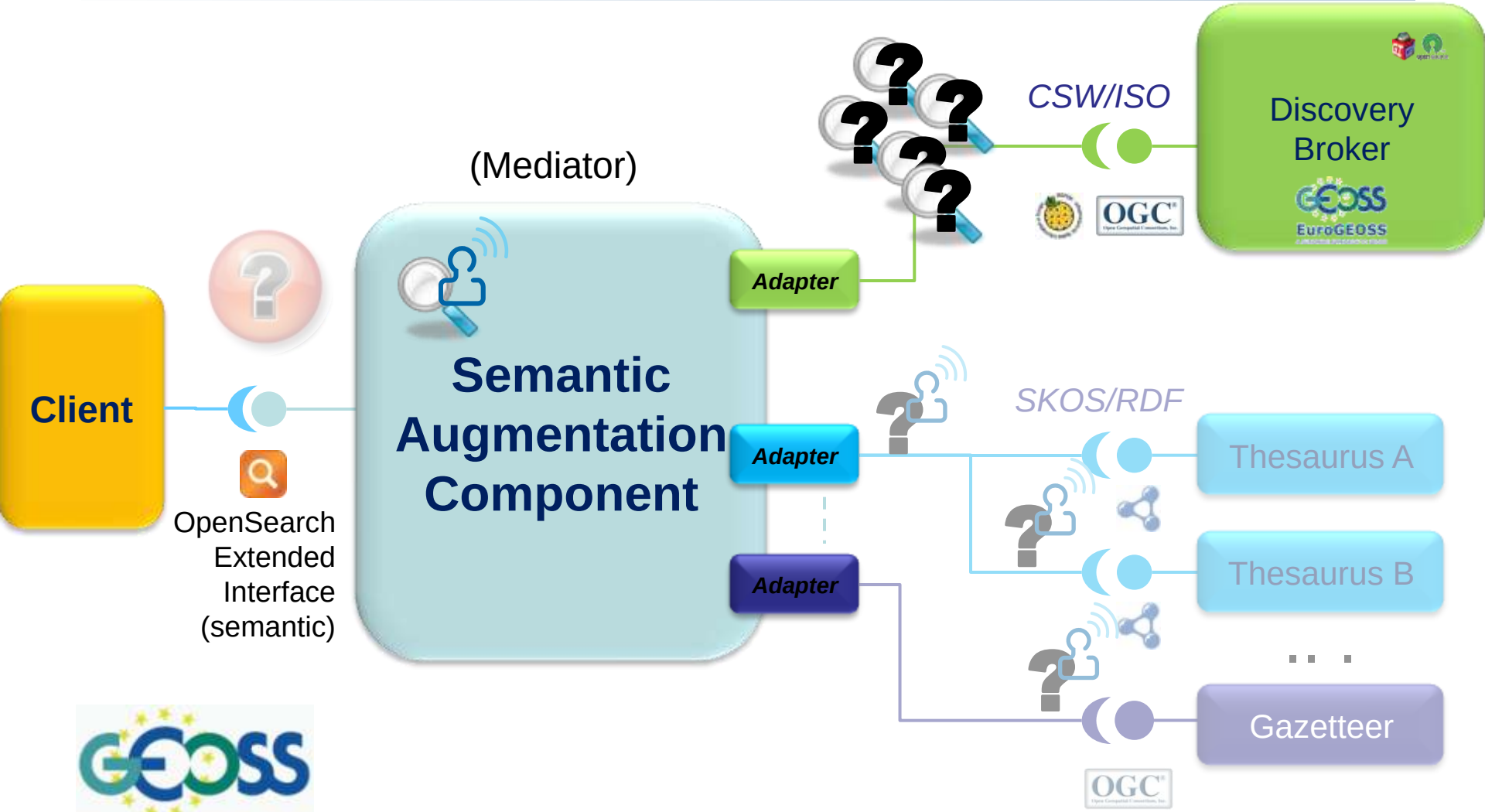
Semantic Augmentation



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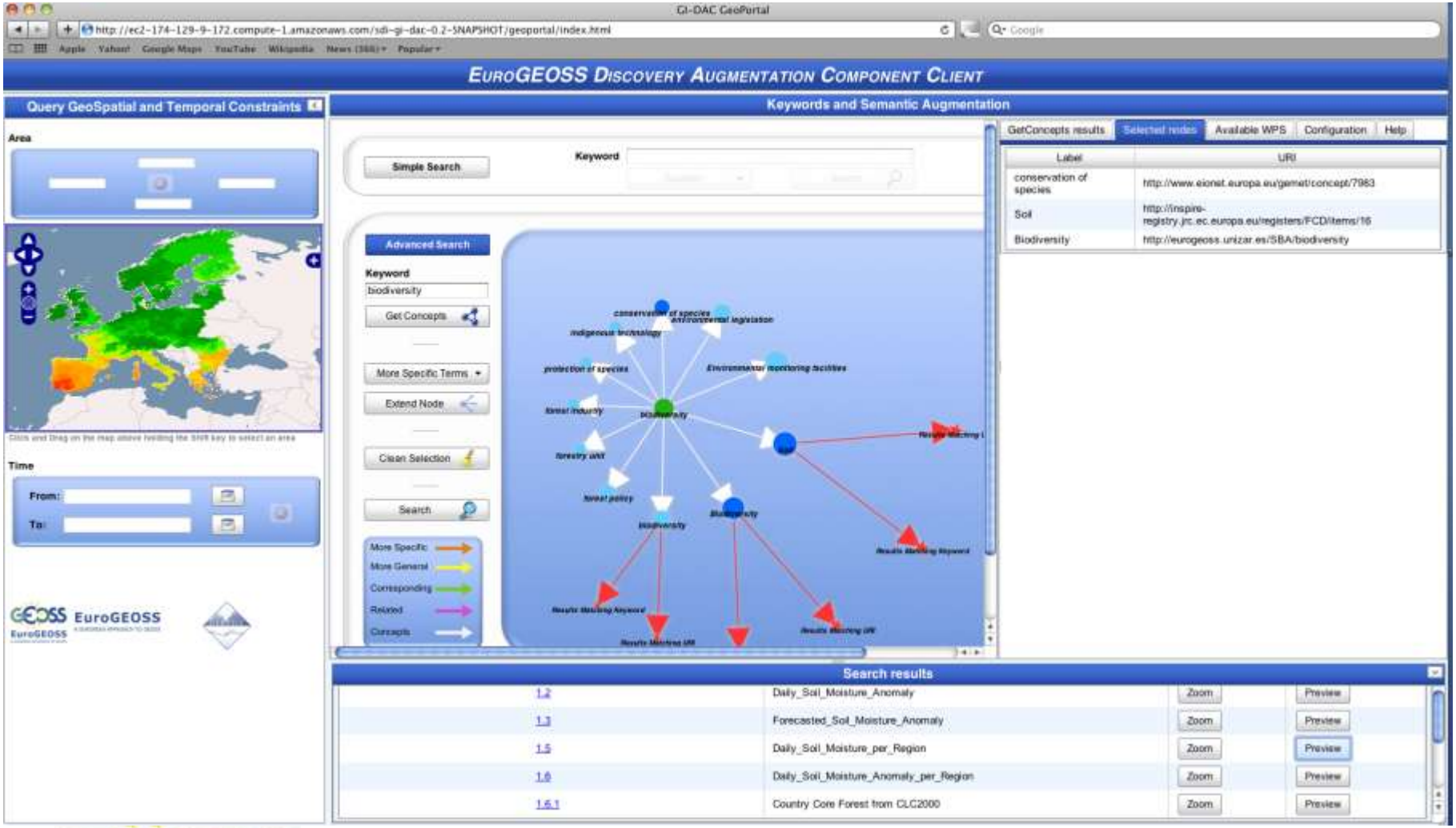
Concepts discovery by semantic network browsing

Concepts discovery by semantic network browsing



COMMON GRID DATA ACCESS

Data Access

- Data Access functionality is composed of:
  - Data pre-processing functionalities to “normalize” data
    - Sub-setting (i.e. trimming, slicing)
    - Format conversion
    - CRS transformation
    - Data Interpolation
    - ….
  - Data Download functionalities
    - Synchronous and asynchronous downloads
    - RESTful and SOAP bindings

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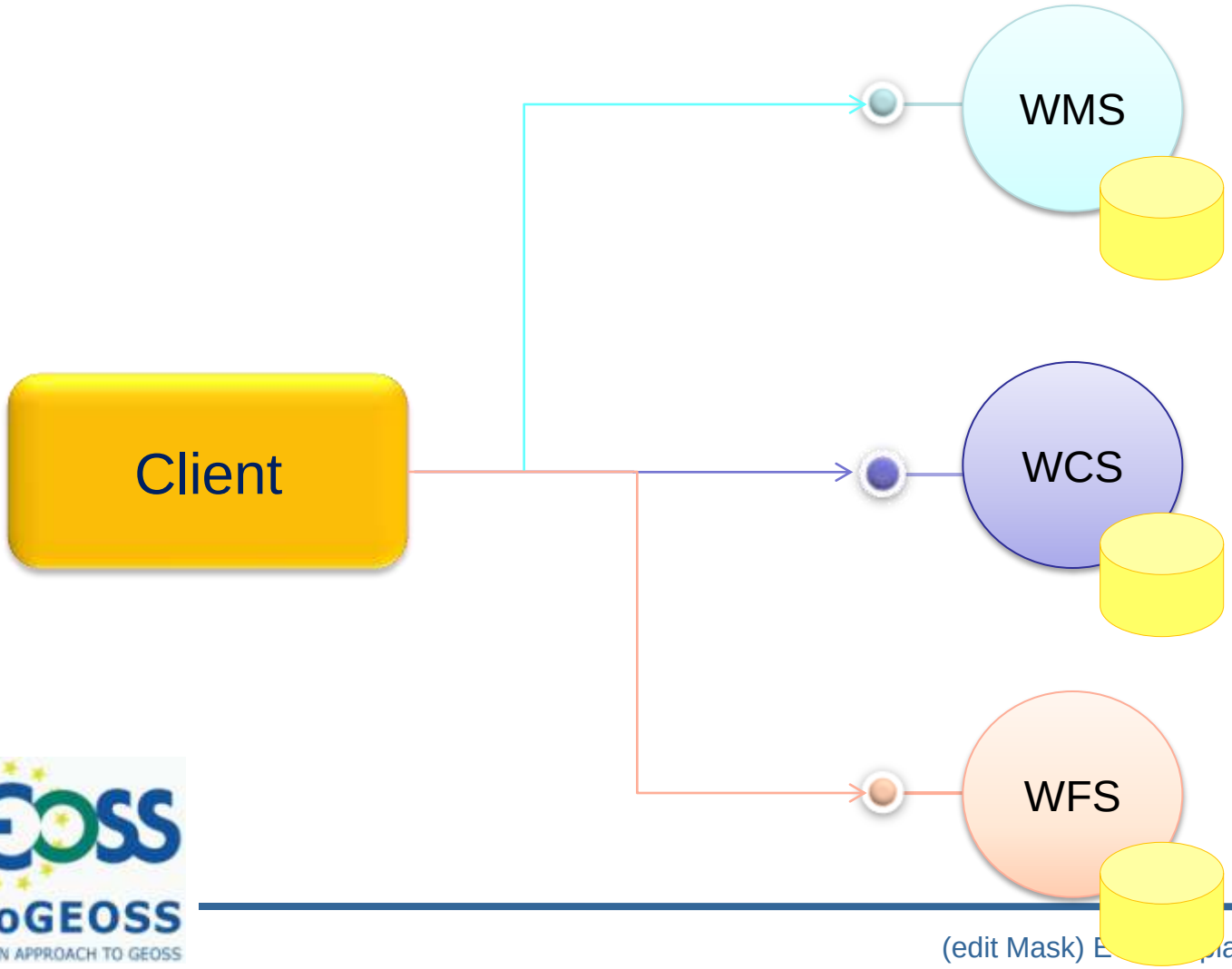
EuroGEOSS IOC



EuroGEOSS
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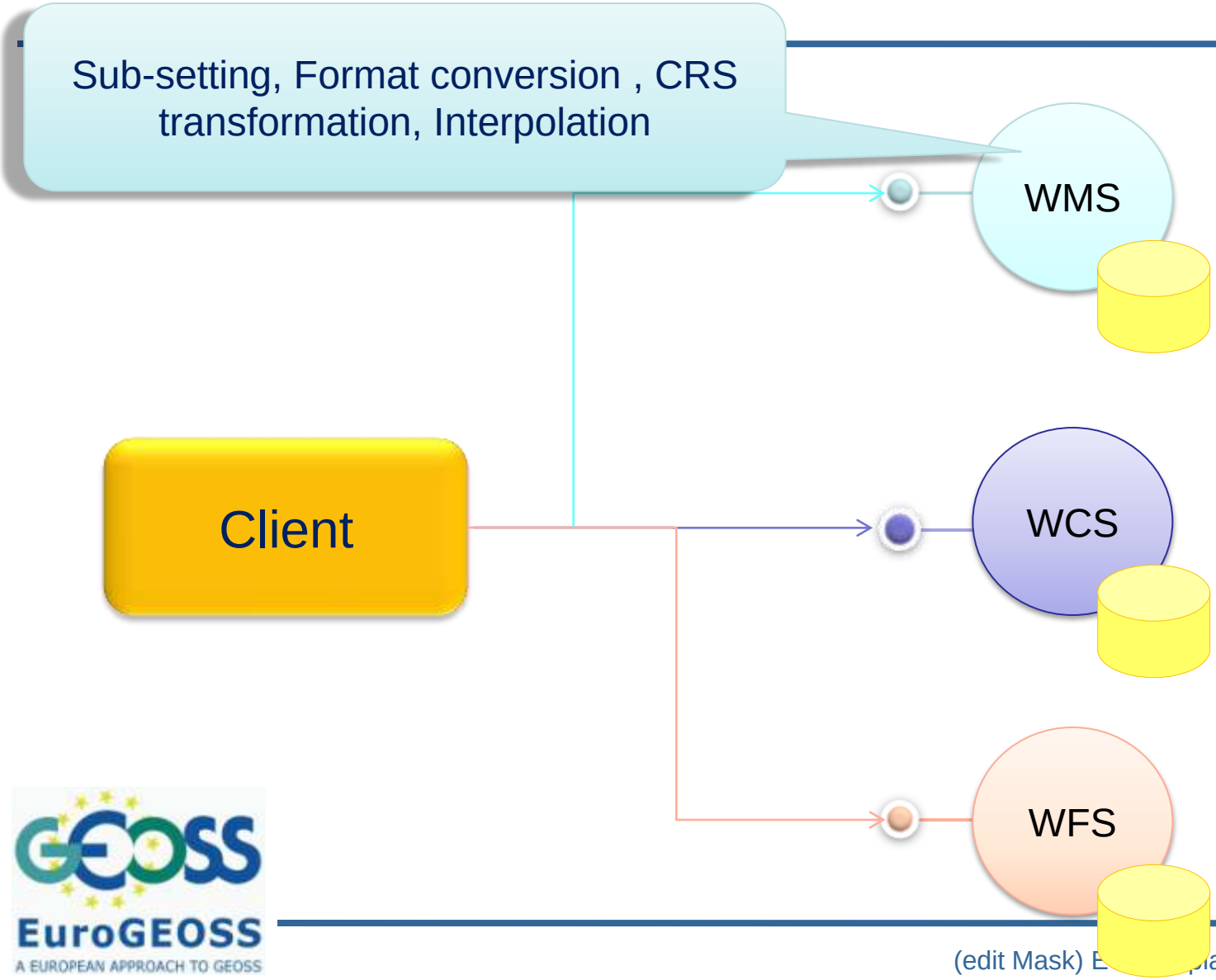
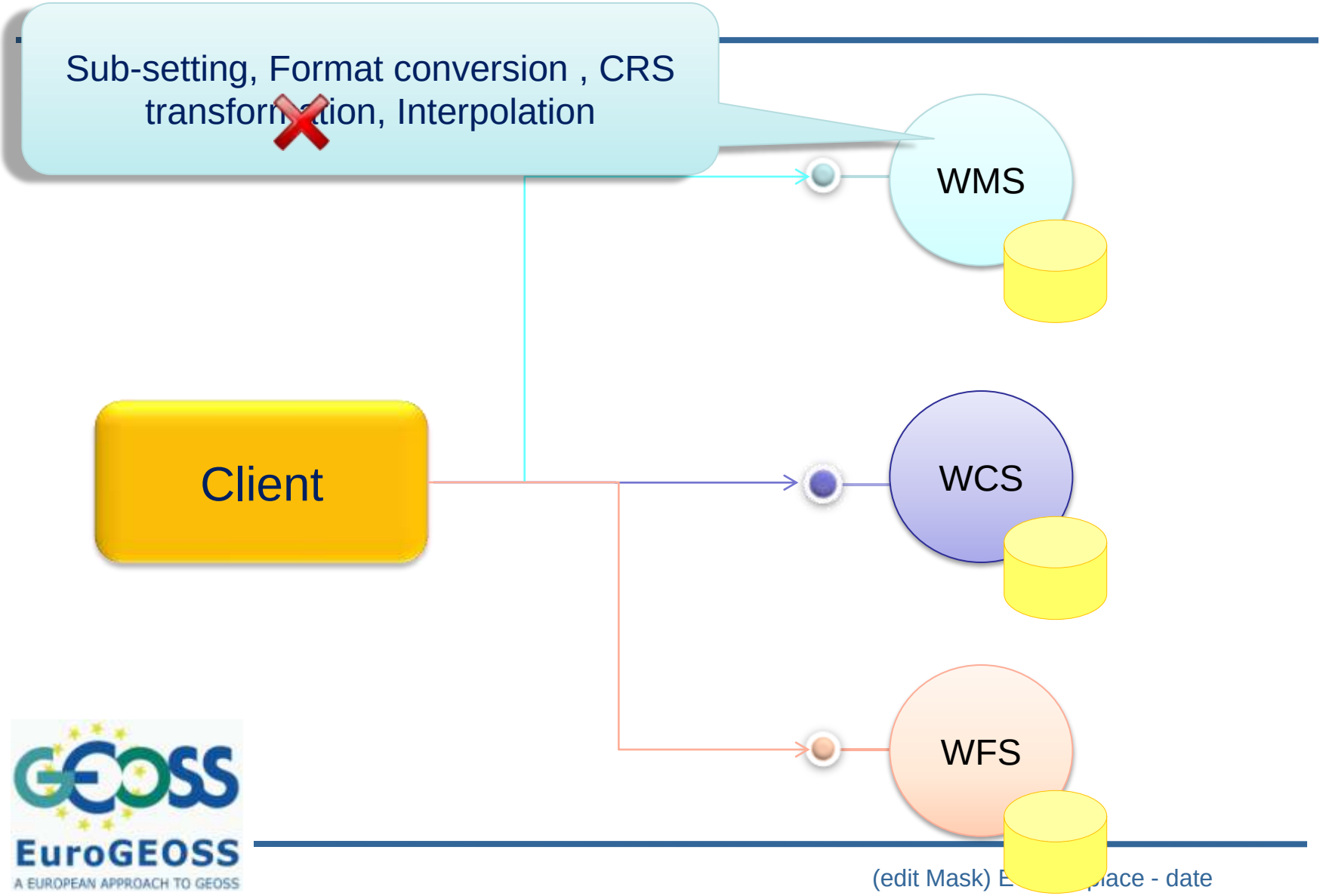
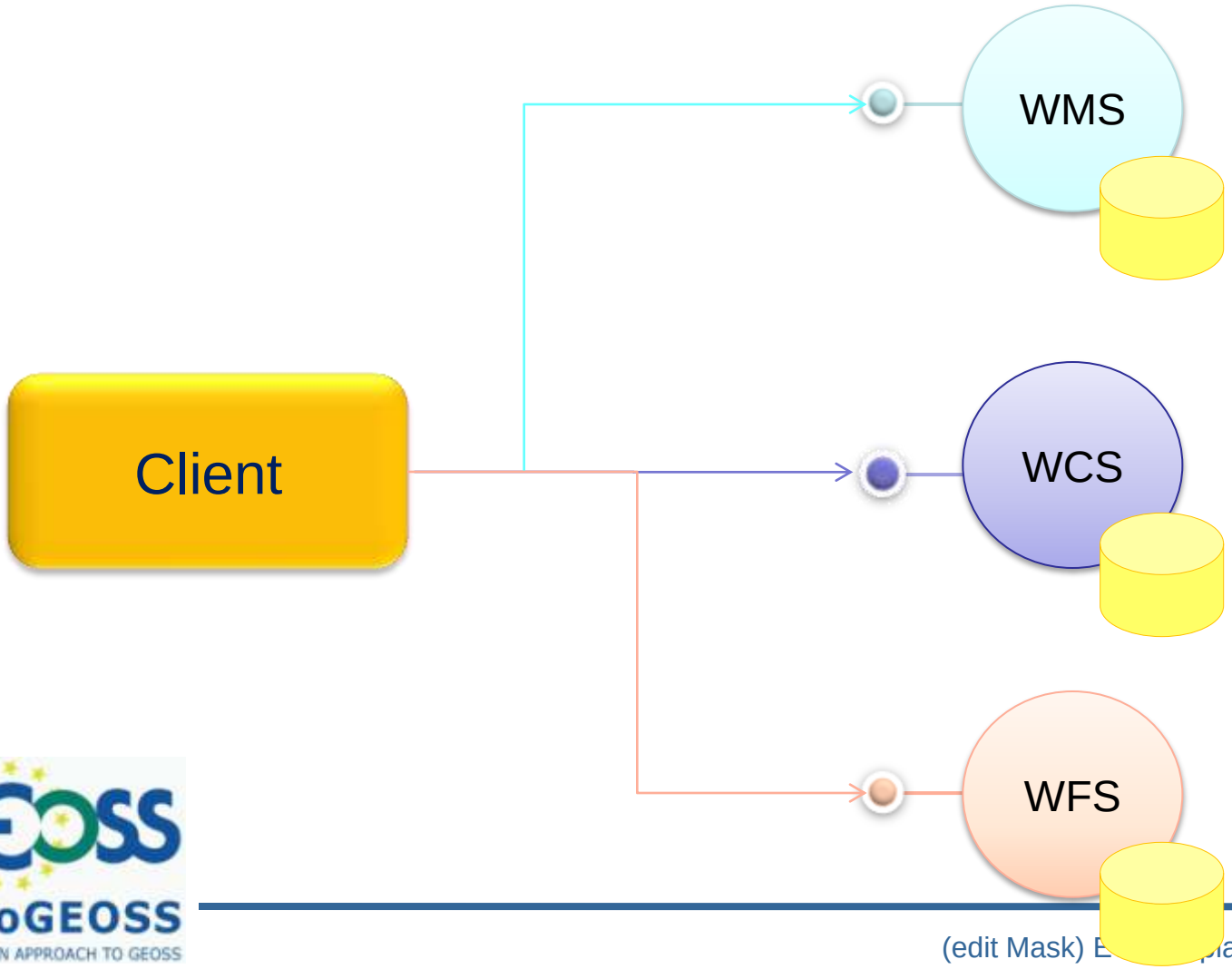
EuroGEOSS IOC



EuroGEOSS IOC



EuroGEOSS IOC



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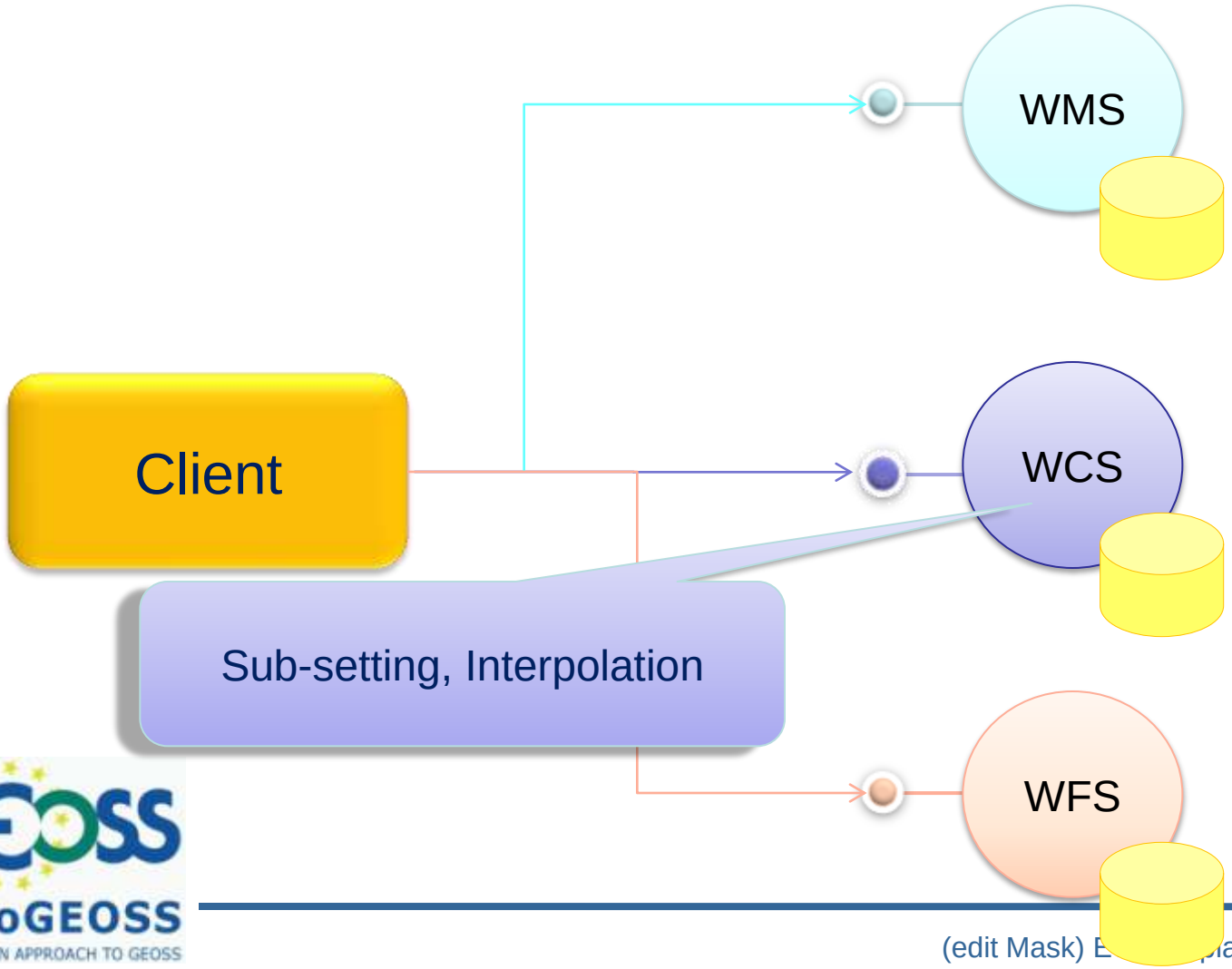

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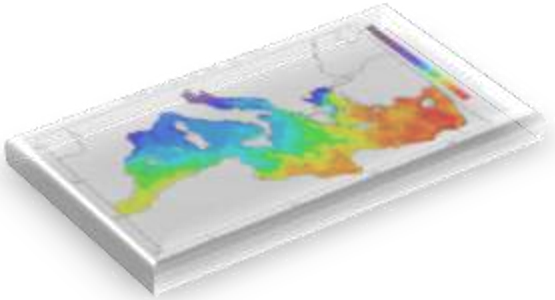

Client

Sub-setting, Interpolation

WMS

WCS

WFS

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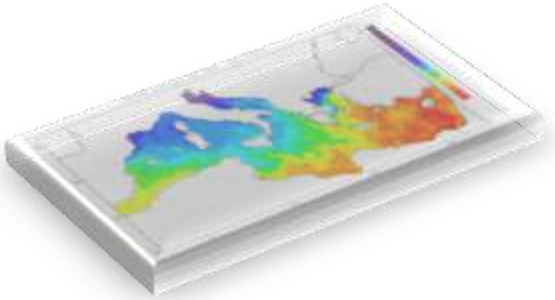
EuroGEOSS IOC



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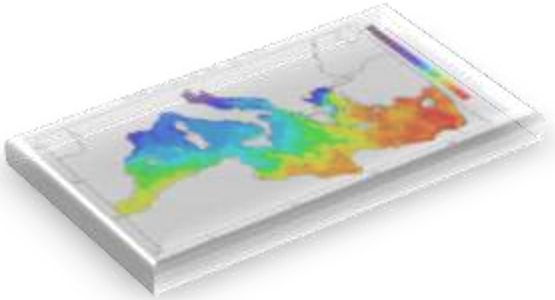

Client

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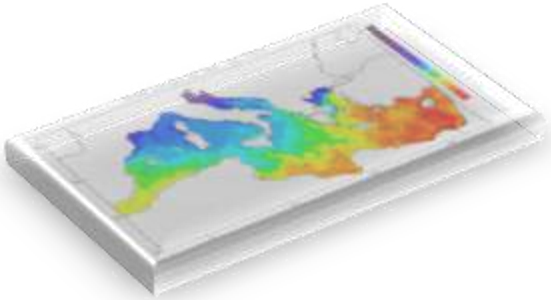
Sub-setting, Format conversion , Interpolation

EuroGEOSS IOC



Client

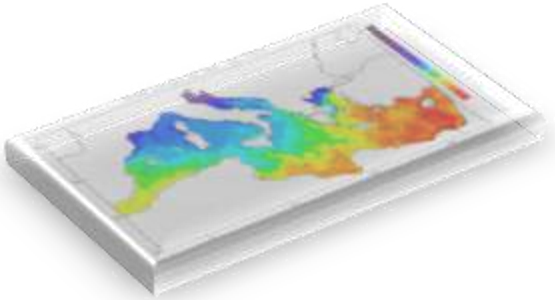
WMS

WCS

WFS

Sub-setting, Format conversion , Interpolation

EuroGEOSS IOC



Client

WMS

WCS

WFS

AOC: Requirements and Objective

- To develop an access framework which does not supplant but complete existing access systems/services
- A flexible framework to allow CoPs to use their pre-processing components/services –where required
- To be compliant with the INSPIRE transformation implementing rules

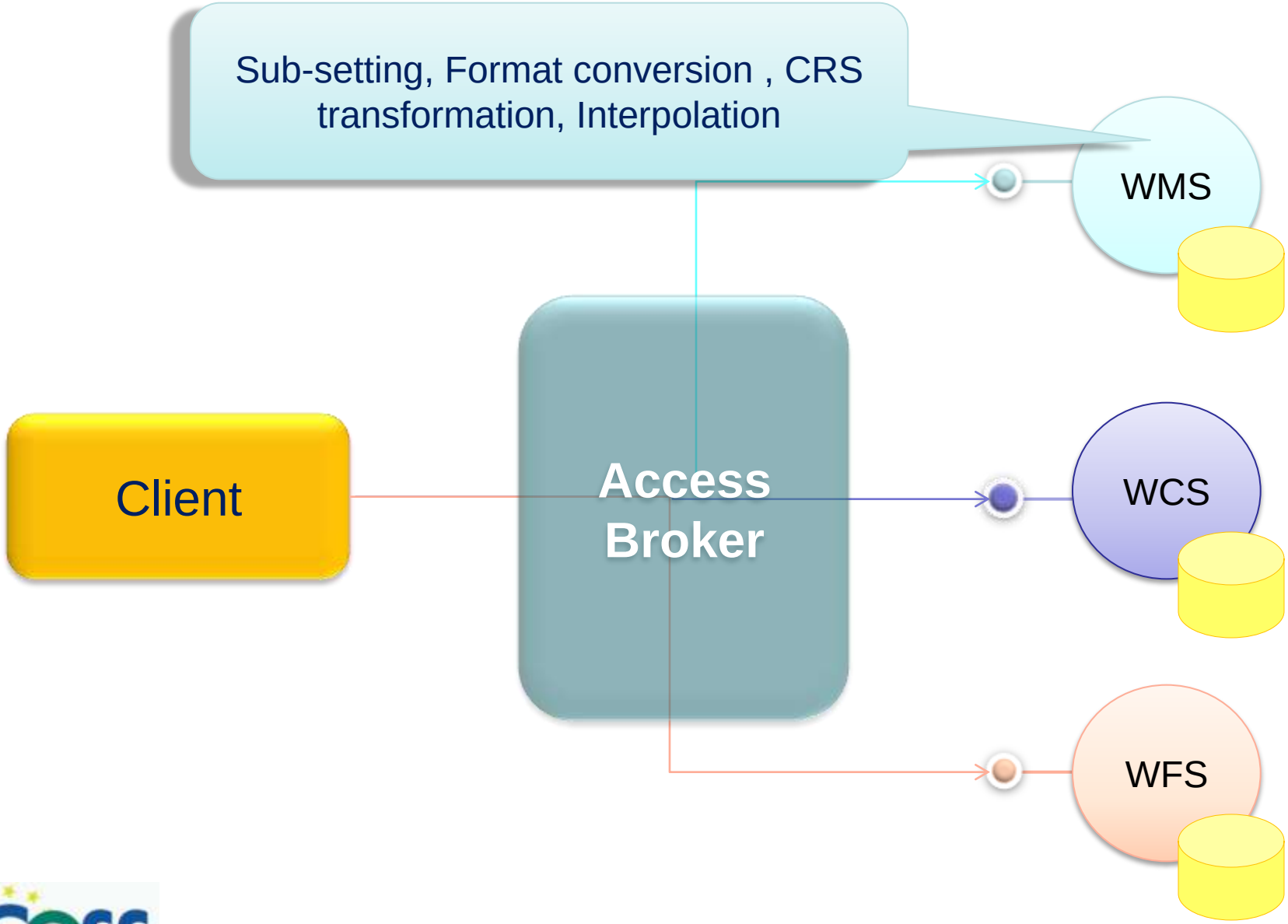
EuroGEOSS
A EUROPEAN APPROACH TO GEOSS

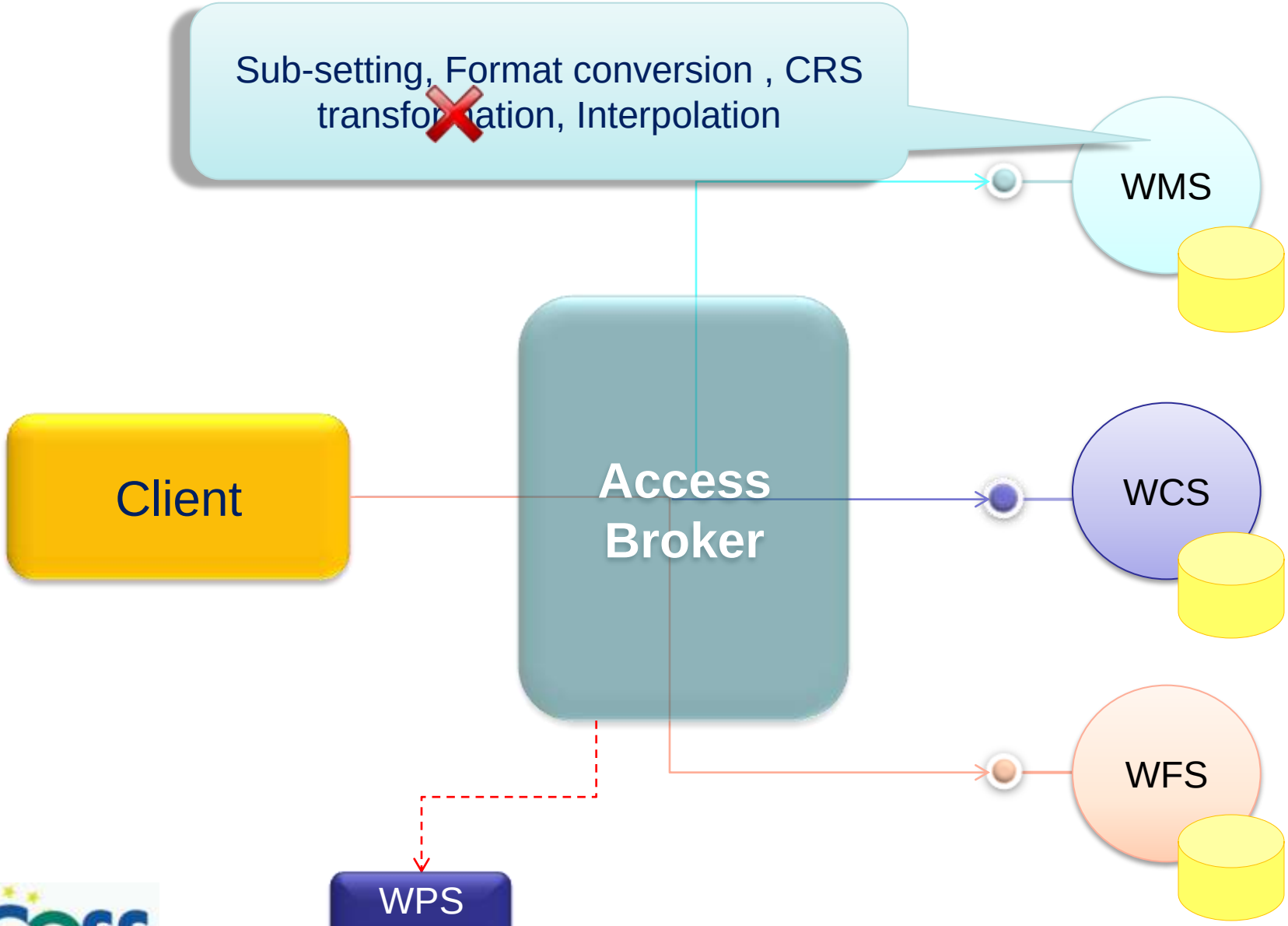
AOC: Requirements and Objective

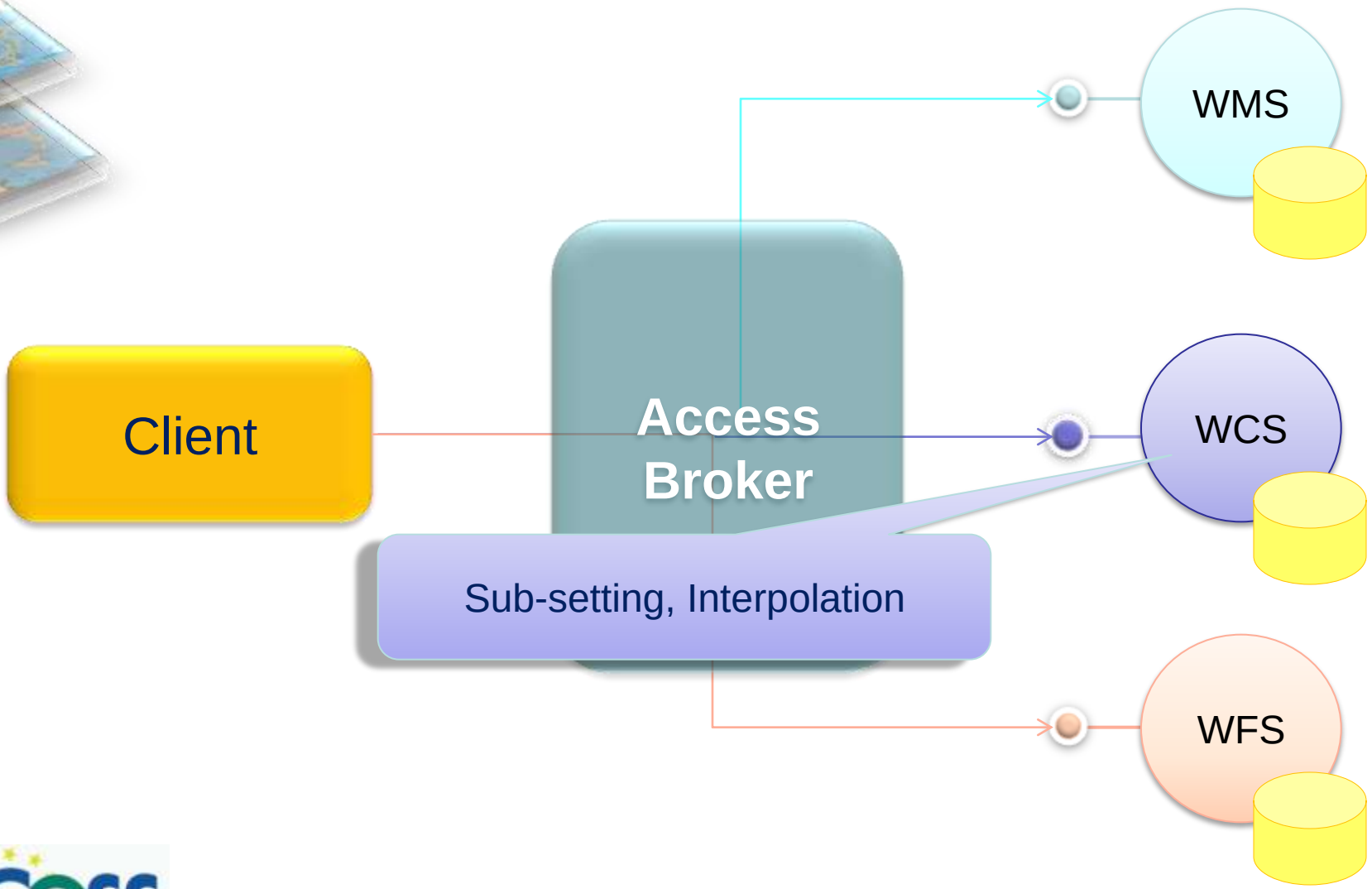
- To develop an access framework which does not supplant but complete existing access systems/services
- A flexible framework to allow CoPs to use their pre-processing components/services –where required
- To be compliant with the INSPIRE transformation implementing rules

A broker system which implements the necessary mediations to make use of existing and future data pre-processing services –to “normalize” discovered data

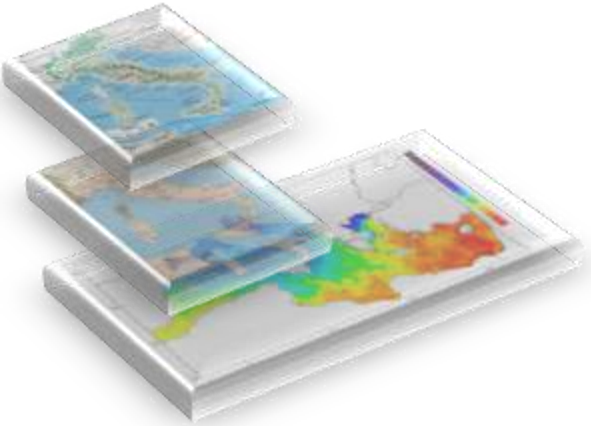
EuroGEOSS
A EUROPEAN APPROACH TO GEOSS


Sub-setting, Format conversion , CRS transformation, Interpolation
WMS
Client
Access Broker
WCS
WFS


Sub-setting, Format conversion , CRS transformation, Interpolation
WMS
Client
Access Broker
WCS
WFS
WPS
reprojection
OGC



EuroGEOSS
A EUROPEAN APPROACH TO GEOSS



Client

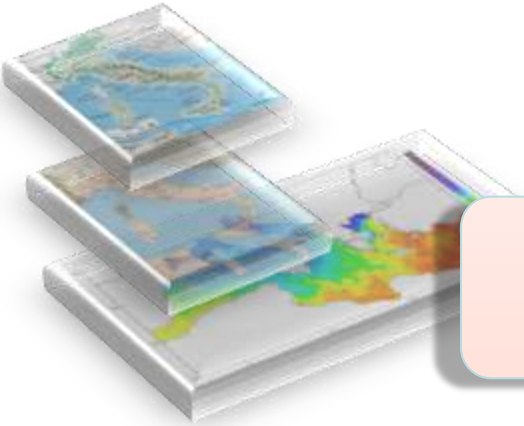
Access Broker

WMS

WCS

WFS

EuroGEOSS
A EUROPEAN APPROACH TO GEOSS



Sub-setting, Format conversion , Interpolation

Client

Access Broker

WMS

WCS

WFS

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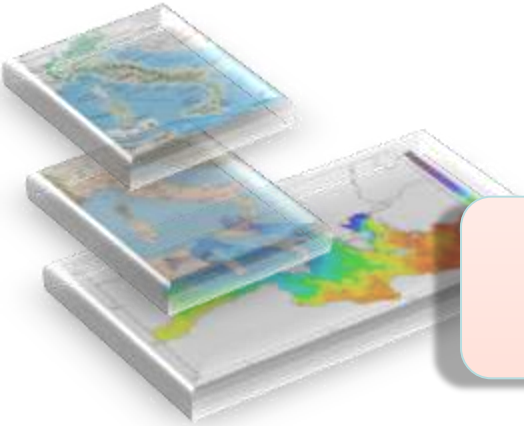
A EUROPEAN APPROACH TO GEOSS



Sub-setting, Format conversion , Interpolation

Client

Access Broker

WMS

WCS

WFS

MATLAB
Web Service

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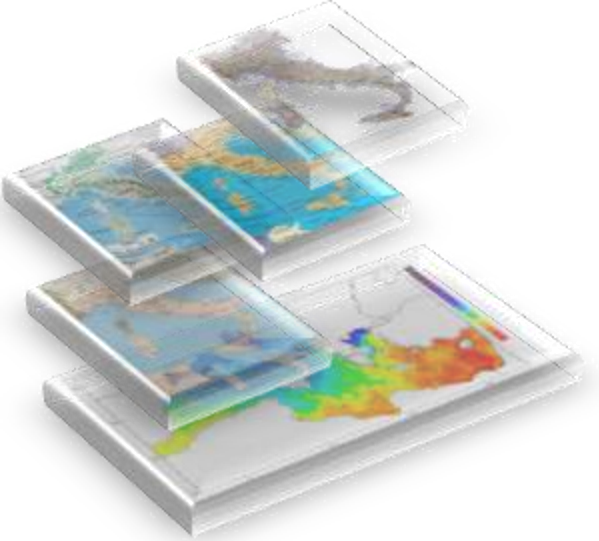
A EUROPEAN APPROACH TO GEOSS



Client

Access Broker

WMS

WCS

WFS

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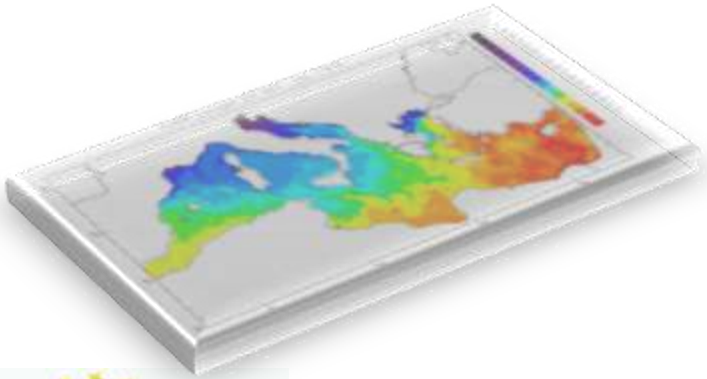
A EUROPEAN APPROACH TO GEOSS

AOC:
Client → Access Broker → Access Services

IOC:
Client → Access Services



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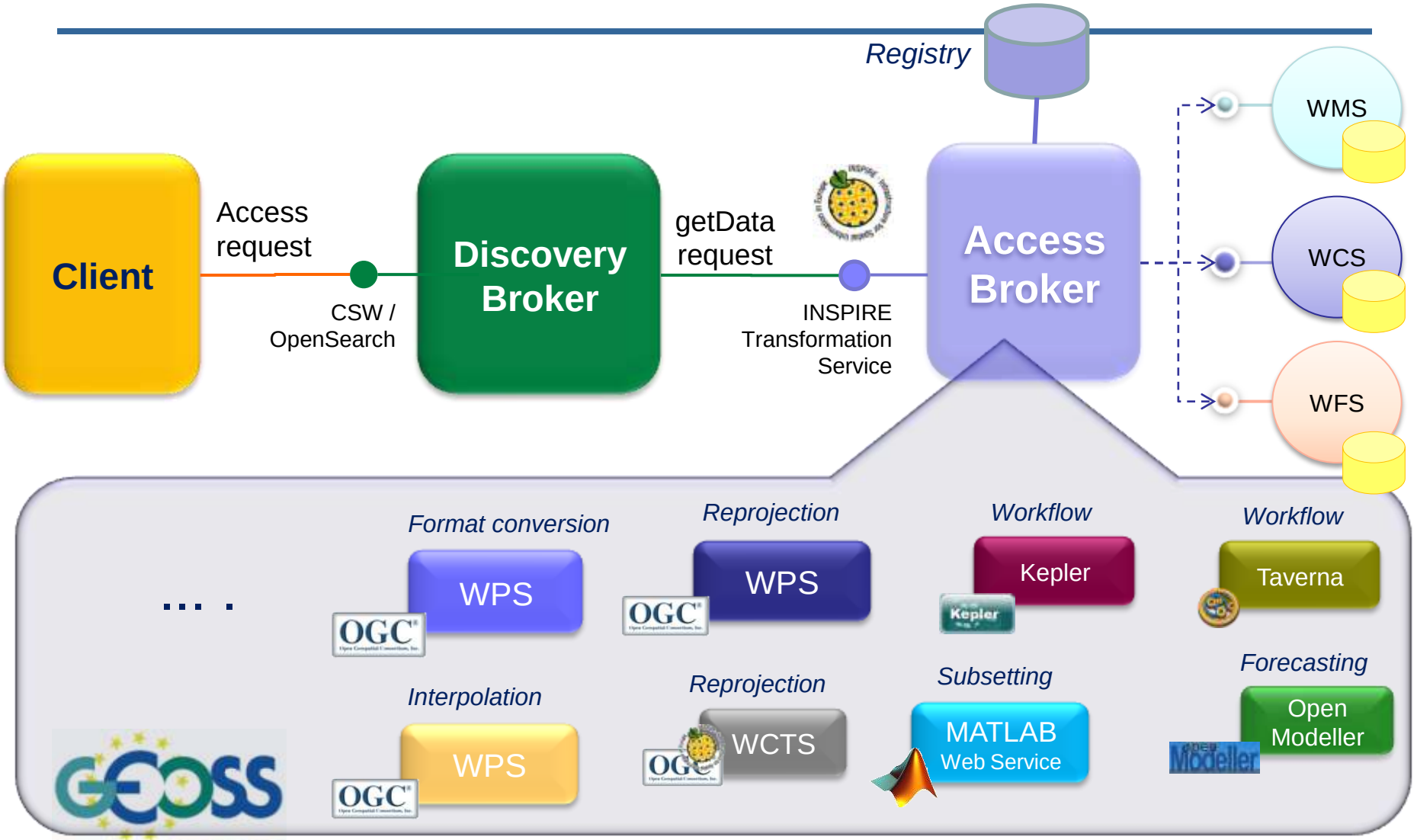
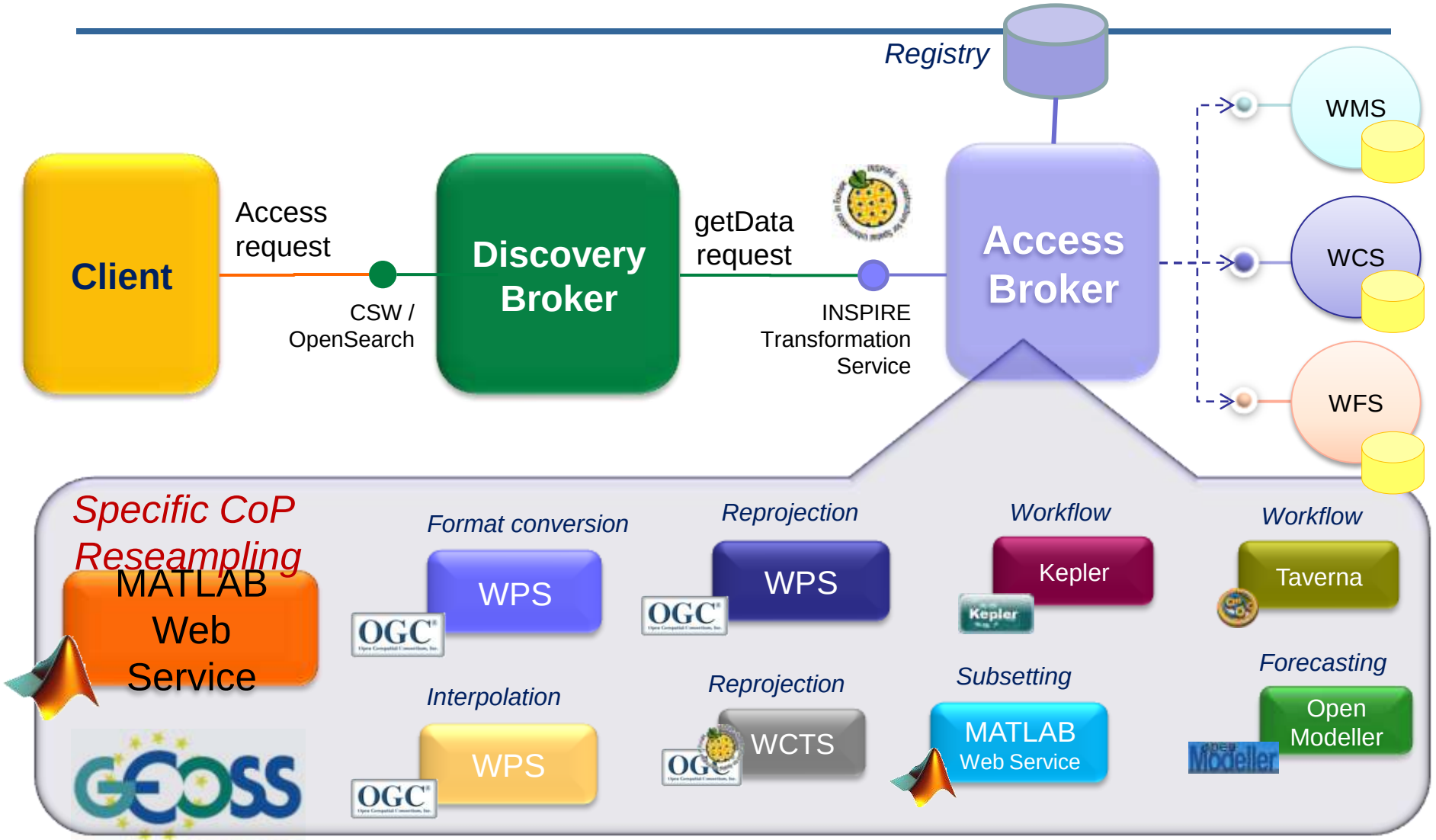
Access Broker: the Context



Access Broker: the Context



WEB 2.0 RESOURCES DISCOVERY

Web 2.0 services considered

Service Name	Available content type
Twitter	short texts
Google Search API	Vector data (KML format)
Panoramio	Raster data (photographs)
Picasa	Raster data (photographs)
Flickr	Raster data (photographs)
OpenStreetMap	Vector data (OSM format)
Wikimapia	Text (place names & descriptions)
Geonames	Text (place names)
Geocommons	Raster and vector data (maps)
Wikipedia	Through Geonames

[Source: EuroGEOSS D2.6.1 (L. Díaz, C. Granell, O. Fonts, J. Gil)]

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[Source: EuroGEOSS D2.6.1 (L. Díaz, C. Granell, O. Fonts, J. Gil)]

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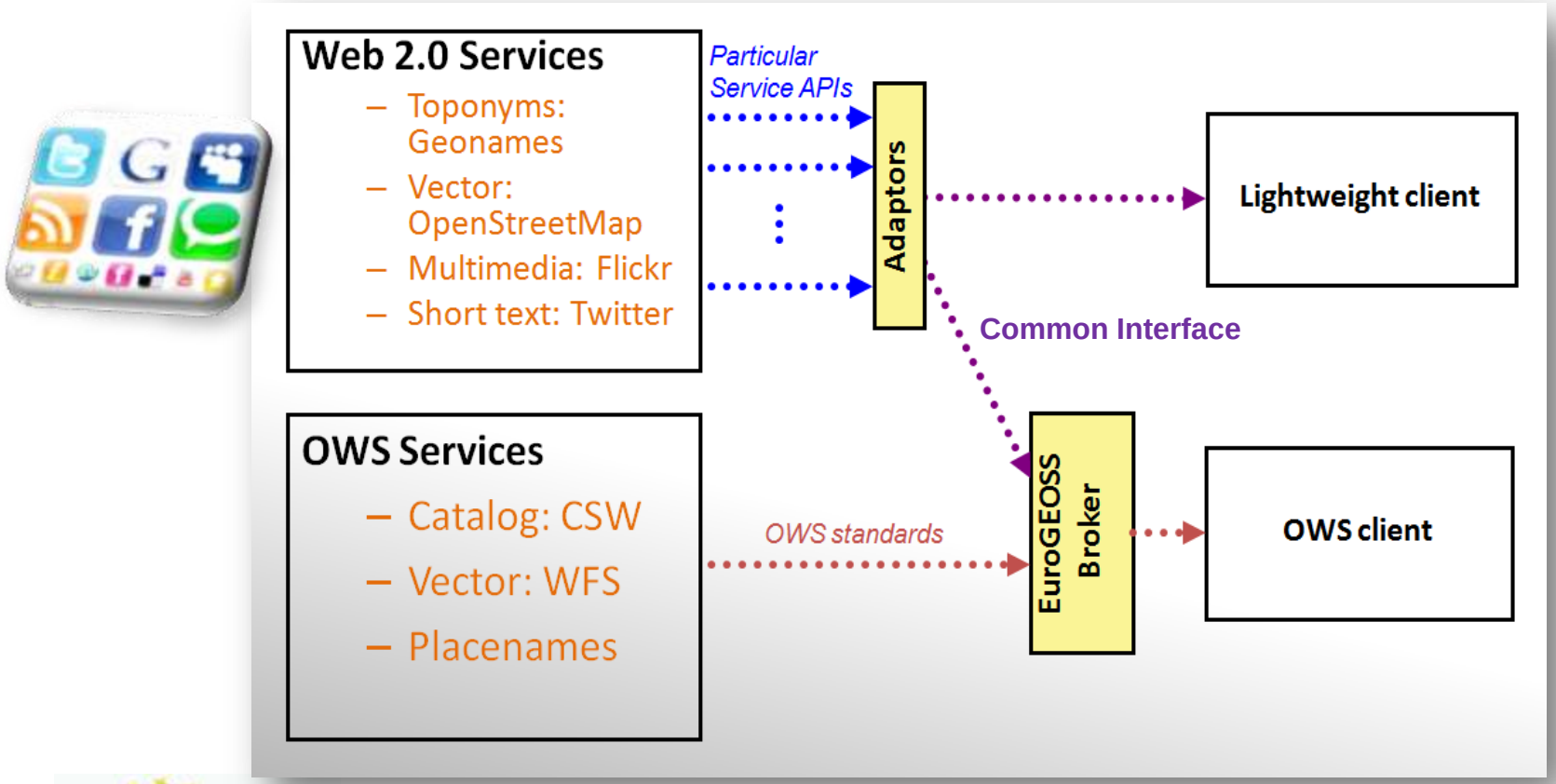
Web 2.0 service Adaptors



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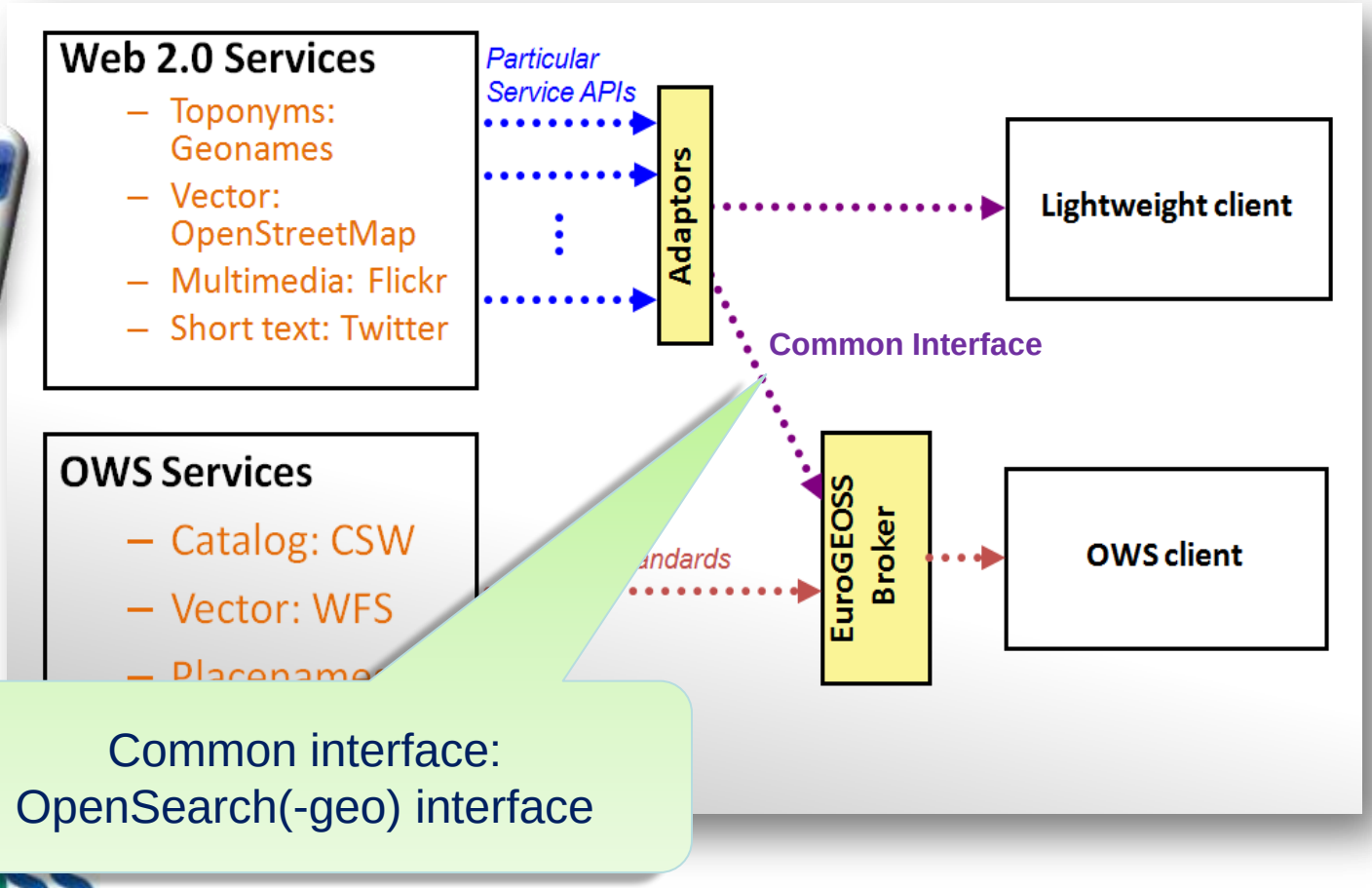
Web 2.0 service Adaptors



[Source: EuroGEOSS D2.6.1 (L. Díaz, C. Granell, O. Fonts, J. Gil)]

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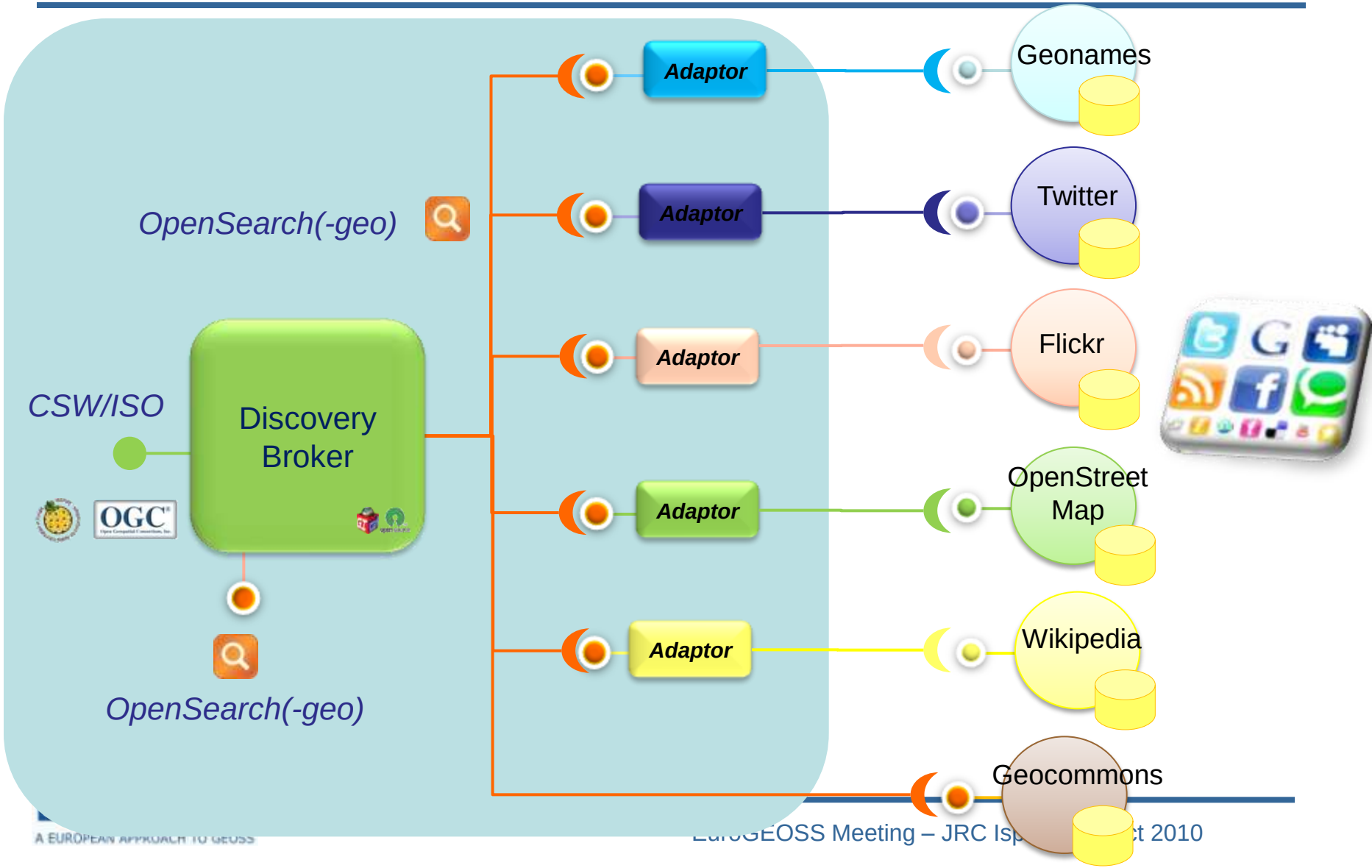
Adaptors capabilities

[Source: EuroGEOSS D2.6.1 (L. Díaz, C. Granell, O. Fonts, J. Gil)]

Web 2.0 Service	Features
Wikipedia	**through Geonames JSON Wikipedia Search Web Service:**
	Response format: KML
	Filter: Text search.
	Paged results: NO
Geonames	**through JSON Search Web Service:**
	Response format: KML
	Filter: Text search
	Paged results: YES
Twitter	**through search API:**
	Response format: Atom + GeoRSS (Supported natively by API).
	Filter: Text search
	Paged results: NO
Flickr	**through REST search API:**
	Response format: KML
	Filter: Text search and bbox
	Paged results: YES
OpenStreetMap	**through *nominatim* API:**
	Response format: KML
	Filter: Text search and bbox
	Paged results: NO

Web 2.0 resources support



ADVANCED PREVIEW

Flexibility: support heterogeneous Clients

- Any “standard” CSW or OpenSearch Client can be used to access the discovery capacity
  - GEO-portal
  - Geonetwork
  - ArcGIS / ArcExplorer
  - Web Browsers (via OpenSearch)
  - WorldWind
  - GI-go (thick) and its thin version: GI-portal
  - ……

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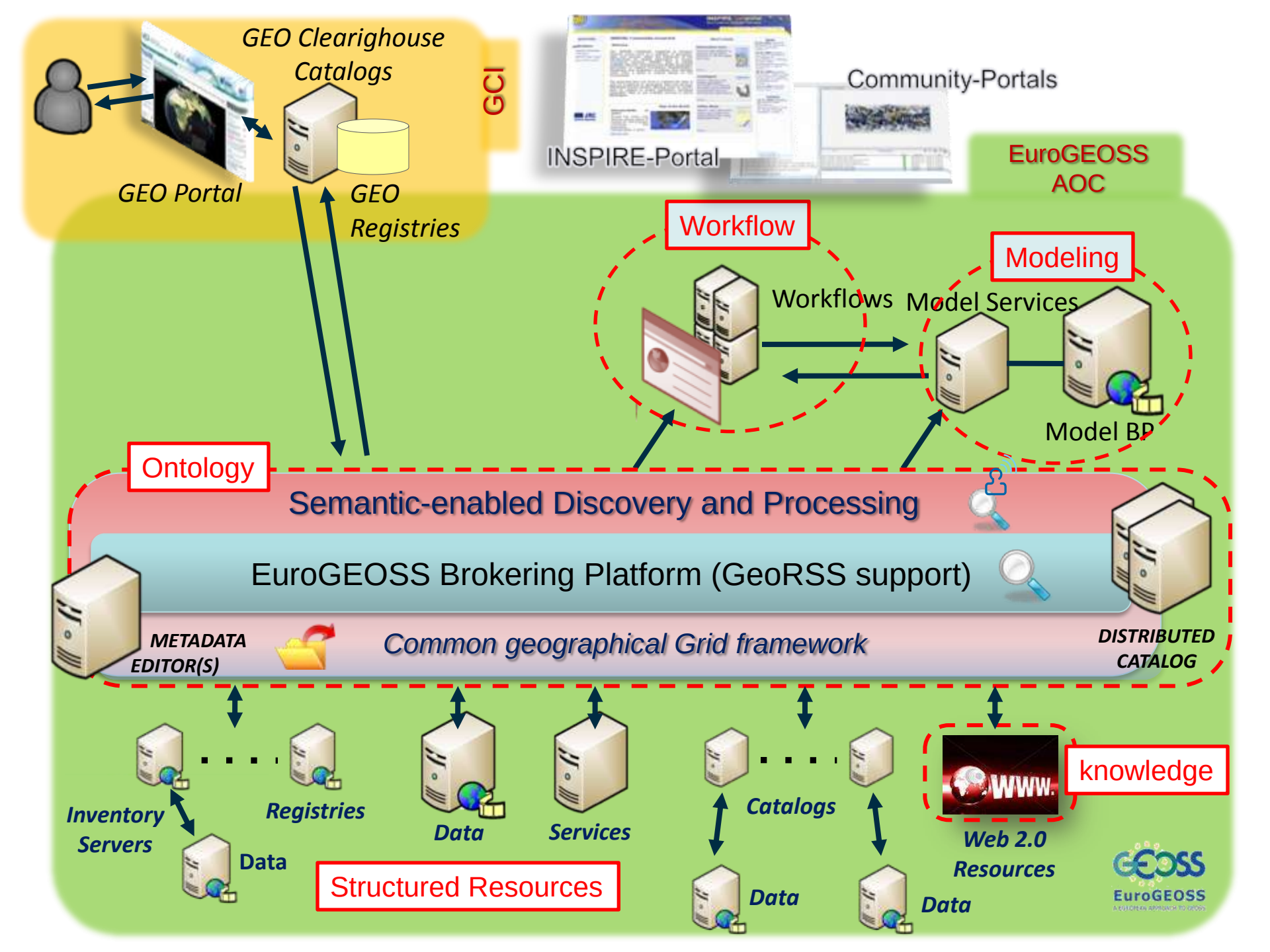
USE SCENARIOS (AIP-3)


GEO Clearighouse
Catalogs
GCI
GEO Portal
GEO
Registries
INSPIRE-Portal
Community-Portals
EuroGEOSS
AOC
Workflow
Workflows
Modeling
Model Services
Model BP
Ontology
Semantic-enabled Discovery and Processing
EuroGEOSS Brokering Platform (GeoRSS support)
METADATA
EDITOR(S)
Common geographical Grid framework
DISTRIBUTED
CATALOG
Inventory
Servers
Registries
Data
Data
Services
Catalogs
Data
Data
Web 2.0
Resources
knowledge
Structured Resources
EuroGEOSS

GEOSS AIP-3 Use Scenarios

- In collaboration with the FP7 GENESIS project
- Biodiversity & Climate Change WG
  - e-Habitat & Species Occurrences Use Scenario
    - A web based decision-making tool for assessing environmental changes due to anthropogenic activities, including climate change
    - The development of the modeling web service for computing habitat similarities and irreplaceability allows the community to assess possible environmental consequences.
  - Scientific patron: Gregoire Dubois (JRC)
- Water (Drought) WG
  - European Drought Observatory (EDO) Use Scenario
    - Assessment of the drought situation in Europe
    - Multi-scale approach based on subsidiarity that integrates drought information from various scales
  - Scientific patron: Stefan Niemeyer (JRC)

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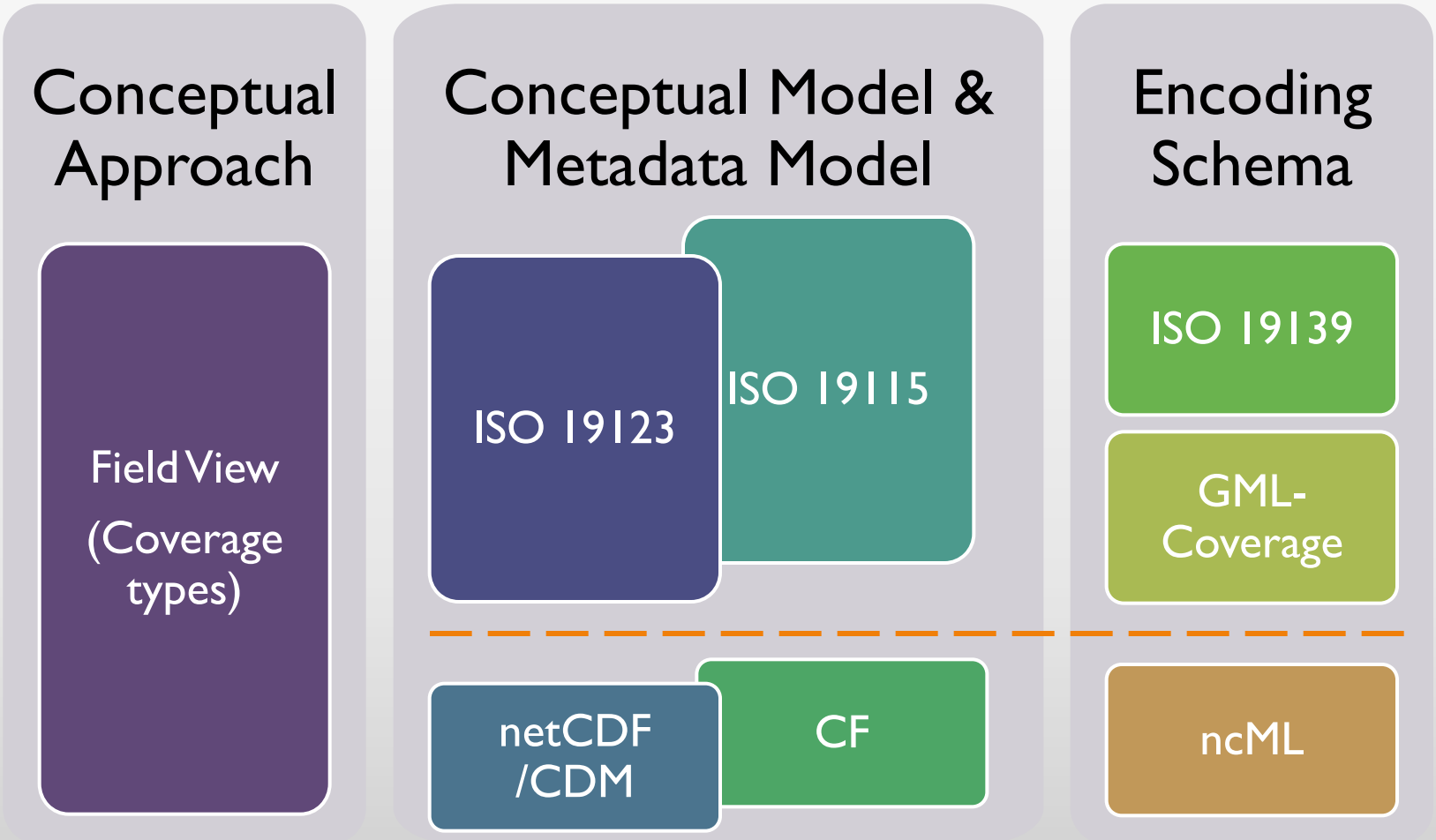
Related Challanges: From ncML to ncML-G+

Encoding Field View Content

abstract → *realization*



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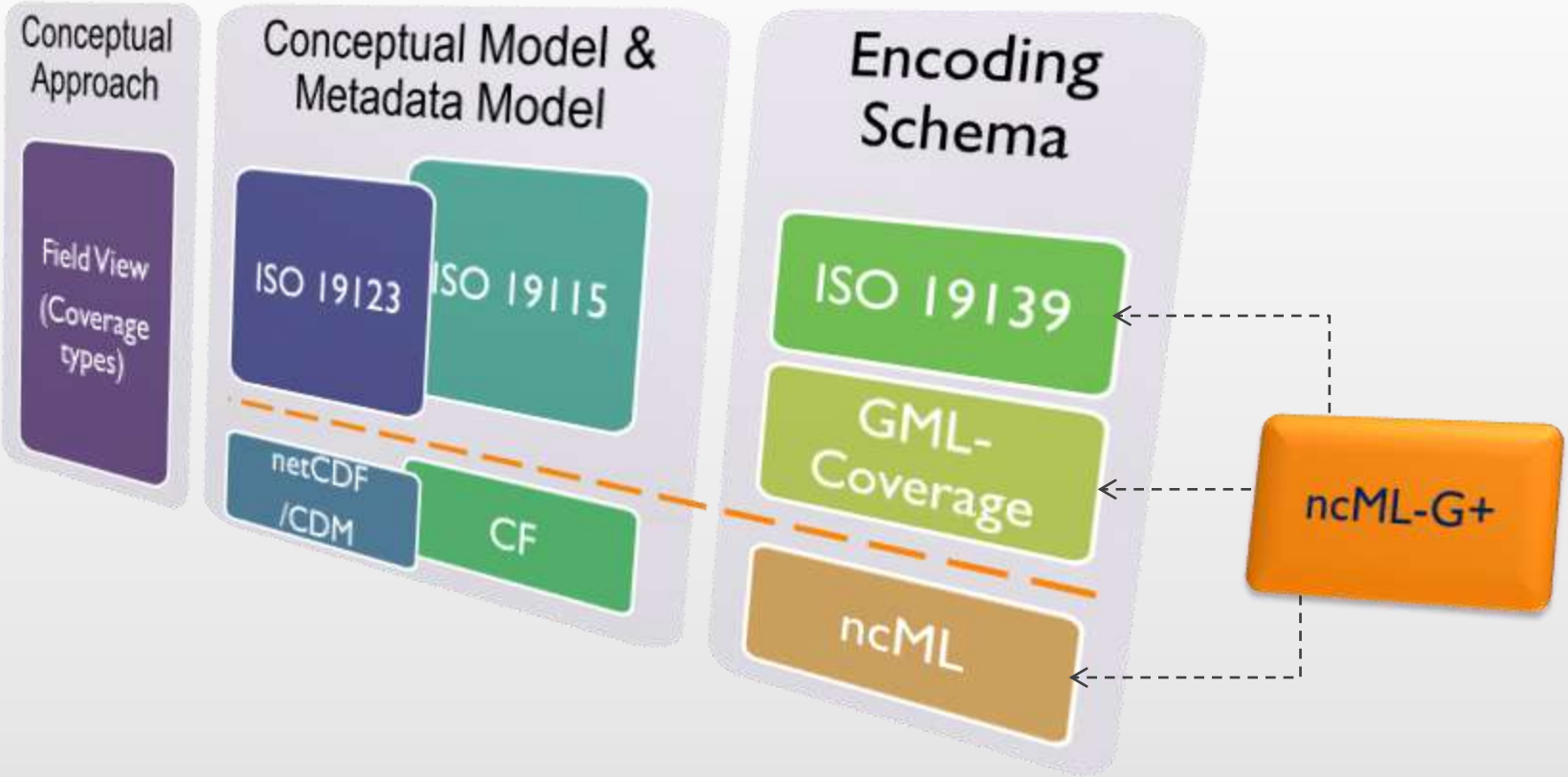
Encoding Field View Content



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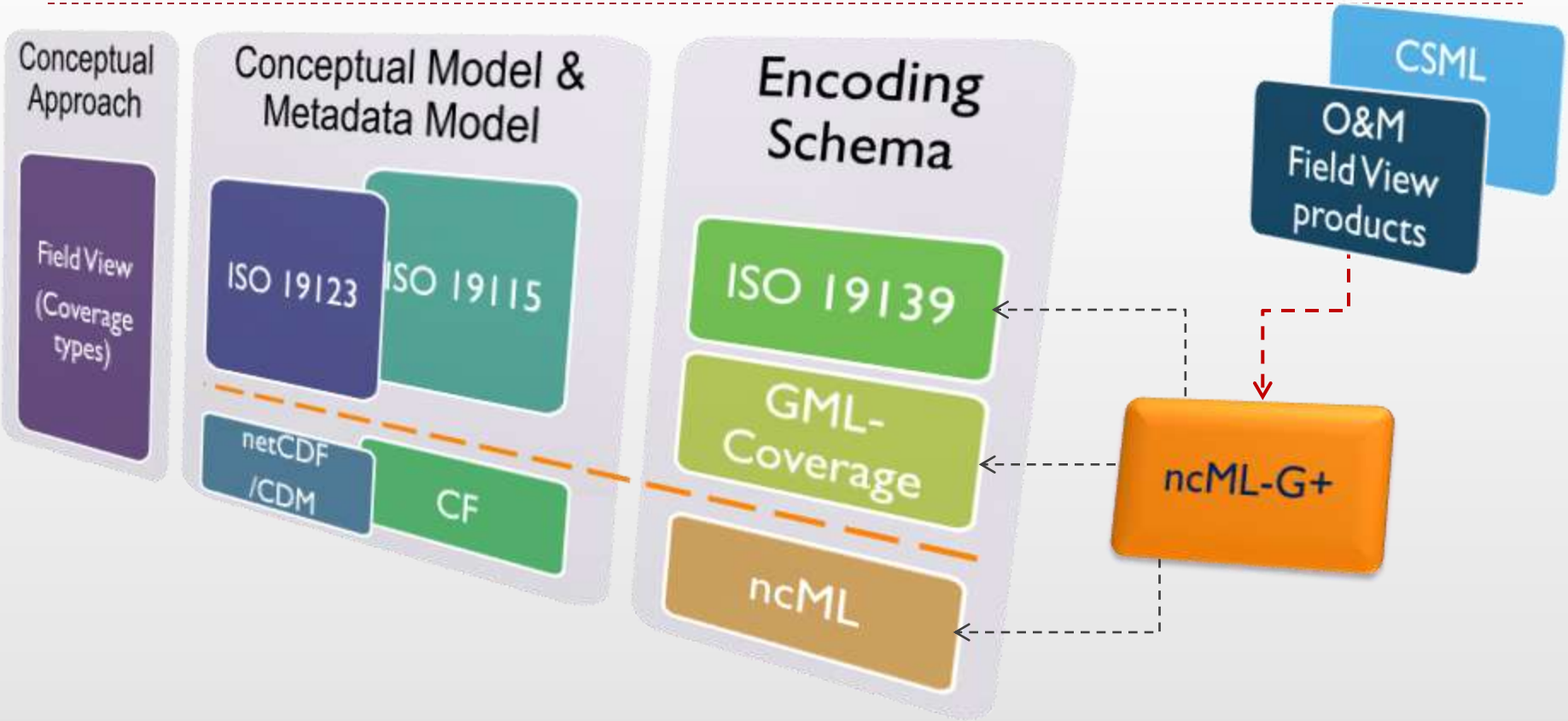

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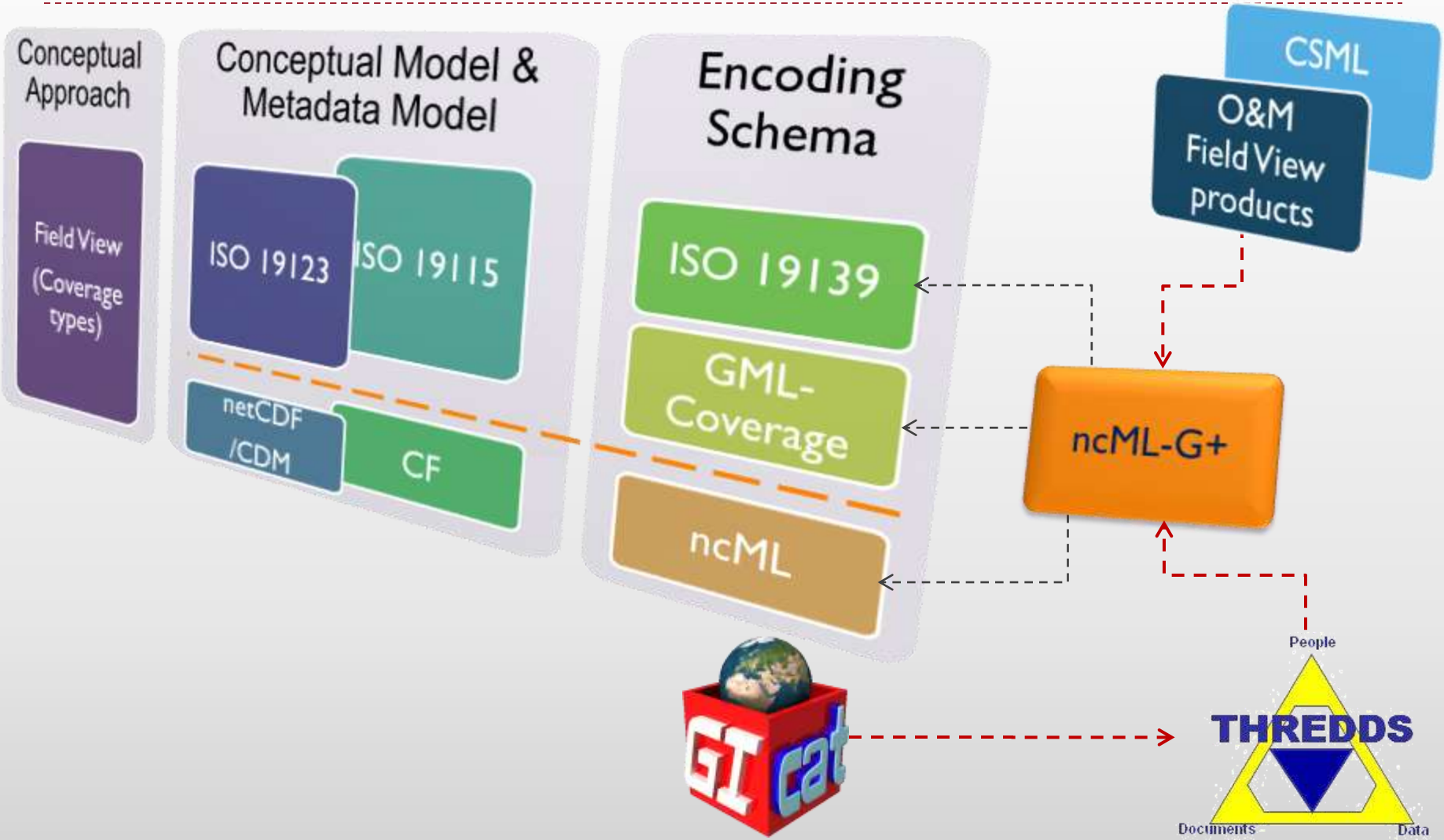

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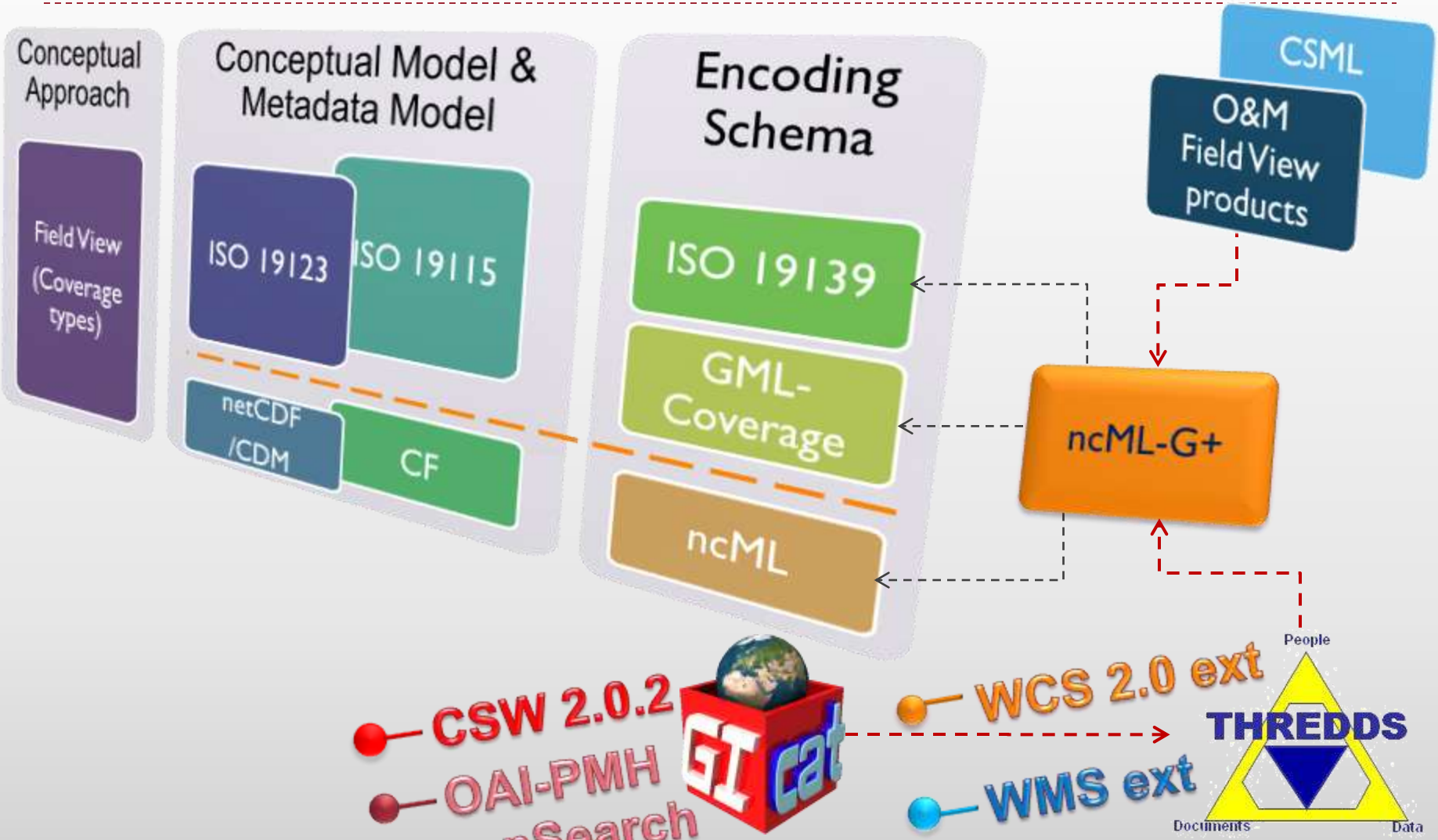

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ncML-G+

- Building on existing artifacts
  - ncML-Gml v. 0.5 specification and APIs
    - netCDF to ISO 19123 models mapping for regular grid data
  - ncISO
    - CF-netCDF to ISO 19115 models mapping for metadata

- Encode different coverage types
  - Regular grid data
  - Irregular grid data
  - Multi-point data
  - …..

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Uncertain Types and Services

uncert | web
uncertainty-enabled model web

Rationale

- Main objectives:
  - Specify and Manage **Uncertainty of Scientific Data**
  - Assess and Control **Uncertainty Propagation** –e.g. in service chaining for models integration

- Constraints:
  - **minimize the impact** on the existing tools and processing schemas
  - **Re-use existing standards** as much as possible

uncert | web
uncertainty-enabled model web

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Proposed approach

Introduce “uncertainty” types/elements

PROCEDURAL APPROACH

e.g. Java data types

PL Scientific Data Types
(e.g. netCDF Libraries)

Basic Data Types

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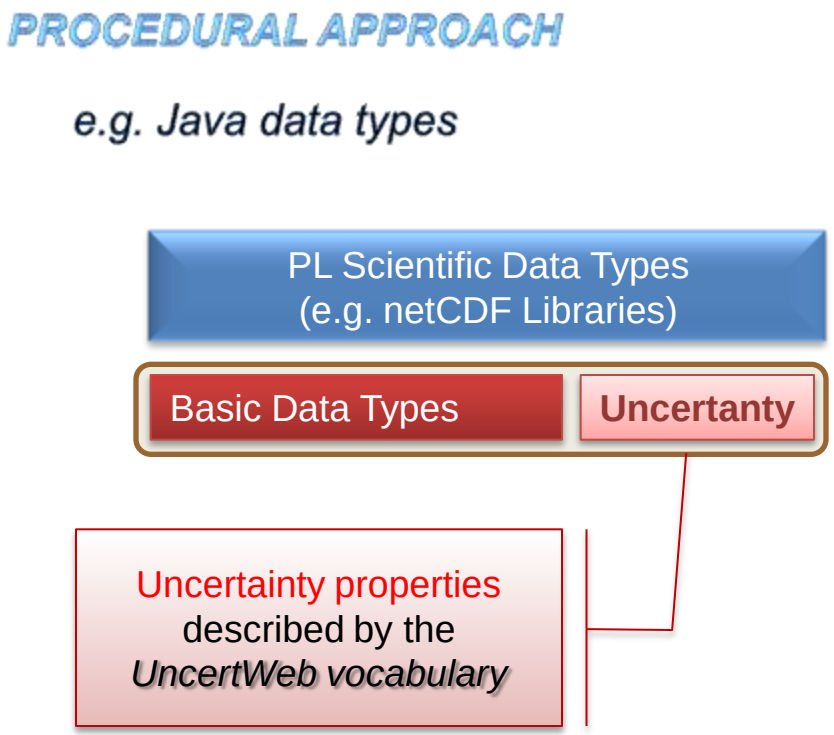
Proposed approach

Introduce “uncertainty” types/elements



Proposed approach

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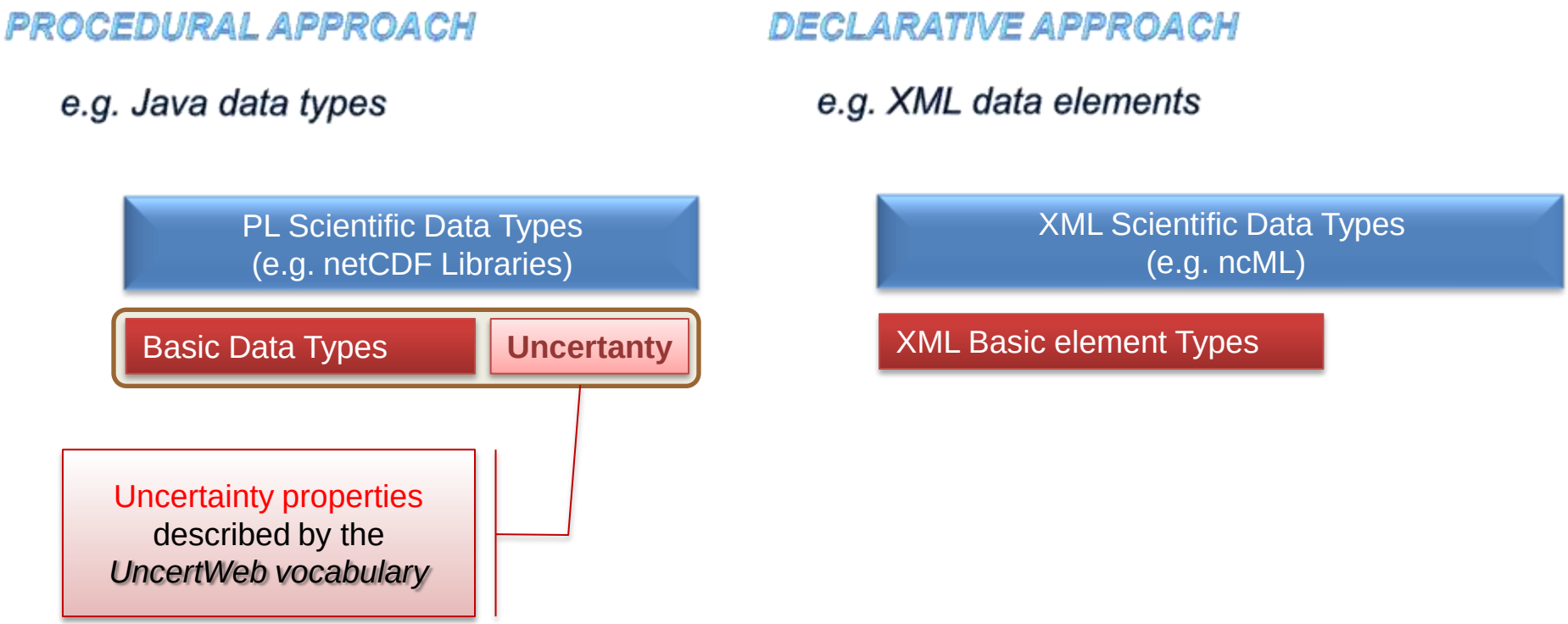

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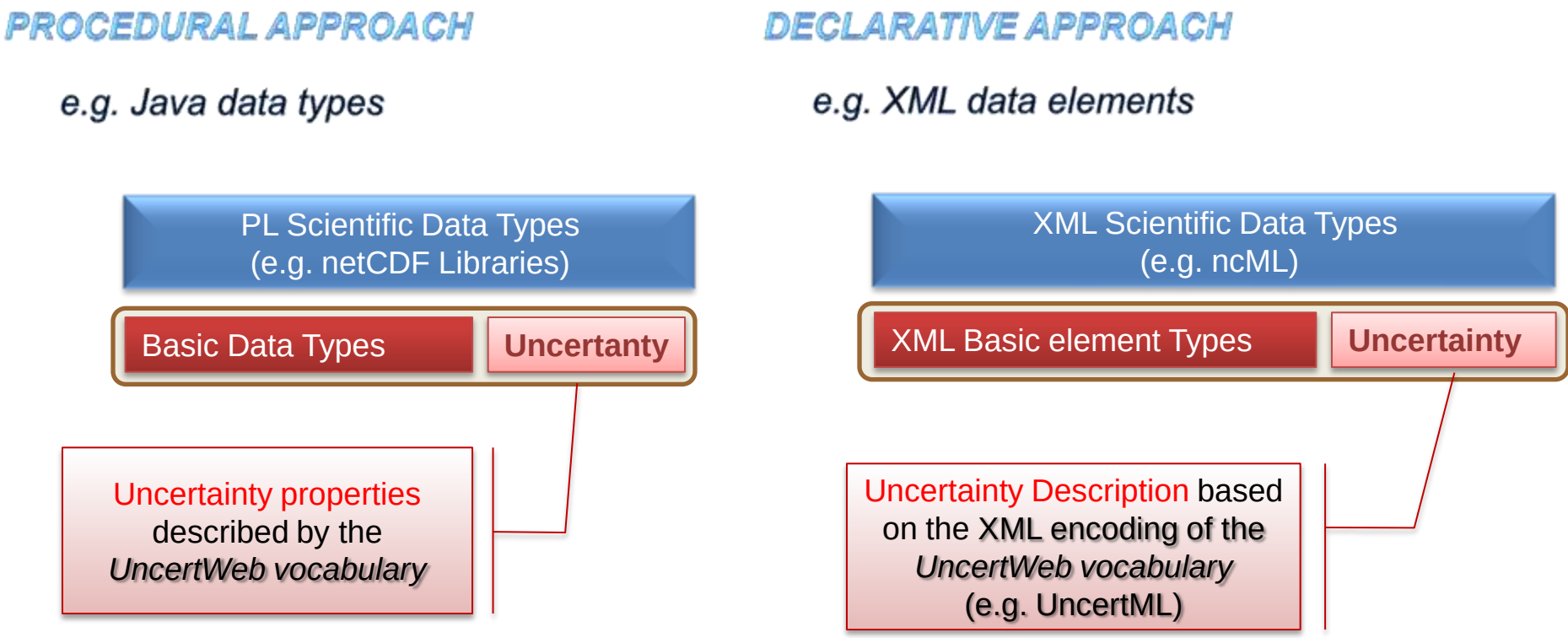

uncert | web
uncertainty-enabled model web

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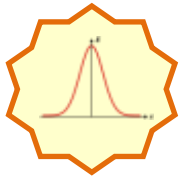
Proof-of-concepts

Uncertainty Information =  **+** 

Basic info *Uncertainty info*

- Different Scientific Data types are considered (i.e. Basic info encodings)
  - XML encoded (e.g. GML, ncML) 
  - Binary encoded (e.g. netCDF, GRIB) 

Example:
netCDF/ncML + (XML) uncertainty Info

```
netcdf avg_min_2050 {
dimensions:
      lat = 1285 ;
      lon = 2446 ;
variables:
      double lat(lat) ;
            lat:units = "degrees_north" ;
      double lon(lon) ;
            lon:units = "degrees_east" ;
      byte avg(lat, lon) ;
            avg:_FillValue = 0b ;

// global attributes:
            :Conventions = "CF-1.0" ;
}
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```
<?xml version="1.0" encoding="UTF-8"?>
<unc:NetCDF_Uncertainty xlink:type="extended">

   <unc:netcdf xlink:type="locator"
xlink:locator="http://zeus.pin.unifi.it/angelini/UncertWeb/Data/avg_min
_2050.nc#/netcdf/variable[@name=avg]" xlink:label="dataset" />

   <unc:unc_description xlink:type="arc" xlink:from="dataset"
xlink:to="uncertainty" />

   <unc:uncertainty xlink:label="uncertainty" xlink:type="resource" >
      <un:Statistic>
         <un:parameters>
            <un:Parameter
definition="http://dictionary.uncertml.org/statistics/mean">
               <un:value>3.2</un:value>
            </un:Parameter>
            <un:Parameter
definition="http://dictionary.uncertml.org/statistics/variance">
               <un:value>0.25</un:value>
            </un:Parameter>
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Portion Ref.

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Portion Ref.

Inbound XLink

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```

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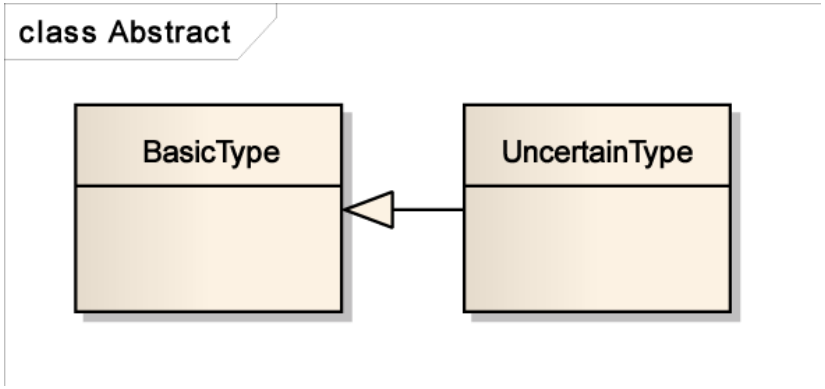
Procedural Approach: the *UncertainTypes definition*

- *UncertaintyTypes* = new library of Data Types which include the Uncertainty Info
- *UncertaintyTypes* = Basic (Data Types) + Uncertainty Info
- Basic (Data) Types = quantities for which the uncertainty is not specified
  - i.e. the PL (or library) data types

Procedural Approach: Modeling the *UncertainType concept*

- The concept of *UncertainType*, is a *BasicType specialization* :
  - UncertainType “is a” BasicType
  - An UncertainType includes additional information regarding its uncertainty.



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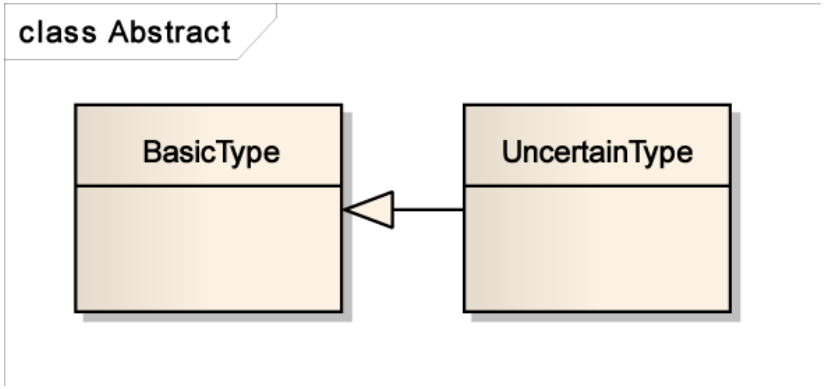

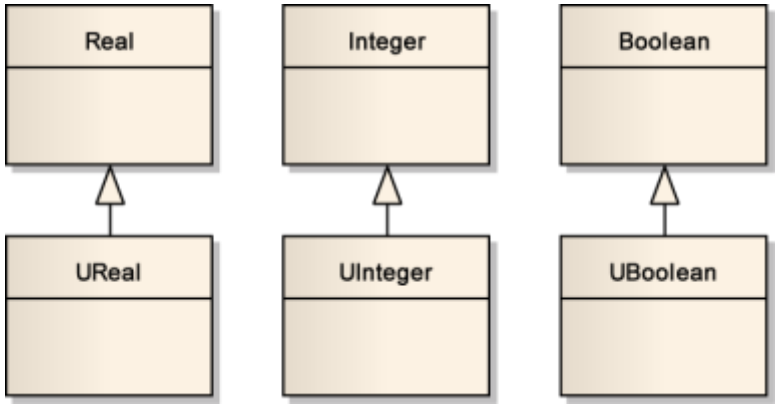

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Sub-typing Issues

- OO programming language and encoding languages/models must support:
  - subtyping of base types

ALLOWED	NOT ALLOWED
ECMAScript (JavaScript)	Java
Python	XML Schema
	C++

  - Operator overloading

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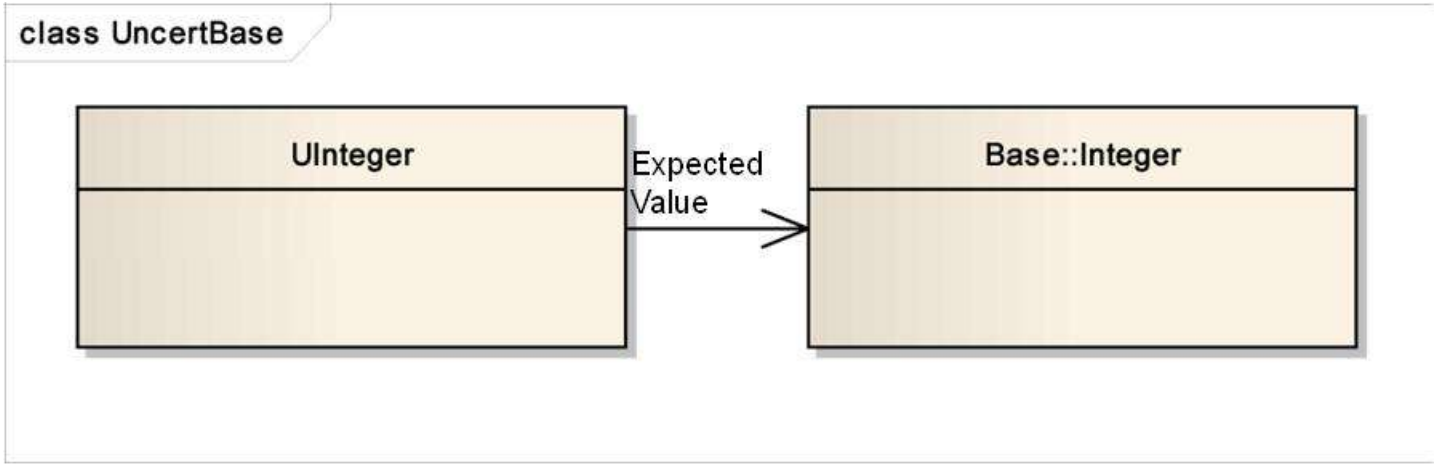
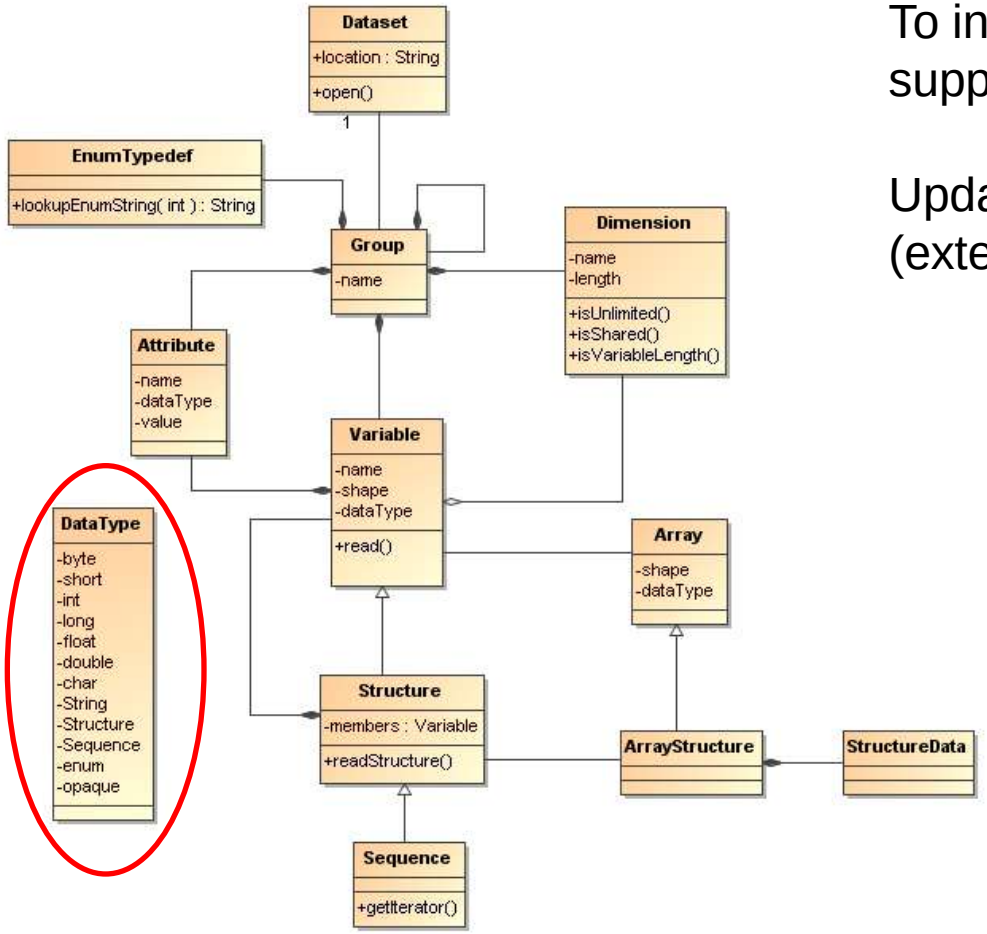
Alternative approach

- To use an “association” relationship
- BasicType becomes a property of the associated UType



- A prototype was developed for Java data types

Possible Integration in netCDF/CDM



To include the uncertain types in the supported *DataType* list

Update the APIs to work on such new (extended) *Datatype* entries

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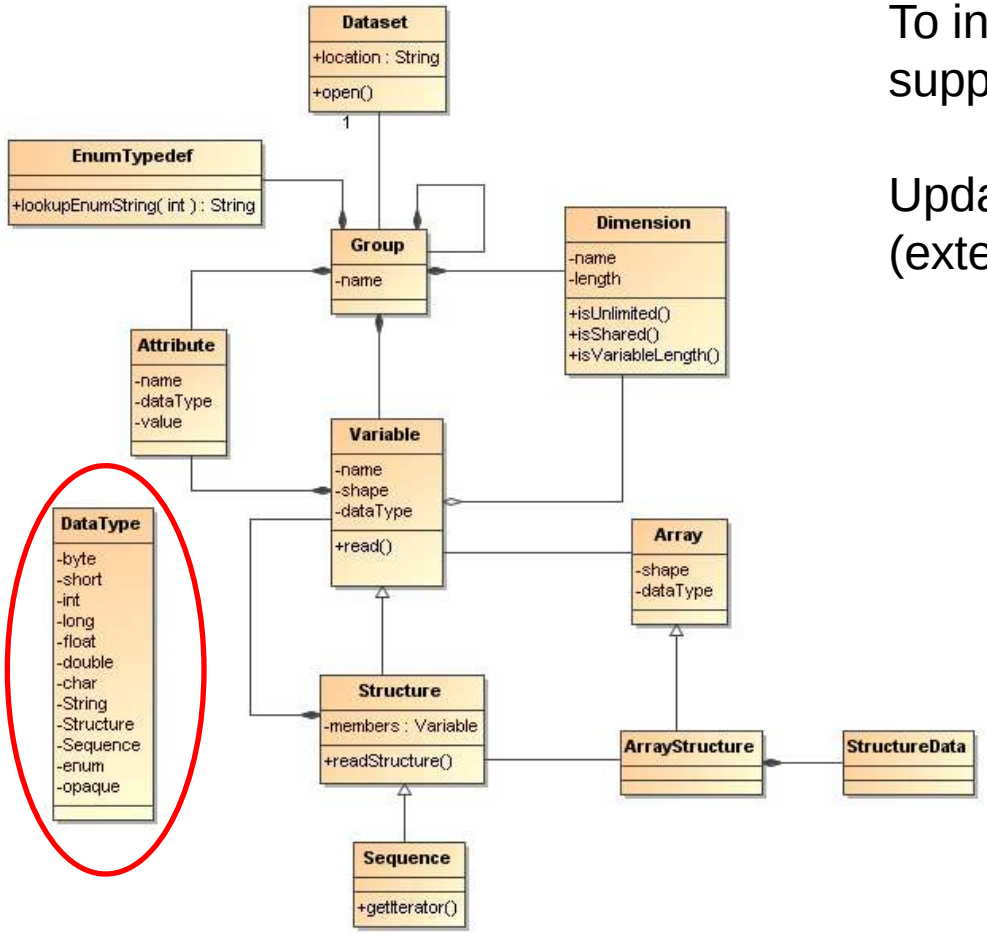
Possible Integration in netCDF/CDM



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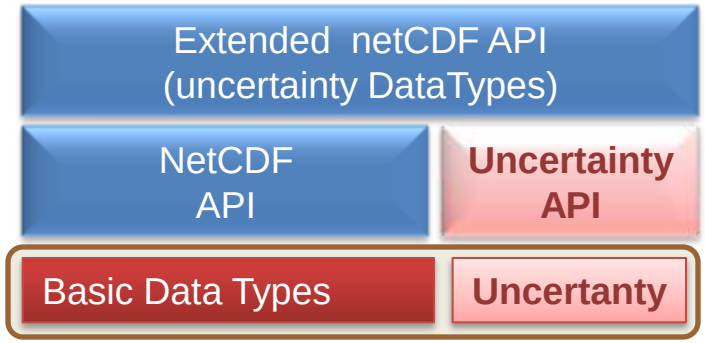

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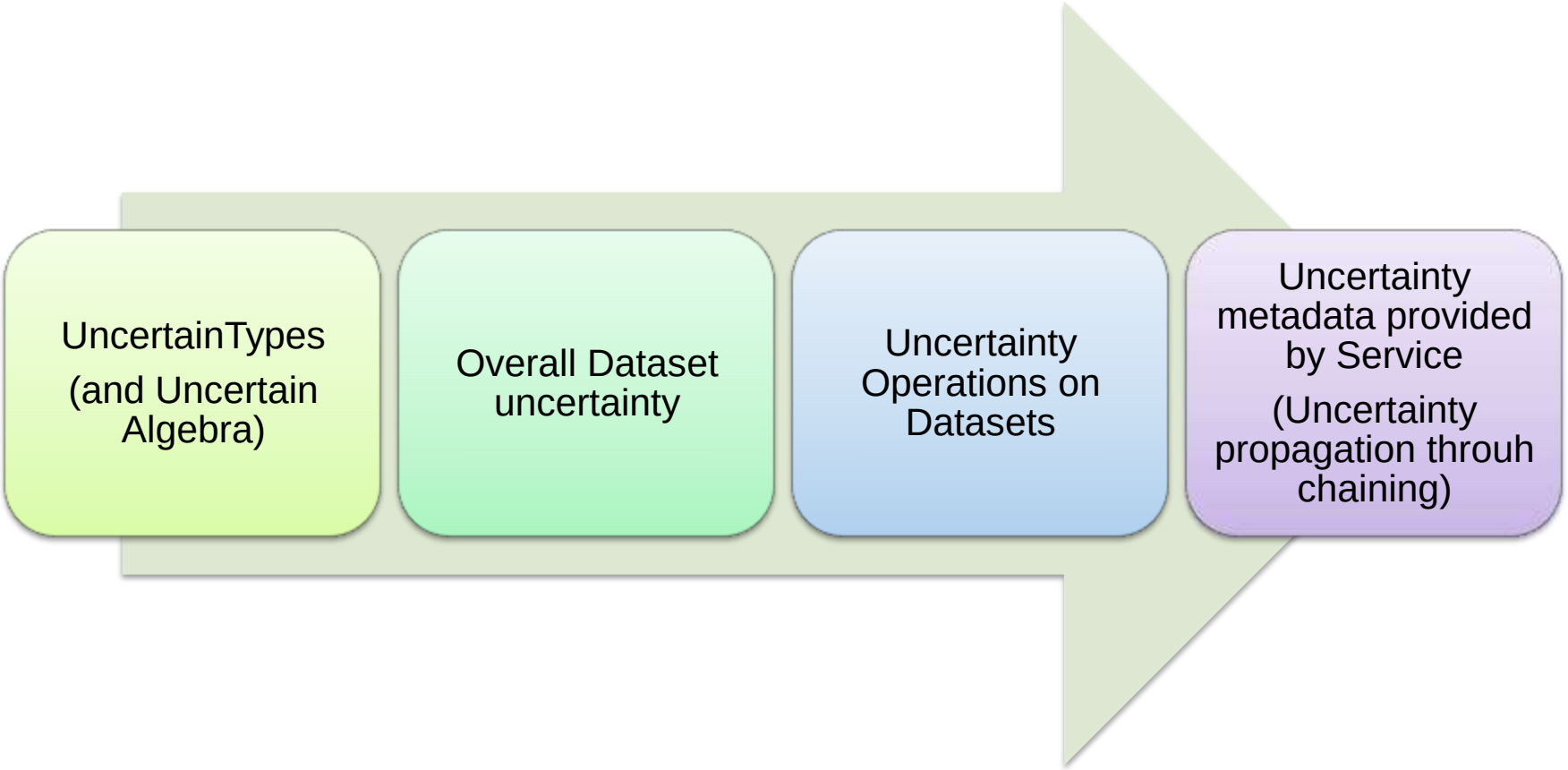
General picture: the Uncertainty propagation



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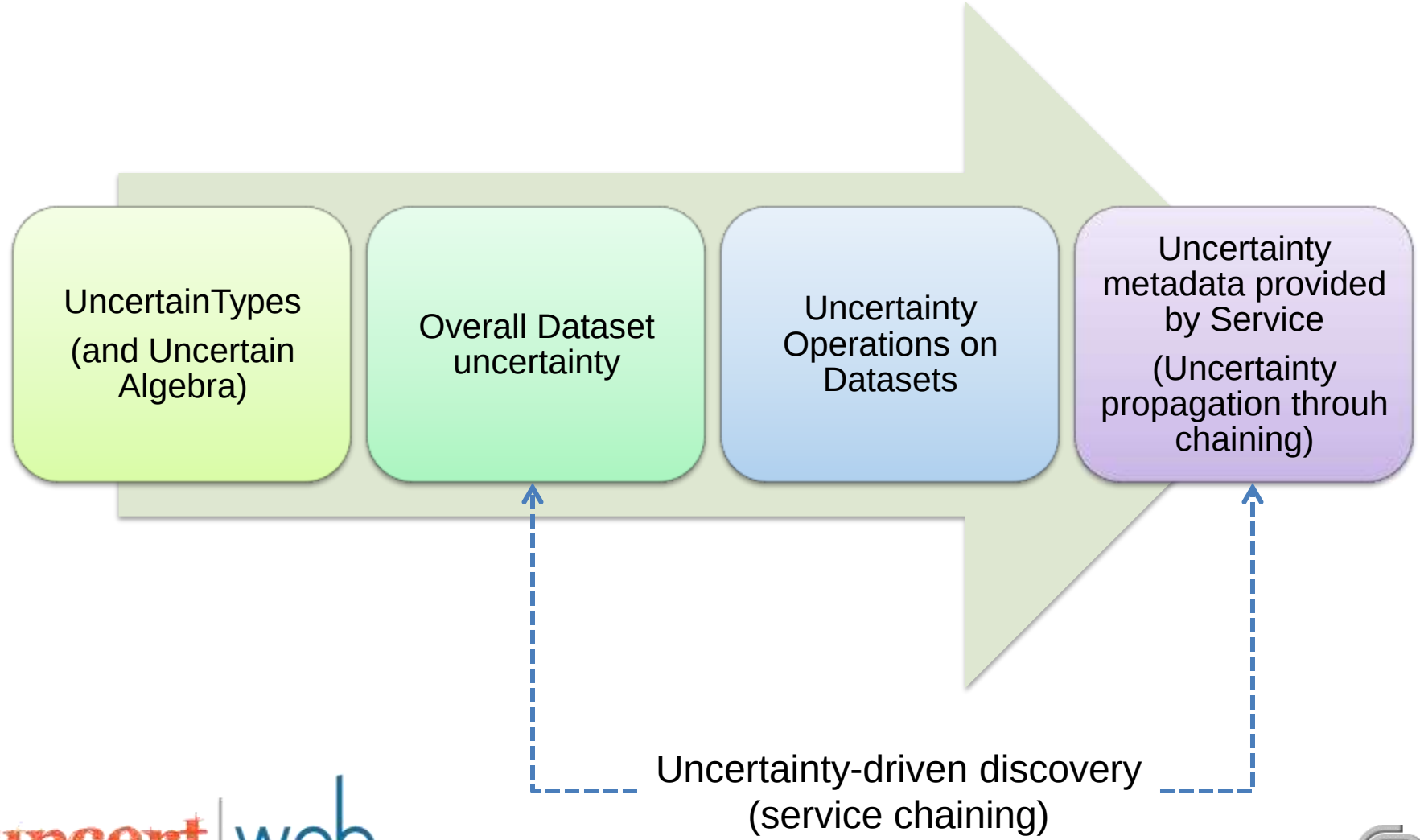

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Thank you for your attention !

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