OGC Testbed-14: Exploitation Platform Thread

Final Demonstration meeting
ESA/ESRIN, January 2019

CRIM CubeWerx GEOMATYS

SOLENIX SPACEBEL

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Agenda

- Introductions
- Problem statement
- Solution Architecture
- Demonstration video
- Components
  - Catalogue
  - Client
  - Application package
  - Execution Management Service
  - Application Deployment & Execution Service
- Technologies
- Applications
- Challenges
- Standardization-related issues
- Conclusion/Achievements

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INTRODUCTIONS

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Introductions

- CRIM
- CubeWerx Inc.
- Geomatys
- Solenix
- Spacebel

PROBLEM STATEMENT

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Problem: complex ecosystem

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Users:

Confused scientists

I see a lot of:
Power
Capacity

I want to:

- Develop once
- Benefit from *X* x *Y* x *Z* explosion
- Not care about details

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Platform: *X* platforms, *Y* implementers

coastal tep

forestry tep

hydrology tep

polar tep

geohazards tep

food security tep

proba-v mep

forestry tep

urban tep

Infrastructure: *Z* suppliers

aws

CREODIAS

mundi WEB SERVICES

sobloo

WEkEO

ONDA

(OGC Testbed-14 EOC) Solution

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- Let's help the confused scientist by:
  - Defining a standardised Application Package (AP):
    - To convey different kinds of information that all applications have/need (executable, interface, required data sources, etc.)
    - So that heterogeneous platforms/implementations and their components can exchange information about an application in a standard and interoperable way
    - So that heterogeneity and infrastructure details are hidden but the same application can be executed on different infrastructure
- Let's help platform developers by:
  - Proposing two standard/essential EP building blocks: the EMS & the ADES
  - Documenting Best Practices and Interfaces for engineering them:
    - EMS: control logic for deploying/executing applications in different MEPs & TEPs, the chaining thereof, overall coherence of the execution chain
    - ADES: single application deployment/execution on specific platform

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Prior-After

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- Pre-requisite: Dockerized application
- Prior (TB13):
  - AP based on OWS Context
  - Simpler architecture: just AMC and ADES, i.e. no Execution Management Service (EMS).
  - Interface based on WPS/XML, two alternative implementations:
    - Standard WPS 2.0 and two dedicated - but regular - WPS processes for deploying and undeploying processes/applications in the ADES;
    - WPS-T, not standardized but described in a OGC discussion paper.
- After (TB14):
  - WPS-T, both for client<->EMS and EMS<->ADES interface.
  - AP based on WPS-T DeployProcess
  - REST/JSON rather than XML: WPS REST/JSON under public review by WPS SWG -> WPS 2.0 SWG and TB-14 EOC coordination
  - CWL for application chaining (workflows)

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SOLUTION ARCHITECTURE

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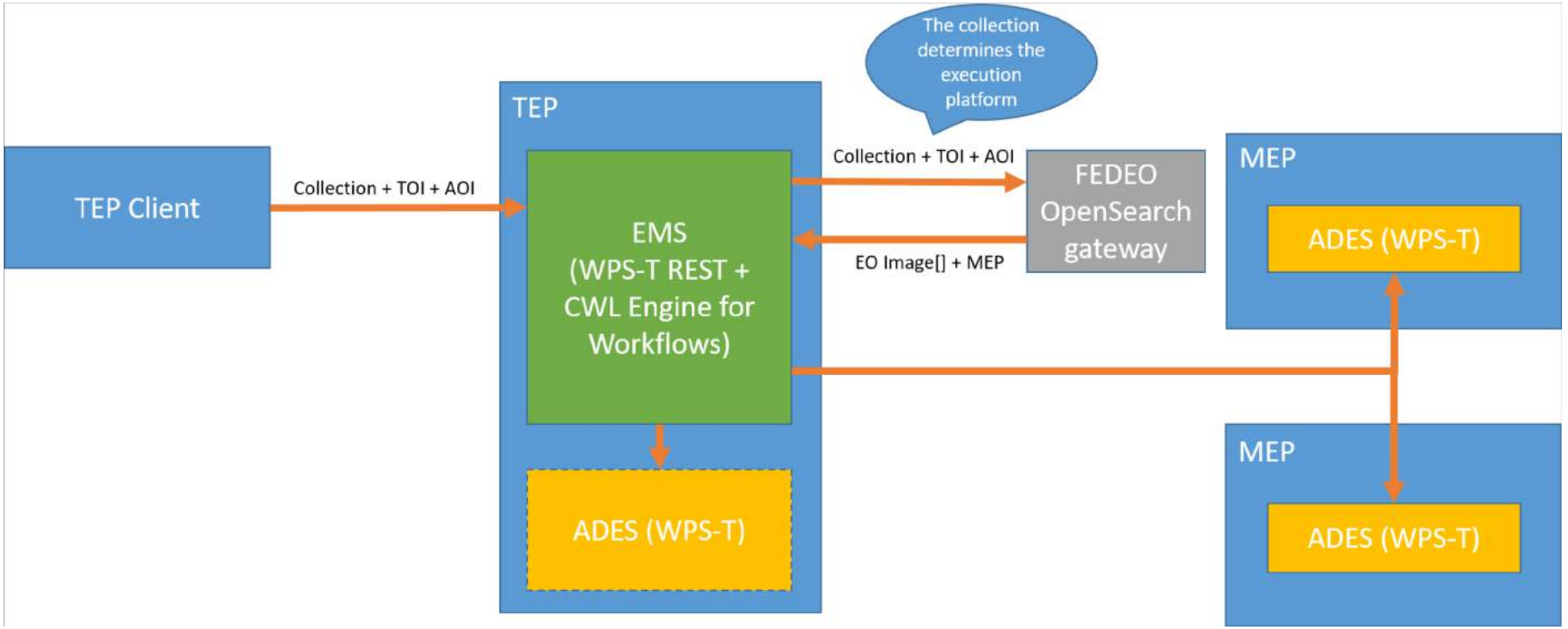
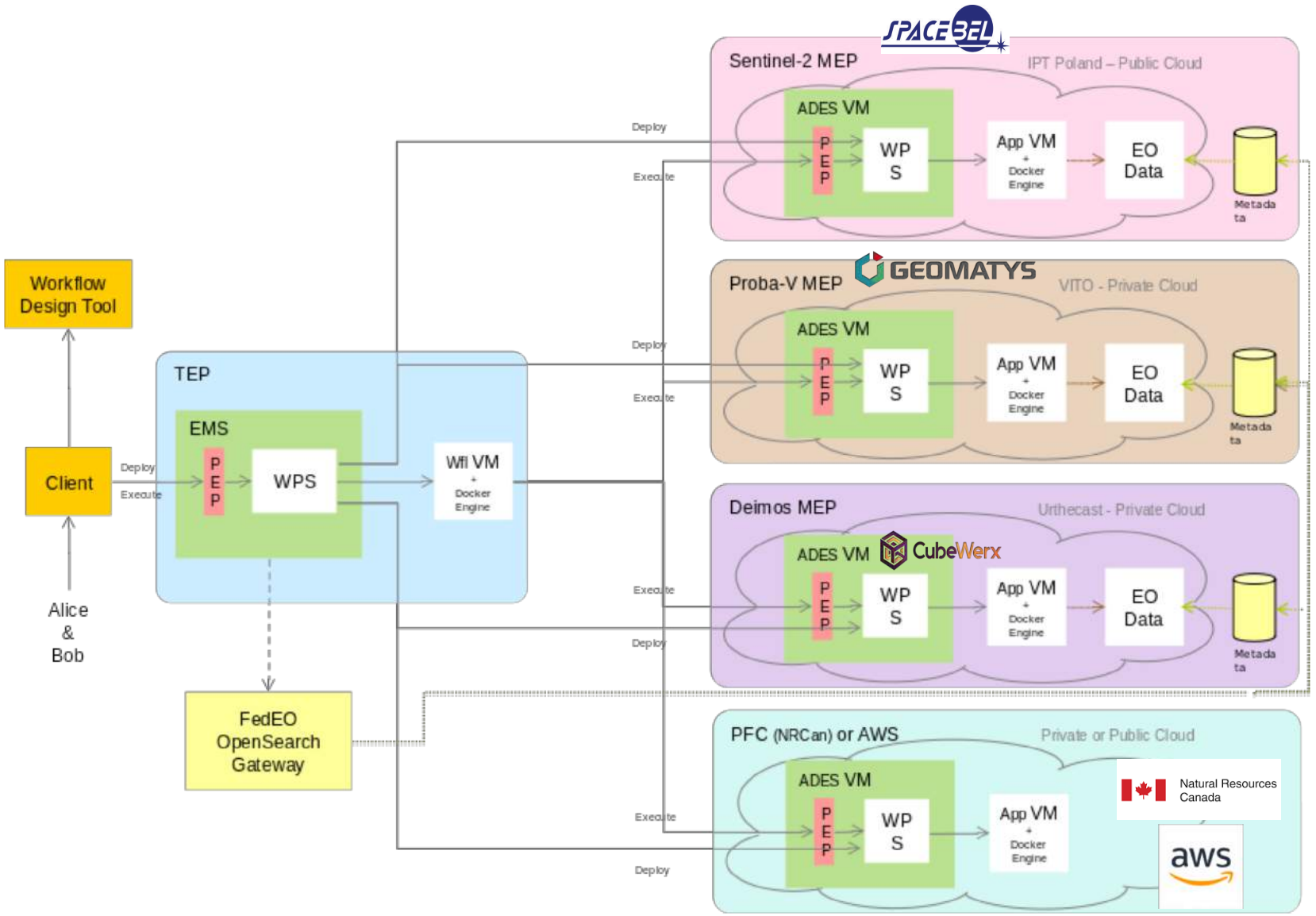
High-Level Architecture

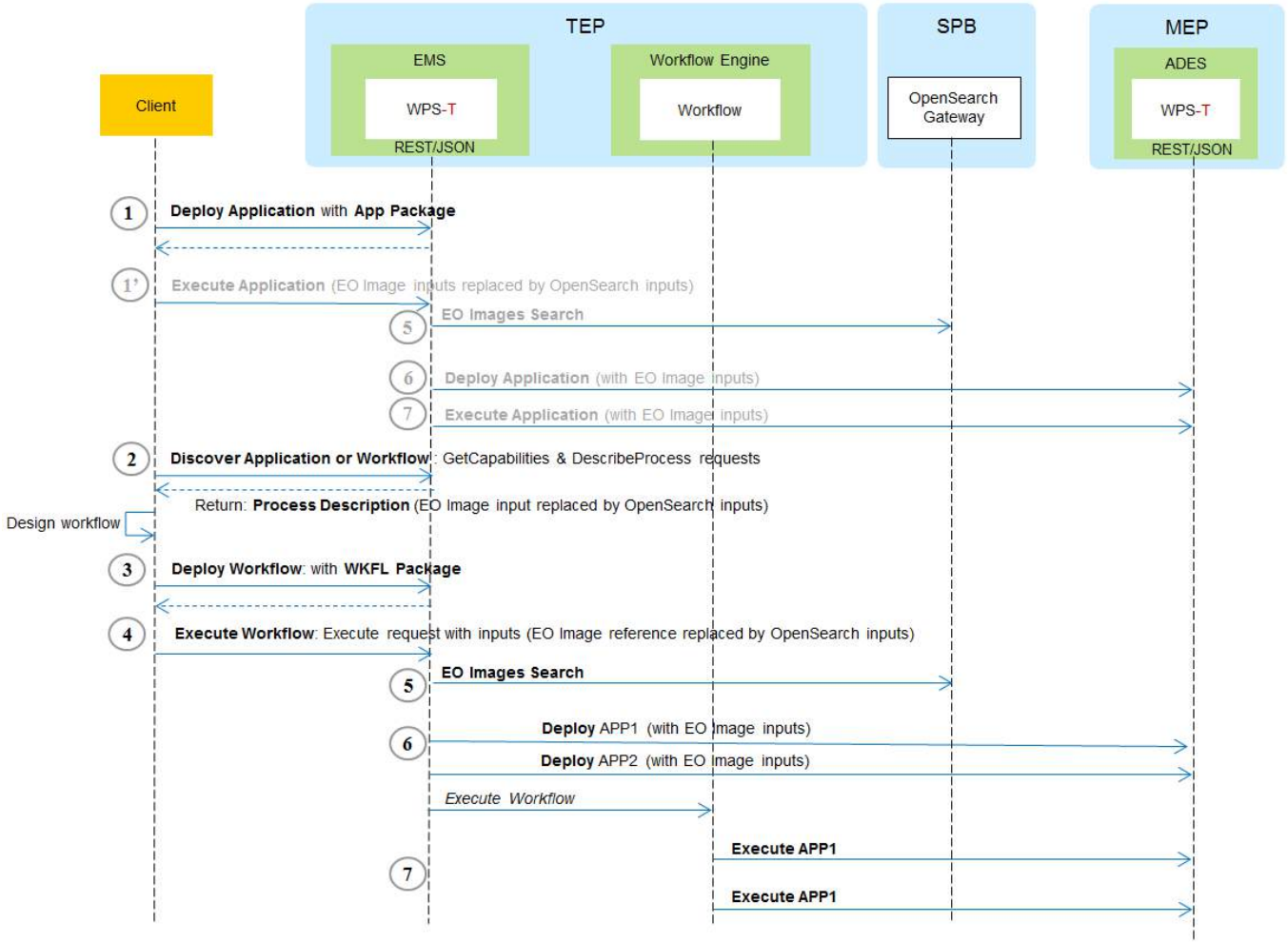


Detailed Architecture



Detailed sequence of steps

1. Alice deploys a newly developed application
2. Alice's sister discovers the new application and builds a workflow including that application.
3. Alice's sister deploys the workflow.
4. Bob discovers the new workflow and executes it.
5. The EMS performs the EO Image Discovery.
6. The EMS triggers the deployment on the ADES.
7. The ADES executes the application.



COMPONENTS

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List of Components

- Authentication (WSO2 bridge) [ATOS]
- Catalogue (FedEO gateway) [Spacebel]
- Client [Solenix]
- Application Package (format, not software)
- Servers
  - Execution Management Service (**EMS**) [CRIM, Geomatys, Spacebel]
  - Application Deployment & Execution Service (**ADES**) [CubeWerx, Geomatys, Spacebel]
- Applications
  - Feature extraction [CRIM]
  - Multi-sensor NDVI [Geomatys]
  - Stacker applications [CRIM, Geomatys]

AUTHENTICATION (WSO2 bridge)

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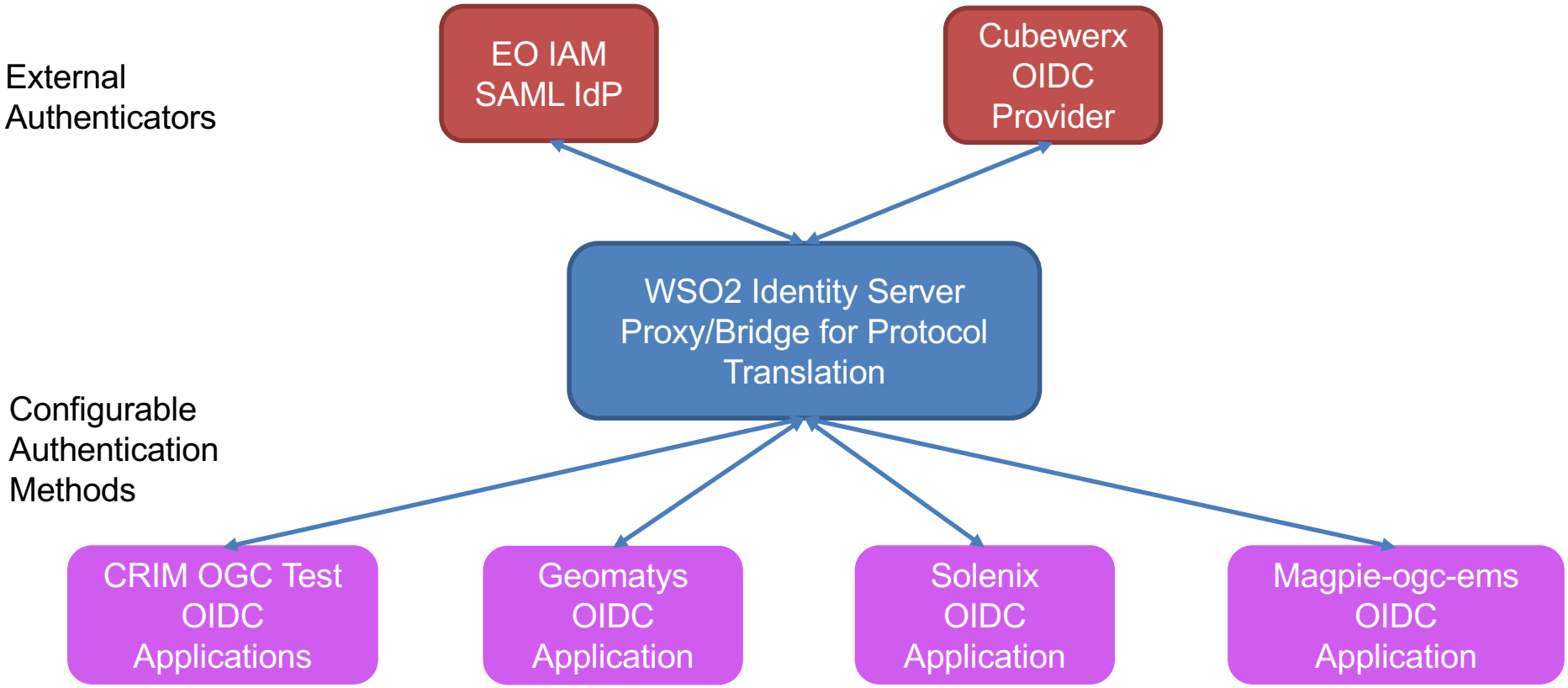
WSO2 Identity Server

- Is an open source Identity and Access Management system.
- It bridges multiple SSO protocols (e.g. SAML, OIDC, WS-Federation) to provide a unified experience by doing protocol translations and transforming identity tokens between heterogeneous identity protocols.
- It has a mapping mechanism between the user attributes received from external authenticators and the attributes sent to service providers.
- In OGC Testbed 14, WSO2 Identity Server acts as a proxy/bridge to allow service providers to choose identity providers that use a different authentication protocol, e.g. a user could login to an OIDC application with a SAML identity provider.

WSO2 Identity Server as a Bridge in the OGC TB14 Context



CATALOGUE

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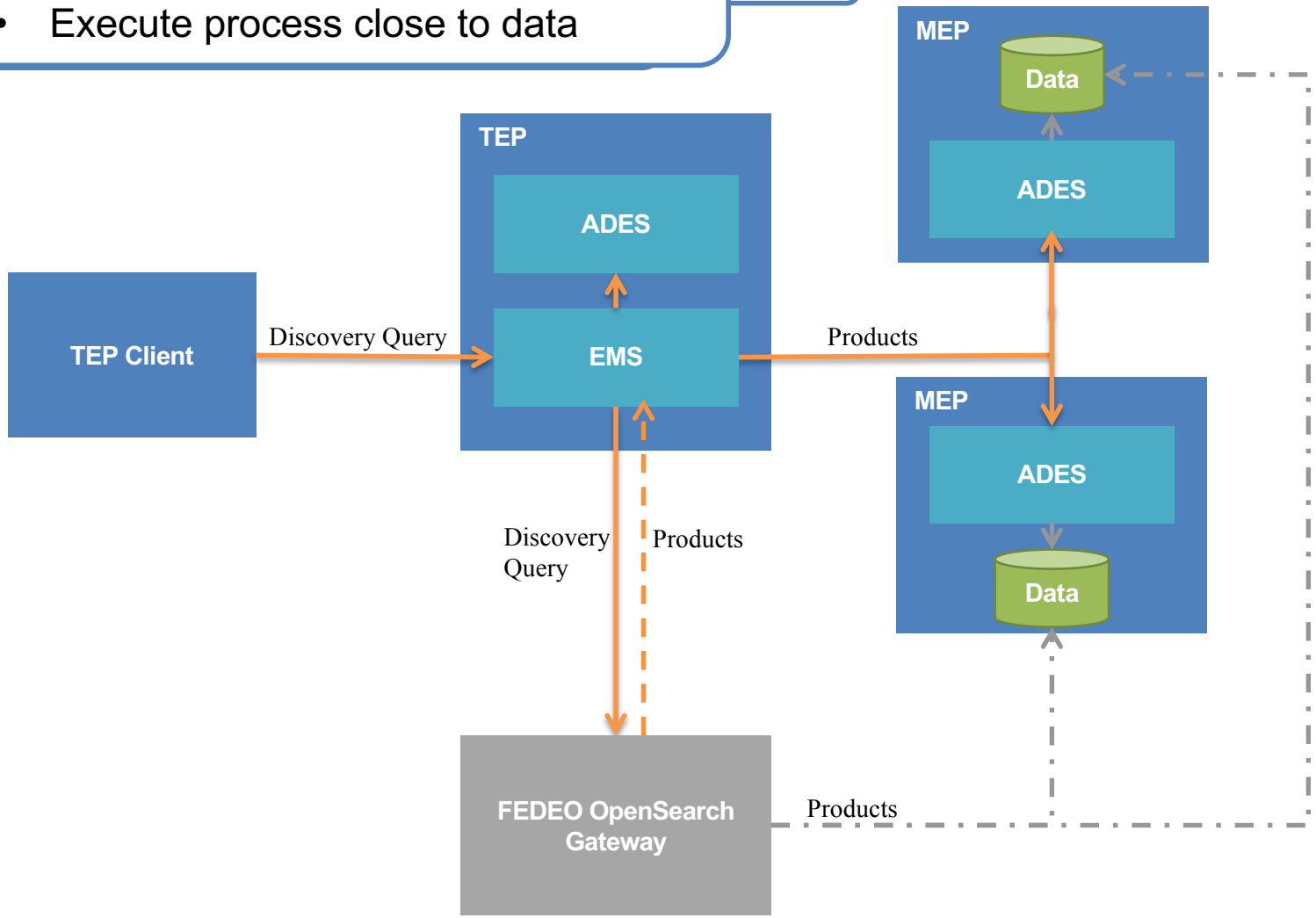
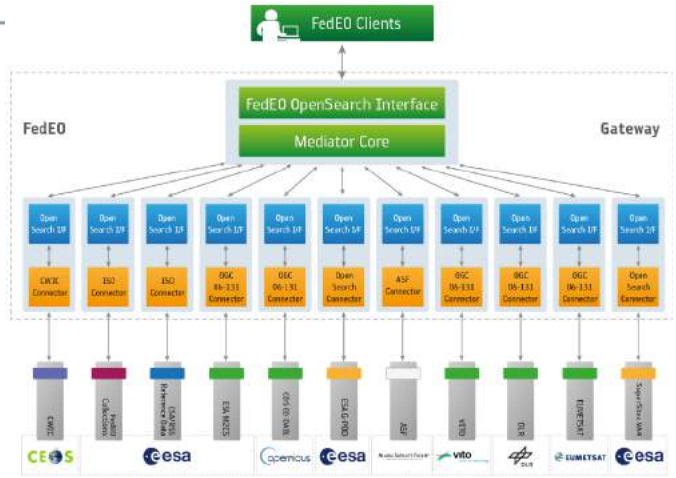
Catalogue Gateway

Objectives achieved by the Gateway:
- Discover products data
- Execute process close to data

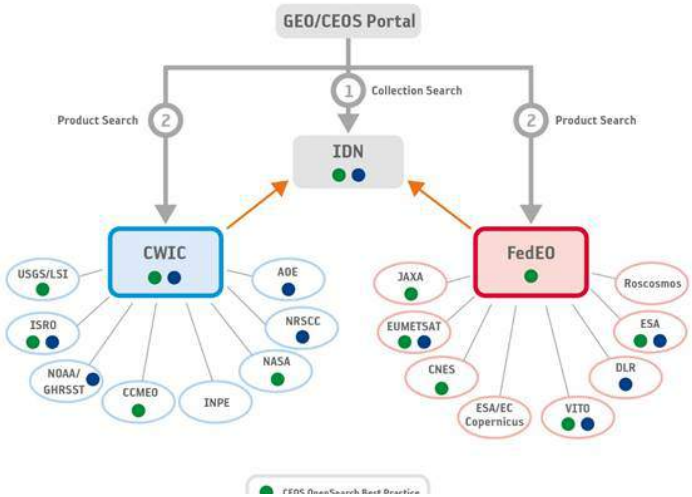
rms.



Fedeo OpenSearch Gateway



- ESA FedEO OpenSearch Gateway
  - Common access point (API) for EO data discovery (EO Collection and Product metadata including product download links).
  - Standards-based access:
    - CEOS OpenSearch Best Practices – incl. "two-step search"
    - OGC 13-026r8 - OpenSearch Extension for Earth Observation
    - OGC 13-032r8 - OpenSearch Geo and Time Extensions
    - OGC 17-003 - GeoJSON(-LD) EO Product Metadata
    - OGC 17-047 - GeoJSON(-LD) OpenSearch Response.
    - Many flavours of responses and EO metadata including Atom, ISO, EOP O&M, GeoJSON(-LD), RDF/XML, JSON-LD, DIF-10, (Geo)DCAT(-AP)* .
  - Deployments:
    - ESA FedEO (CEOS Context)
    - ESA Catalog (OADS) - transfer into operation Q1/19.
    - German Space Agency (DLR) CODE-DE
    - Copernicus CDS 3.0



* Experimental

CLIENT

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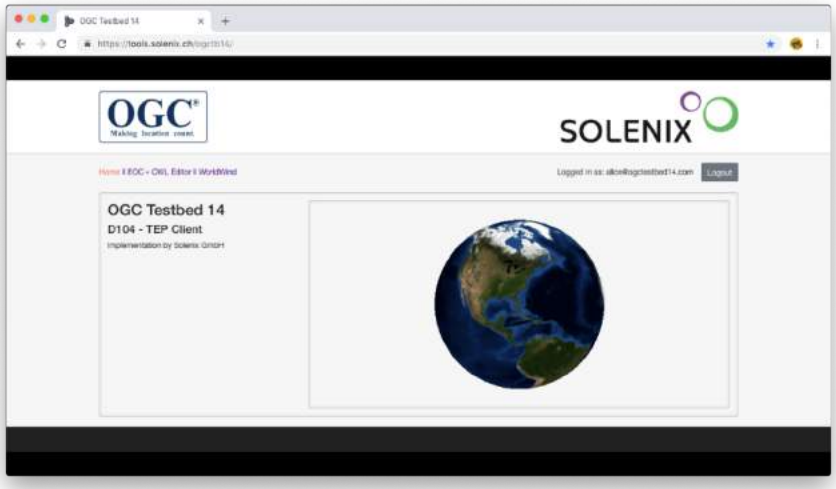
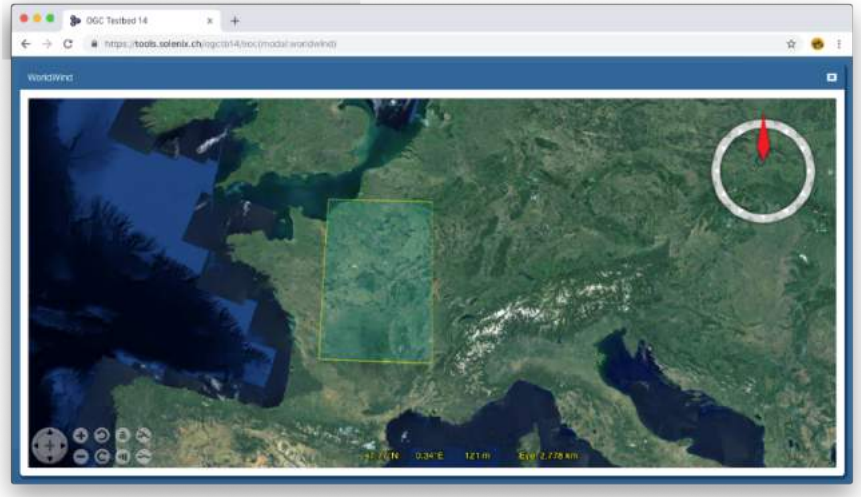
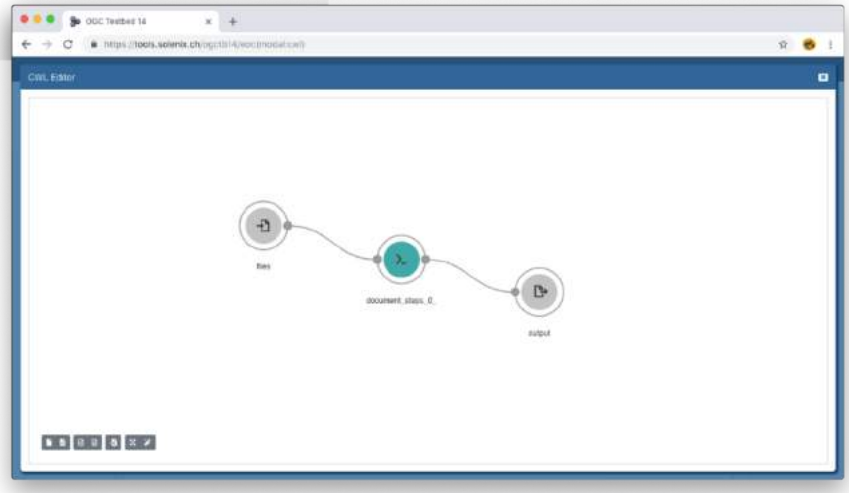
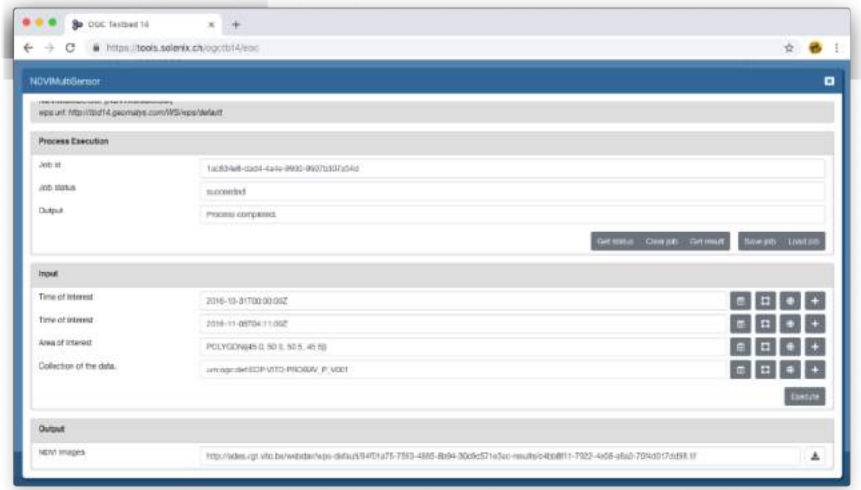
TEP Client

- https://tools.solenix.ch/ogctb14/









APPLICATION PACKAGE

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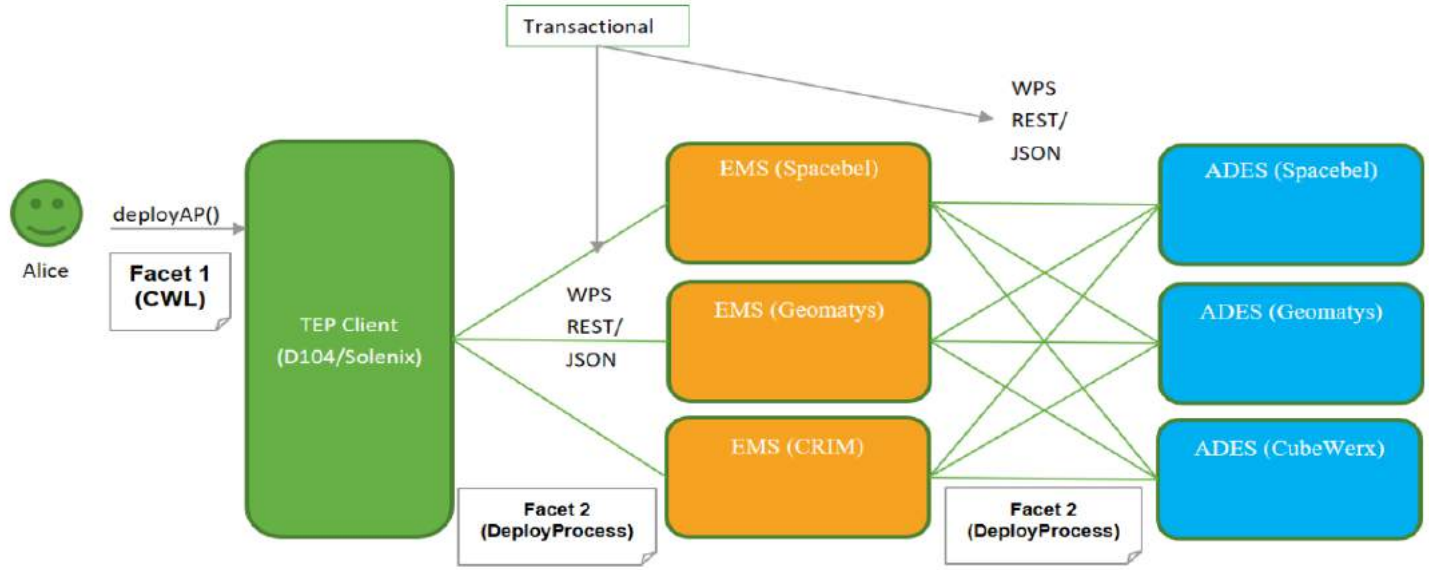
Application Package in the architecture



- Facet 1 (for users) is CWL file -> user-provided or built using client (CWL editor)
- Facet 2 (for M2M) is WPS-T DeployProcess document -> The execution unit can be a Docker container for simple applications or a CWL file for workflows

WPS-T Deploy executionUnit points to Docker WPS-T Deploy deploymentProfileName indicates it's a Docker	WPS-T Deploy executionUnit points to CWL workflow WPS-T Deploy deploymentProfileName indicates it's CWL
1 AP format (WPS-T DeployProcess in JSON) = 2 uses	For CWL-supporting ADES, CWL solves open issue from TB-13 concerning how to map inputs/outputs for use by Docker

EXECUTION MANAGEMENT SERVICE (EMS)

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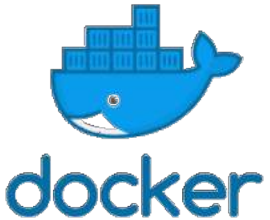
Execution Management Service

- 3 Implementations provided by:
  - CRIM
  - Geomatys
  - Spacebel

EMS

Execution Management Service (EMS)

- WPS-T using PyWPS / OWSLib with REST API
- OAuth2 support with WSO2 Gateway
- User permissions for visibility / execution of each application
- OpenSearch queries to obtain EO Image Data from collections
- Dynamic ADES deployment & execution based on collection data location
- CWL Workflow execution using **CWLTools** engine
- Error handling & logging, e.g. EMS, remote ADES monitoring, …

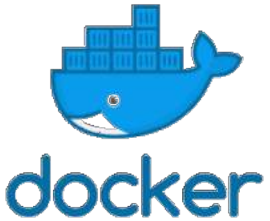


EMS

- WPS 2.0 JSON API proxy using spring boot / swagger codegen pojo.
- Validates user credentials and ACL for deployment/execution
- Performs product search on the FEDEO OpenSearch catalogue
- Transfers WPS request to the relevant ADES based on collection parameter.
- Merges result / quotation / status when multiple ADES are involved
- Executes CWL Workflow (manual parsing), dispatching each step to different ADES and merging the results

Github : https://github.com/Geomatys/Testbed14/tree/master/EMS

Demo server : http://tbd14.geomatys.com/WS/wps/default



EMS (& ADES)

- Java
- Based on 52° North Implementation
- Updated our WPS-T Extension from Testbed 13
- Docker & CWL workflow modules
- Workflow: rewrite the CWL to be executed on any CWL engine
- WPS-T REST proxy in front of XML implementation
- Proxy stub generated with Swagger Generator

APPLICATION DEPLOYMENT & MANAGEMENT SERVICE (ADES)

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ADES

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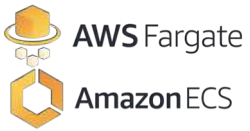
- Implemented in C
- Implements OGC WPS 1.0 & 2.0 Interfaces
- Implements REST-JSON API defined in this thread
  - Supports **WPS transactional** extension
  - Supports **quotation and billing** resources
  - Supports access control via /visibility resources
  - Messages encoding in JSON, XML or HTML
  - Implements notification extension (in addition to polling)
  - RFC 2616 content negotiation & 'f' parameter for minting encoding-specific URLs
- Can execute containers on local host OR using **AWS Fargate** compute engine



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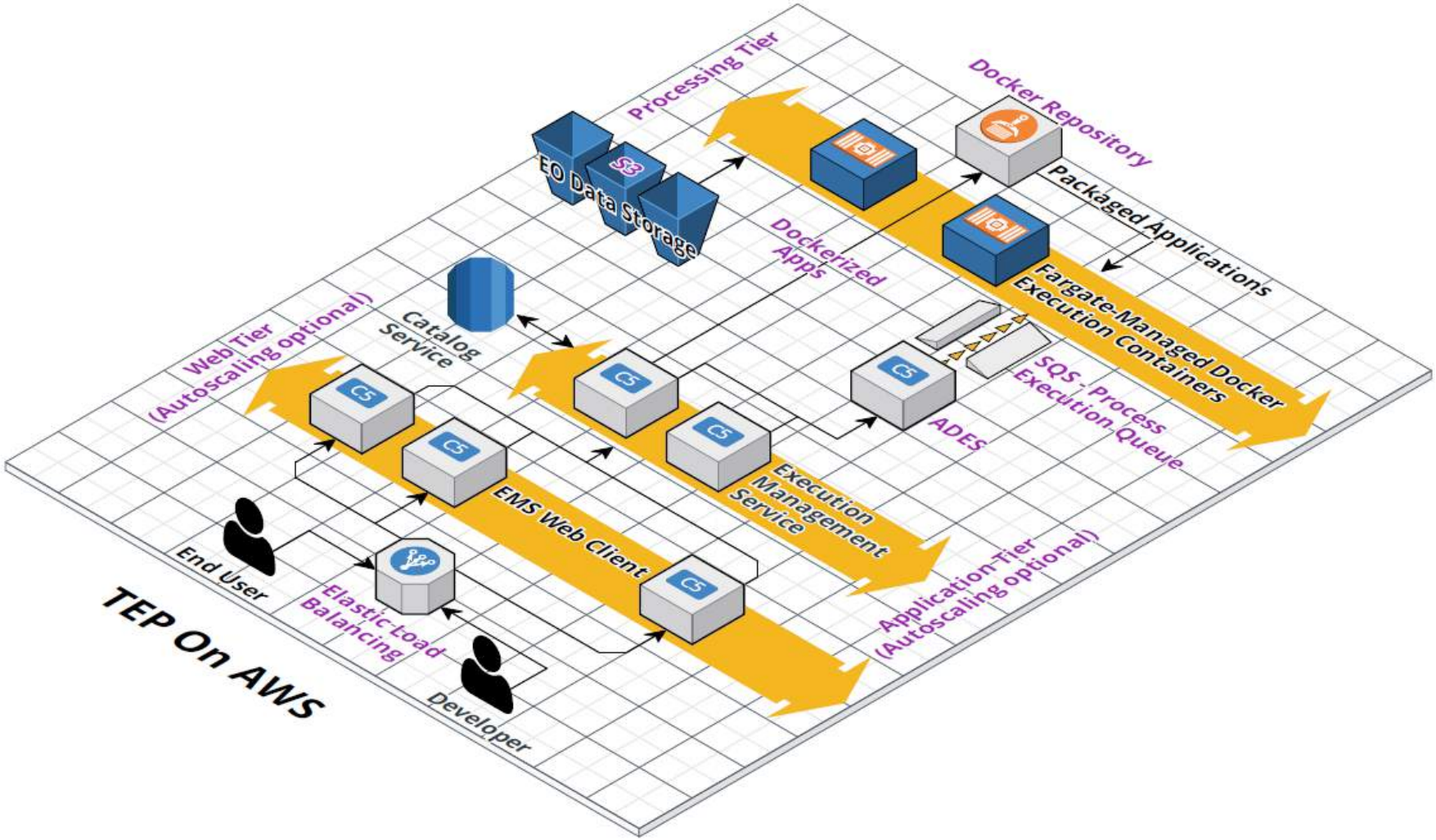
ADES

CubeWerx



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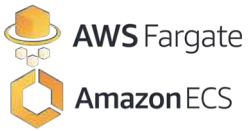
ADES

CubeWerx

- Secured using Oauth 2
- Access controlled
  - Who can execute what WPS operation
  - Who can see, execute or undeploy what process
    - A process is owned by the user who deploys it
    - Can grant describe, execute and undeploy privileges to other users and roles
- Security requirements advertised in server's OpenAPI doc
- Implements CORS support
- Secured server available here.
- Unsecured server available here.



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ADES

- Based on the Examind-server WPS 2.0. It's a java based software, using Geotoolkit library.
- Handles WPS 1.0/2.0 in XML and JSON.
- Implements "Transactional" and "Quotation" profile
- Validates user credentials and ACL for deployment/execution
- Deploys/Executes CWL process using CWLTools Engine
- Located on VITO data center to access PROBAV product files
- Computes quotations and bills (based on input size)

Github : https://github.com/Geomatys/Testbed14/tree/master/ADES

Demo server (VITO) : http://ades.vgt.vito.be/WS/wps/default

DEMONSTRATION VIDEO

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Demo

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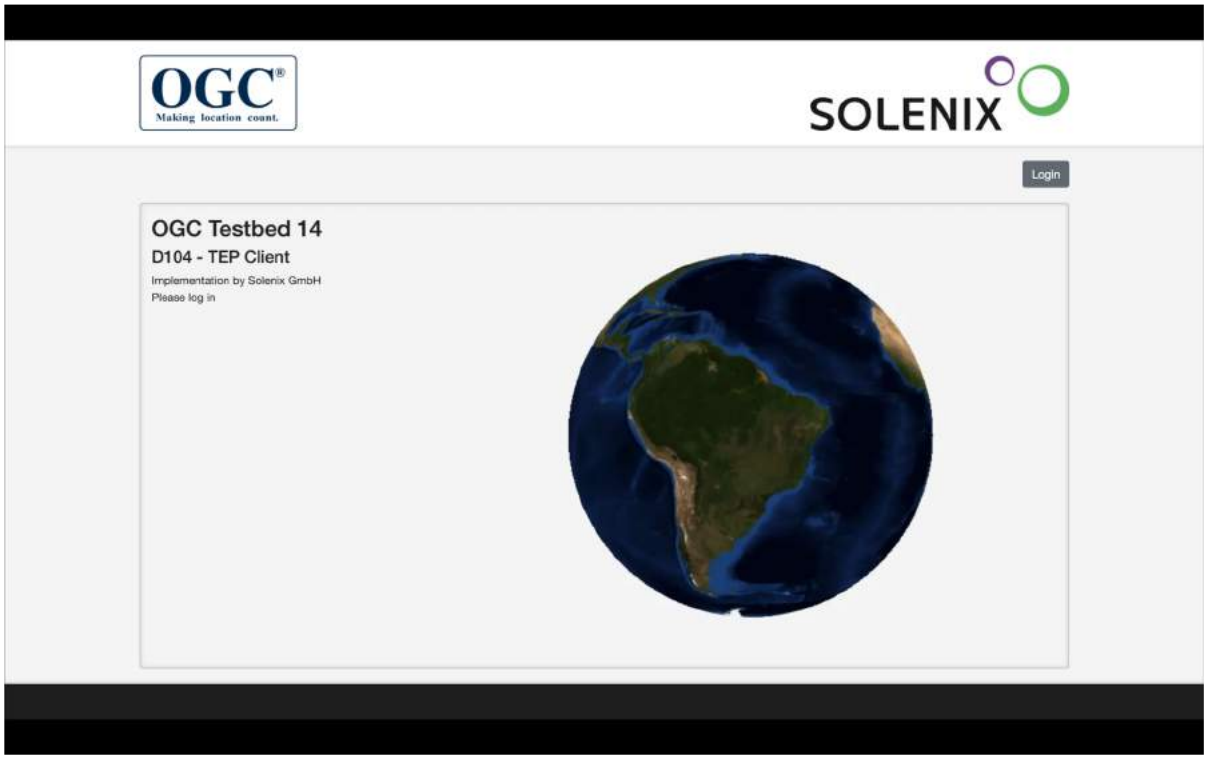
- Alice deploys individual application(s)
  - Deploy MultiSensorNDVI (from Geomatys)
  - Deploy Stacker (from Geomatys)
- Alice's sister deploys a workflow MultiSensor NDVI Stack Generator (chaining the two individual applications - MultiSensorNDVI and Stacker)
- Bob executes workflow

Demo



- Other videos:
  - Spacebel: https://portal.opengeospatial.org/files/?artifact_id=82366
    (acknowledgements: Neon Science – Microsoft – NASA – Spacebel)
  - CubeWerx: https://portal.opengeospatial.org/files/?artifact_id=82448

Not shown in video but in CFP

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- Billing/quotation
  - Proposed API covers some of it and some servers implement it
- Application visibility/execute-ability
  - Proposed API covers visibility and some servers implement it
- Error handling
  - Standard REST/JSON architecture approach over HTTP: JSON messages and standard HTTP error codes

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TECHNOLOGIES

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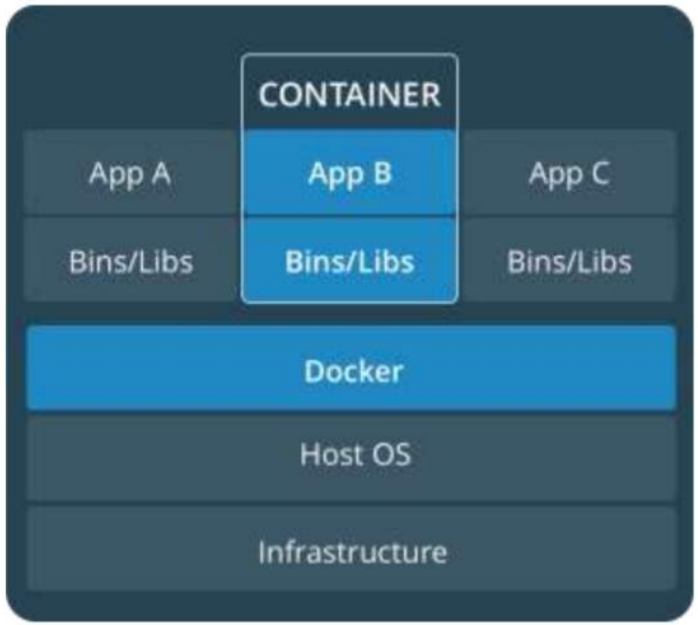
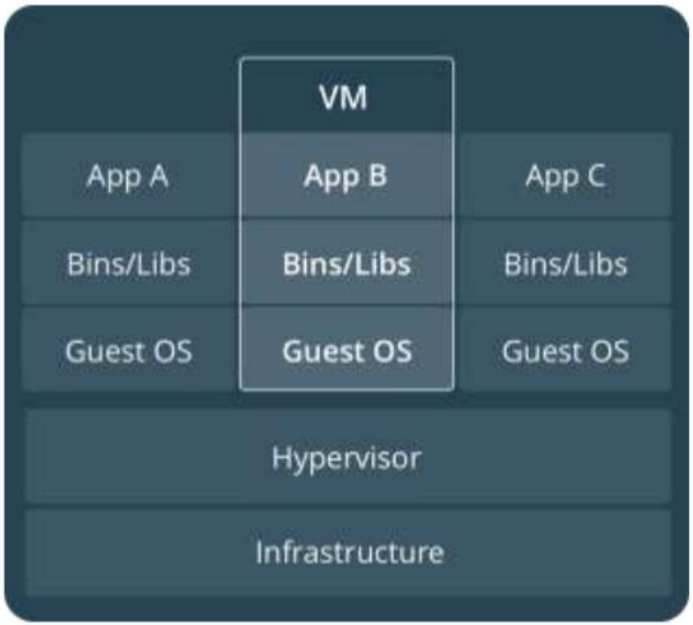
Containers -VS- Virtual Machine

CubeWerx

- Containers are an “app level” thing
  - They encapsulate everything needed to run an application
- Virtual machine are an “infrastructure level” thing
  - They turn one machine in many servers





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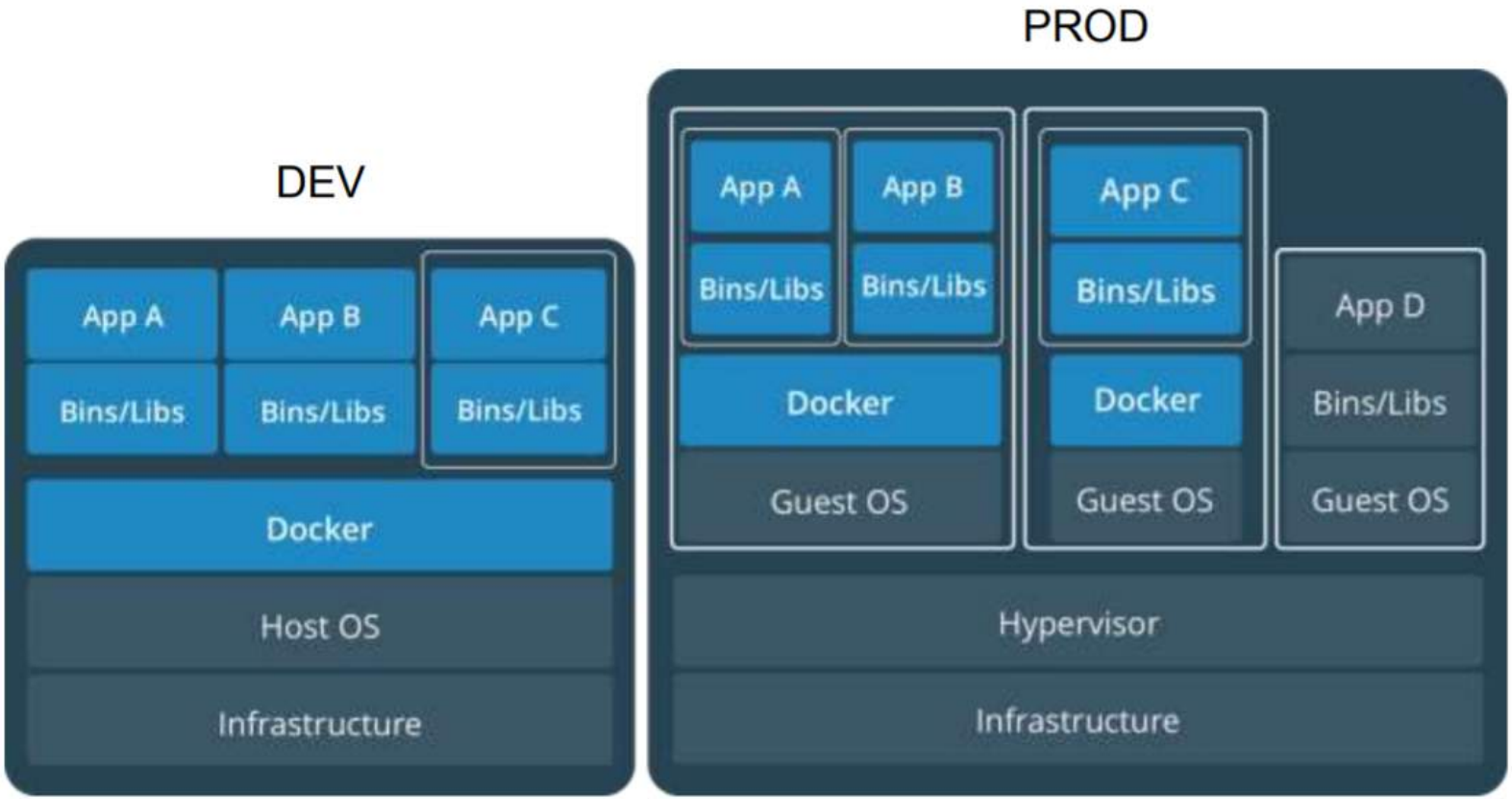
Containers -AND- Virtual Machine

CubeWerx

- Together containers and VMs offer a significant amount of flexibility to optimally deploy, manage and scale applications ...



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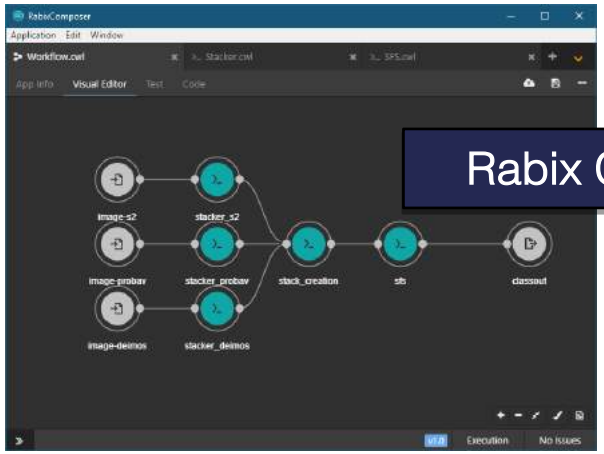
Common Workflow Language (CWL)

- A specification for describing analysis workflows and tools.
- Used in TB14 for :
  - Specifying the execution of a Docker application
  - Describing application chaining in a machine-readable way
- Advantages
  - Open standard supported by the scientific community
  - Multiple engine implementations (workstations, cluster, cloud, HPC)
  - Built for Docker (which is consistent with the AP deployment)
  - JSON is both **human** and **machine**-readable
  - Editors and viewers are available at no cost
  - Can be embedded in other applications



Rabix Composer

TB14 embedded editor (Solenix)

TB14 Workflow in CWL: Application Chaining

CRIM

```
{
    "cwlVersion": "v1.0",
    "class": "Workflow",
    "requirements": […],
    "inputs": {…},
    "outputs": {
        "classout": {
            "type": "File",
            "outputSource": "Stacker/output"
        }
    },
    "steps": {
        "NDVIMultiSensorCollection1": {
            "run": "GeomatysNDVIMultiSensor.cwl",
            "in": {
                "files": "image-collection1"
            },
            "out": ["output"]
        },
        "NDVIMultiSensorCollection2": {…},
        "Stacker": {
            "run": "GeomatysNDVIStacker.cwl",
            "in": {
                "files": {
                    "linkMerge": "merge_flattened",
                    "source": ["NDVIMultiSensorCollection1/output",
                    "NDVIMultiSensorCollection2/output"]
                }
            },
            "out": ["output"]
        }
    }
}
```

Describes workflow

Defines inputs / outputs

Declares output from steps

Workflow steps defined as CWL !

Implicit chaining by inputs

TB14 Application in CWL: Execution

```
{
    "cwlVersion": "v1.0",
    "class": "CommandLineTool",
    "requirements": {
        "DockerRequirement": {
            "dockerPull": "docker-registry.crim.ca/ogc-public/snap6-stack-creation:v2.12"
        }
    },
    "inputs": {
        "files": {
            "inputBinding": {
                "position": 1,
                "prefix": "-Pfiles=",
                "separate": false,
                "itemSeparator": ","
            },
            "type": {
                "type": "array",
                "items": "File"
            }
        }
    },
    "outputs": {
        "output": {
            "outputBinding": {
                "glob": "output.dim.zip"
            },
            "type": "File"
        }
    }
}
```

Describes application

Docker image reference

CWL engine automatically executes docker image

File type triggers volume mounting in docker container…

…and output retrieval

CWL resolves an open issue from Testbed-13

APPLICATIONS

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Applications

- Stacker
- Feature extraction
- Flood detection
- MultisensorNDVI
- Workflow(s) chaining some of these

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Applications

Applications

- Stacker (Overlapping region detection & alignment)
- Structural Feature Set
- Flood Detection

Packaged in Docker images

- Provides everything an application needs to run anywhere
- Wraps SNAP workflows in a docker

Delivered with CWL File

- Executed using standard interface

Built a complex workflow using chaining of the 3 applications !

Stacker Application

Overview

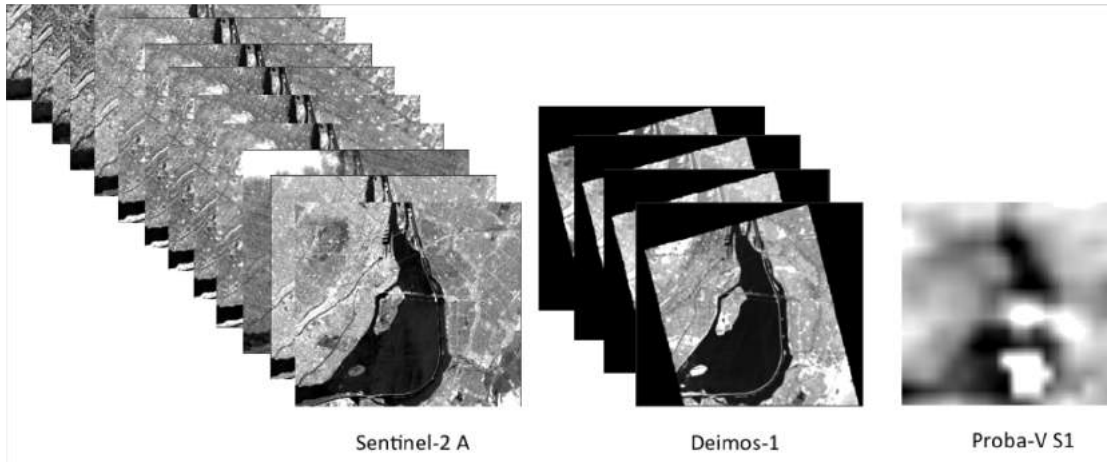
- Automatically selects overlapping regions of all input files
- Selects infrared bands
- Outputs BEAM_DIMAP stack ready for processing

Can be run on all MEP to produce a stack

- Sentinel (1, 2 or Radarsat, using collection Sentinel_2)
- ProbaV (Level 2 or 3, using collection PROBAV_S1-TOA_1KM_V001)
- Deimos (Format tiff, using collection DE2_MS4_L1B)

Can also be chained with itself

- Creates a single stack from results of 3 MEP stacks

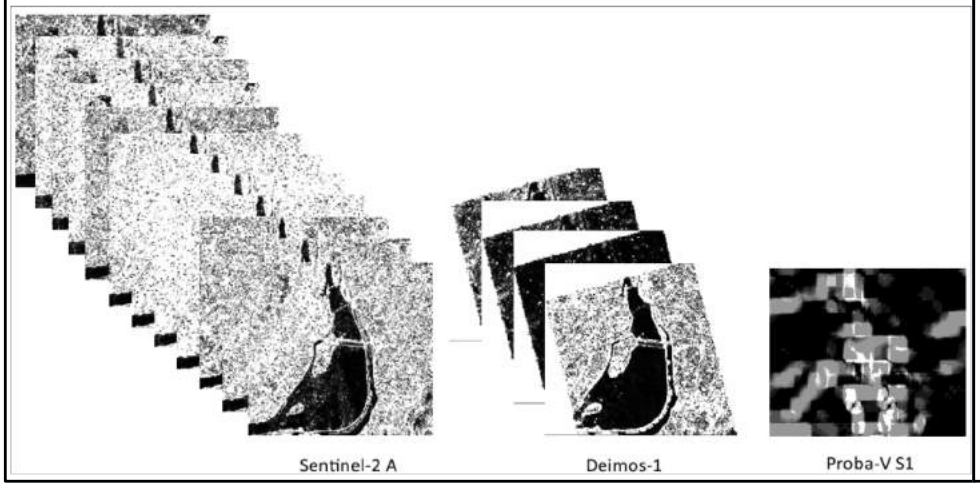


SFS & Flood Detection Application

CRIM

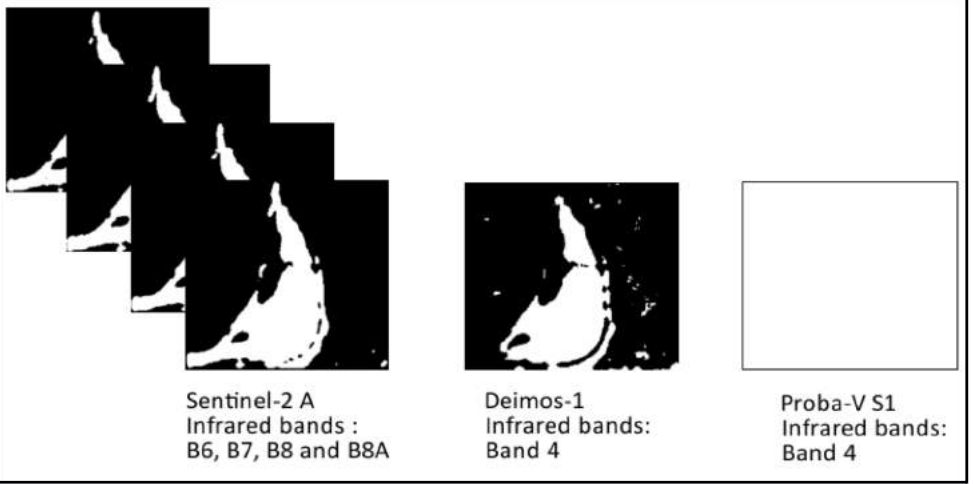
Structural Feature Set (SFS)

- Computes features for each pixel and produces a features stack
- Currently extracts standard deviation



Flood Detection

- Uses SFS features
- Produces a stack of binary images of water-covered areas



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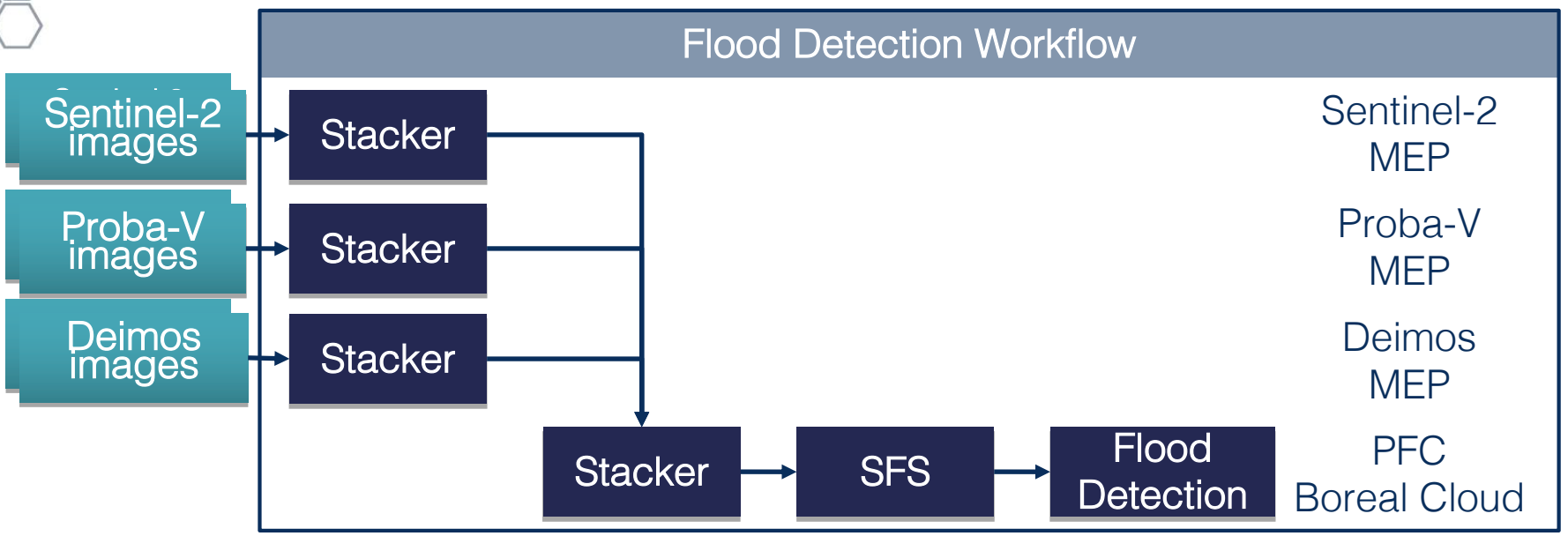
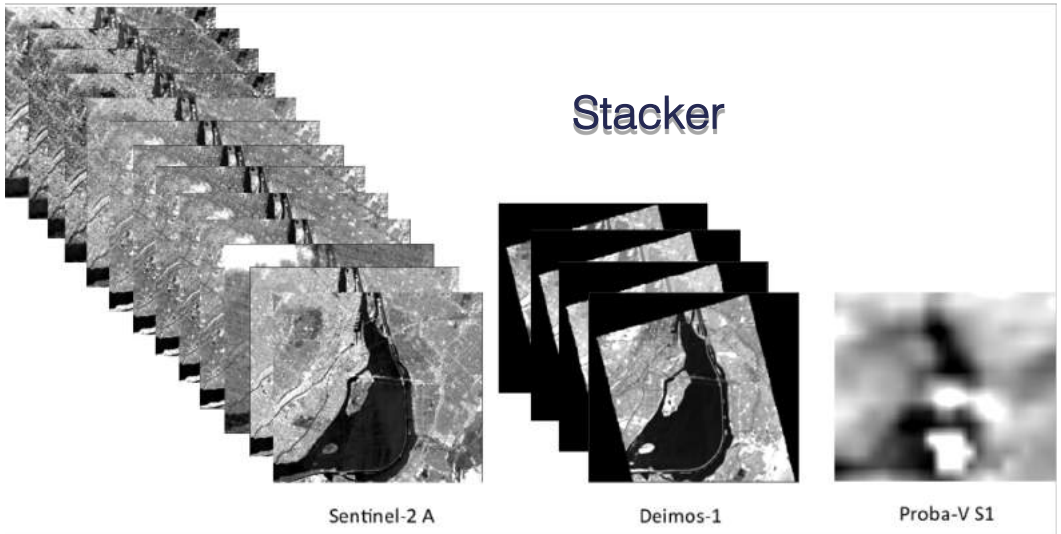
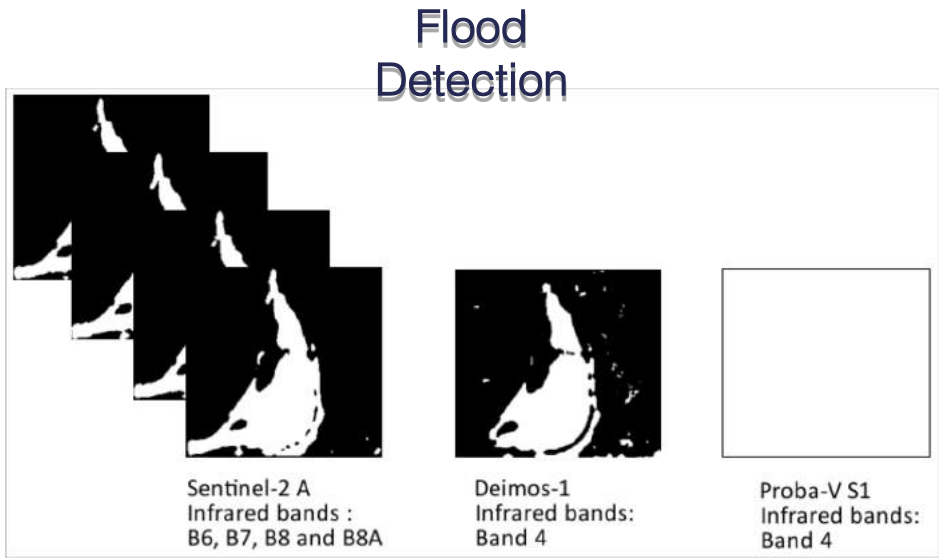
Example of a Complex Workflow







MultiSensorNDVI

- Overview
  - Takes as input *1..n* Sentinel-2 (Zipped SAFE file), Proba-V (HDF5 file) and/or Deimos (TIFF file)
  - Provides as output one NDVI image in TIFF format per input image
  - Python script using GDAL/Numpy provided as docker image
- Launch

```
# Work directory is current directory
export WORKDIR=`pwd`
# The file to process is located under ${WORKDIR}
export S2FILE=S2A_MSIL1C_20180610T154901_N0206_R054_T18TXR_20180610T193029.SAFE.zip
# Compute NDVI processing
docker run -v ${WORKDIR}/${S2FILE}:/${S2FILE} -v ${WORKDIR}:/outputs --
workdir=/outputs images.geomatys.com/ndvims:latest /${S2FILE}
```

https://github.com/Geomatys/Testbed14/tree/master/application-packages/NDVIMultiSensor

Stacker

- Overview
  - Takes as input *2 .. n* GeoTIFF images
  - Provides as output a single GeoTIFF in the same CRS as input images (or in EPSG:4326 if input CRSes differ) at the lowest resolution of input resolutions
  - Python script using GDAL provided as docker image
- Launch

```
# Work directory is current directory
export WORKDIR=`pwd`
# The file to process is located under ${WORKDIR}
export PV1FILE=PROBAV_L1C_20160505_232748_3_V101.tif
export PV2FILE=PROBAV_L1C_20160505_232949_3_V101.tif
# Compute NDVI processing
docker run -v ${WORKDIR}/${PV1FILE}:/${PV1FILE} -v ${WORKDIR}/${PV2FILE}:/${PV2FILE} -
v ${WORKDIR}:/outputs --workdir=/outputs images.geomatys.com/ndvis:latest /${PV1FILE}
${PV2FILE}
```

https://github.com/Geomatys/Testbed14/tree/master/application-packages/NDVIStacker

CHALLENGES & FUTURE WORK

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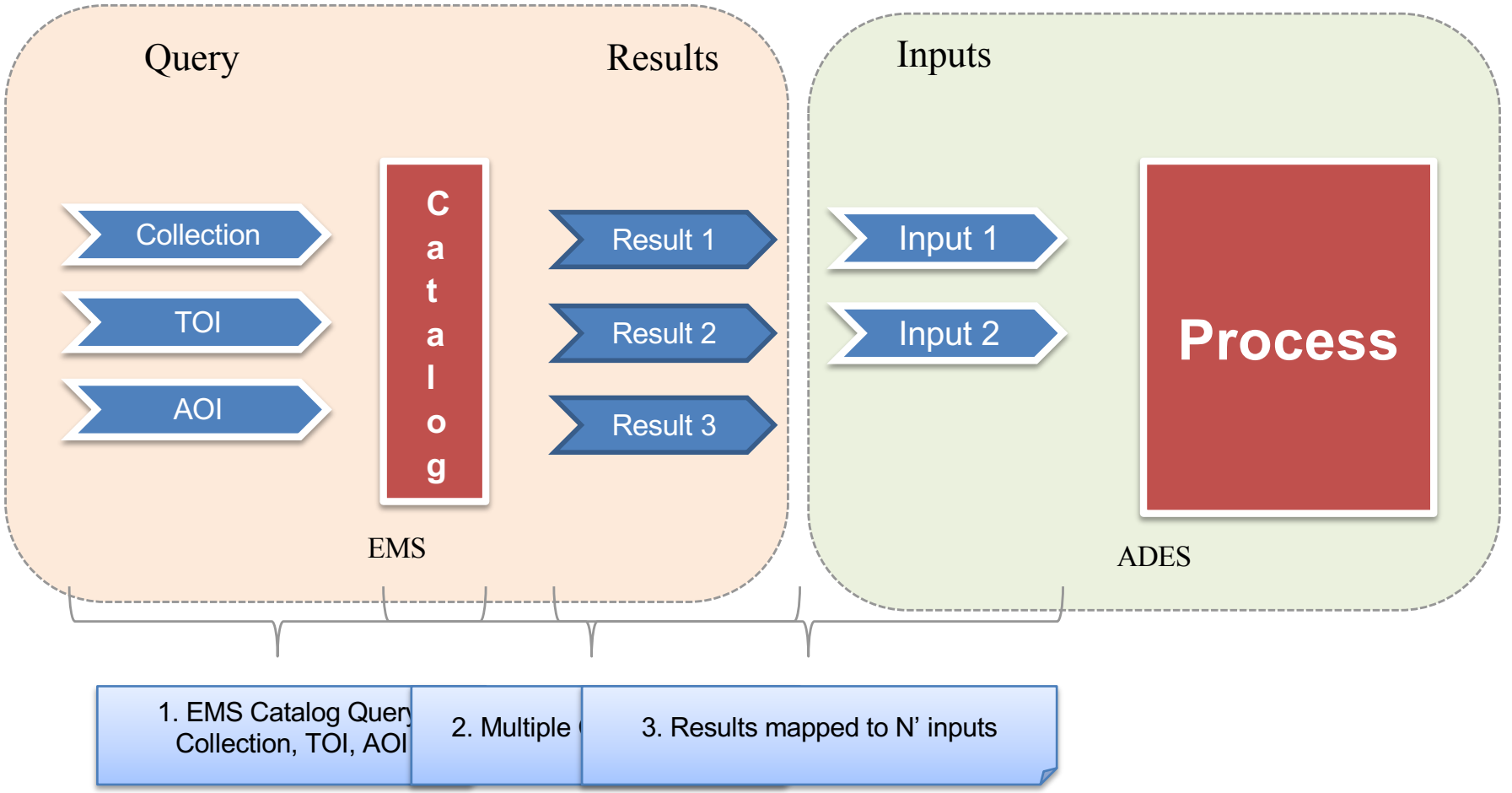
Issues of interest

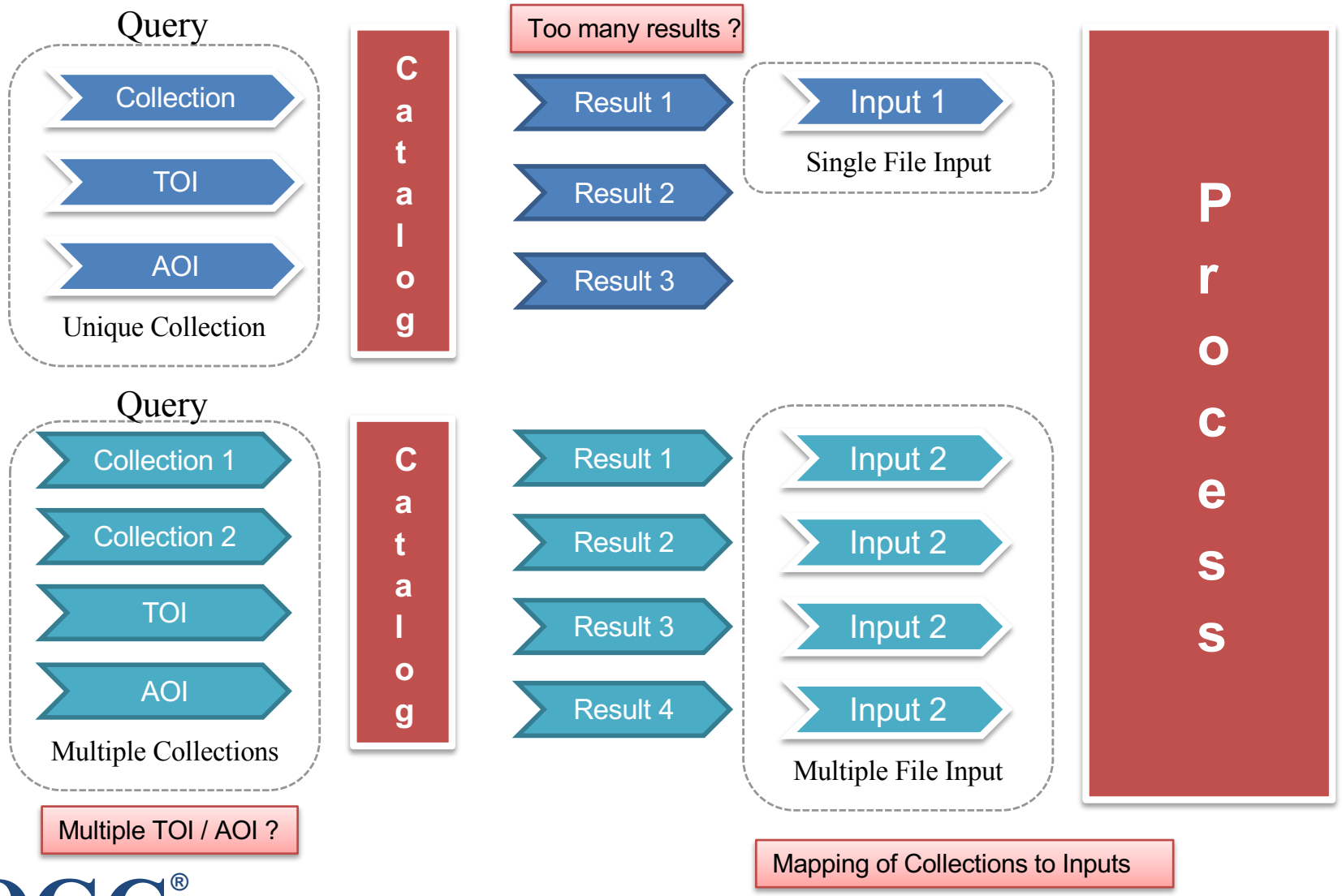
- Mapping of catalogue results
- Handling of multiple outputs
- Inputs/Outputs format
- EO image access on MEP
- CORS and other connectivity issues
- Short validity time of authentication token
- Many others (read D009 – “EMS and Best Practices ” ER)

Issue 1 – Mapping of Catalogue Results



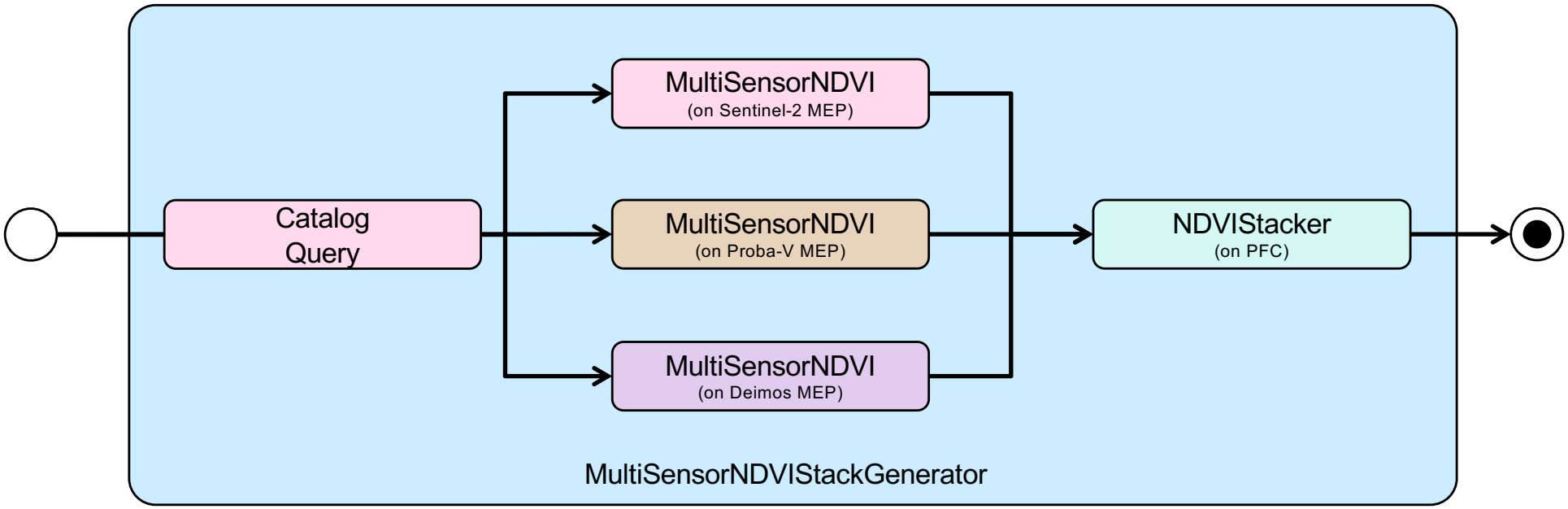
Real Cases: Multiple Combinations

How do we map Results to Inputs ?



Issue 1 – Solution

- Include Catalog Query in the Processing Chain
  → allows to define appropriate rules



Issue 2 – Handling of Multiple Outputs

- WPS 2.0 does not support Output arrays !
- Evaluated approaches :

Method	Cons
Archive (e.g. zip)	Resource consuming for large files
Metalink	Parser required, file reference only
Multipart/mixed	Not supported by all browsers. No statement about individual files.

→Recommandations:

- Metalink if external output reference is available
- Otherwise: WPS 3.0 support ?

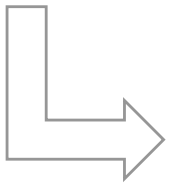
Issue 3 - Inputs/Outputs Format

File Mime Type: TIFF, JPG, ZIP

➔ Not satisfactory : not precise enough

Processes consumes specific formats:

- Optical Sensors: Sentinel-2, Sentinel-3, Spot, NOAA, …
- Radar Sensors: Sentinel-1, TerraSAR, Kompsat-S, …
- Vector Data: Shapefile, GeoJSON, …
- Generic Data: JP2000, GeoTiff, ENVI, …



```
<wps:Input minOccurs="0" maxOccurs="unbounded">
  <ows:Title>S2 Input Image</ows:Title>
  <ows:Identifier>image-s2</ows:Identifier>
  <ows:AdditionalParameters>
    <ows:AdditionalParameter>
      <ows:Name>EOImage</ows:Name>
      <ows:Value>true</ows:Value>
    </ows:AdditionalParameter>
    <ows:AdditionalParameter>
      <ows:Name>Format</ows:Name>
      <ows:Value>Sentinel-2</ows:Value>
    </ows:AdditionalParameter>
```

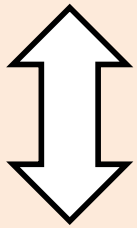
Process Description

Issue 4 - EO Image Access

- As opposed to Testbed 13, the external (HTTP) URL of data is provided by the Catalogue.

- ADES needs to map the URL to the local file location

http://185.48.233.249/Sentinel-2/MSI/L1C/2018/01/30/S2B_MSIL1C_20180130T034959_N0206_R104_T47PPT_20180130T064159.SAFE



/nfs/eodata/Sentinel-2/MSI/L1C/2018/01/30/S2B_MSIL1C_20180130T034959_N0206_R104_T47PPT_20180130T064159.SAFE

Issue 5 - Network-level issues

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- To be addressed in operational/realistic context:
  - CORS
    - Either configure servers to accept all origins:
      - Access-Control-Allow-Origin: *
    - Bypass using browser plugin (Chrome-specific):
      - https://chrome.google.com/webstore/detail/allow-control-allow-origin/nlfbmbojpeacfghkpbjhddihlkkiljbi?hl=en
  - Mixed HTTP/HTTPS content (particularly due to WSO2 endpoint):
    - Browser-specific solution:
      - Firefox and Chrome: shield icon on address bar to bypass
      - IE: “Show all content” at bottom of screen

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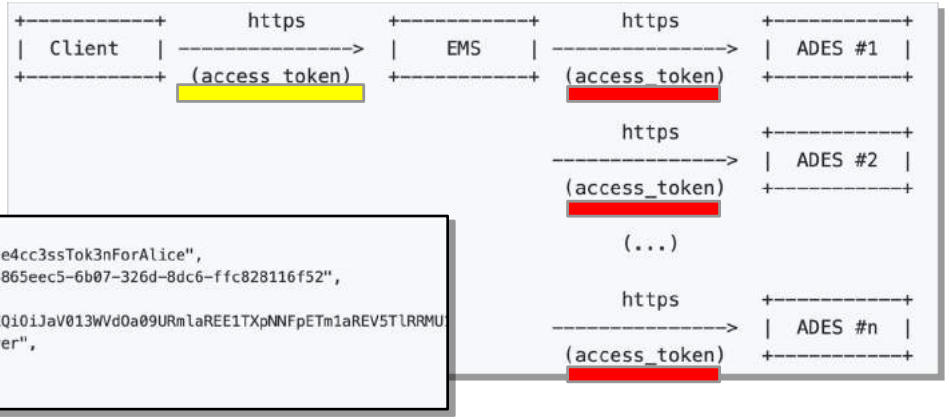
Issue 6 - Token Validity



- Issue #1
  - Web Client should update the *access_token* on a regular basis to ensure that requests sent to the EMS/ADES provide *fresh access_token*
  - Concern if *access_token* expires during workflow execution

- Issue #2
  - To deploy ADES on MEPs, EMS must provide a user's *access_token* that give rights to deploy process on ADES. Since the execute request is sent by Bob, the EMS has access to the *access_token* from Bob and not from Alice
  - Two solutions
    - We give Bob the right to deploy process on ADES
    - We introduce an "ems user" associated to EMS. This user can deploy process on ADES. Each request from EMS to ADES uses the credentials of this user instead of the real user (i.e. Alice or Bob)

Future Work

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- CRs to WPS SWG and/or Best Practices for use of WPS-T DeployProcess as EP AP
- Consolidate the WPS REST API
- Initiate standardization path for WPS-T
- Broader issues:
  - How to transform message-based protocols such as WPS (GetCapabilities, DescribeProcess, Execute) into resource-based protocols such as WPS REST (*processes, jobs* resources, HTTP GET/POST/PUT) -> straightforward conversion may result in non-intuitive and semantically unclear APIs
  - How to transform/encode XML into JSON content
- Relevance of CWL to OGC -> potential Community Standard
- Many other suggestions (read D009 – “EMS and Best Practices ” ER)

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STANDARDIZATION-RELATED ISSUES

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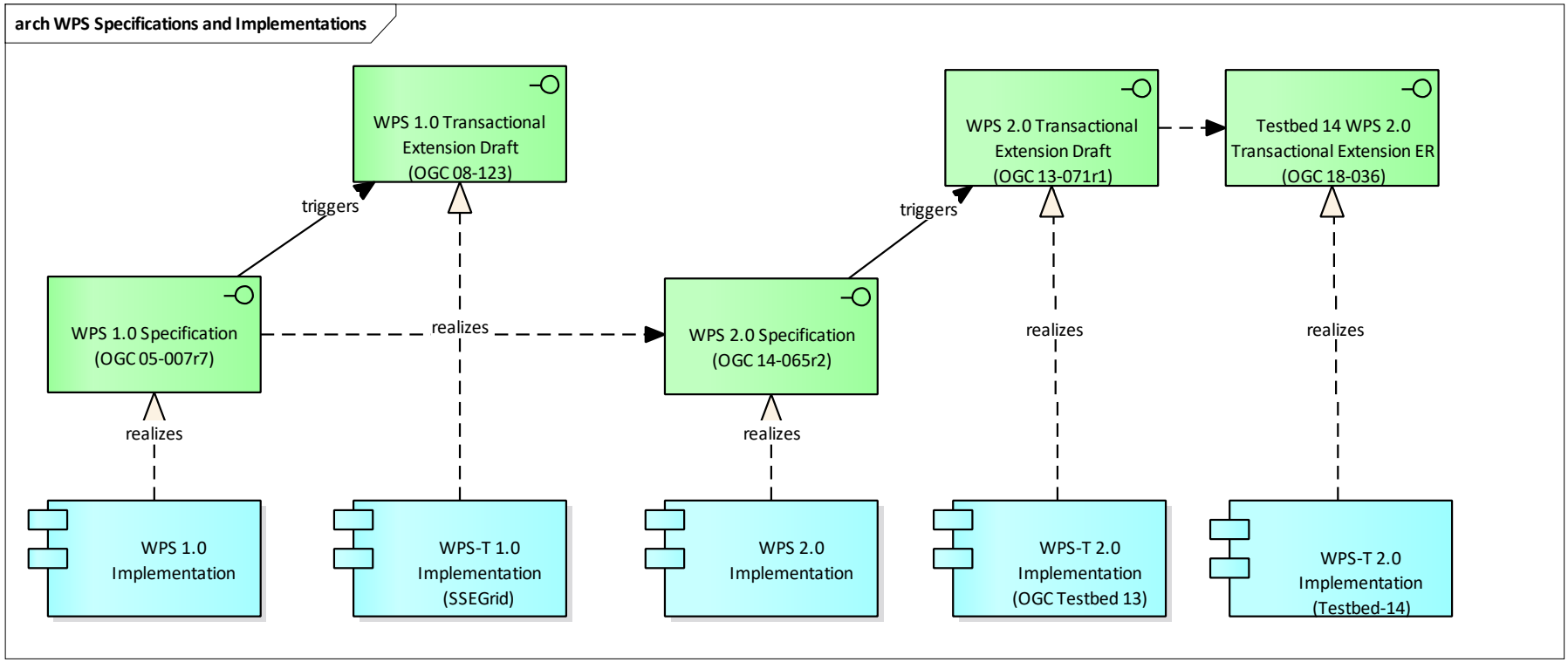
WPS Specifications

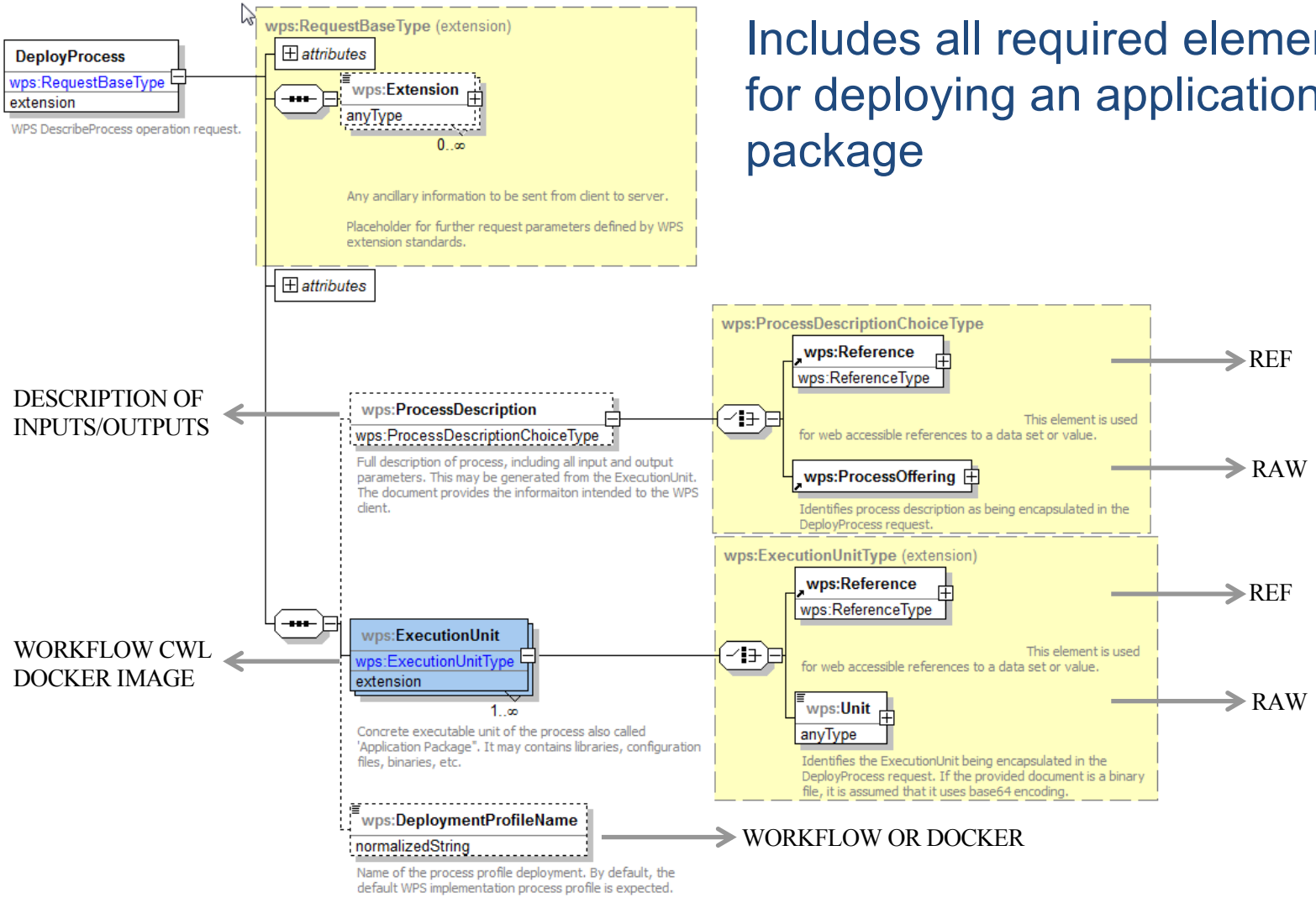
- Participated in WPS-T 2.0 draft (OGC 13-071r1)
- Some WPS-T implementations (e.g. TB-13, SSEGrid, …)

→ Cooperated with NextGen Thread (WPS-T ER)



Historical Summary of WPS spec. & impl.

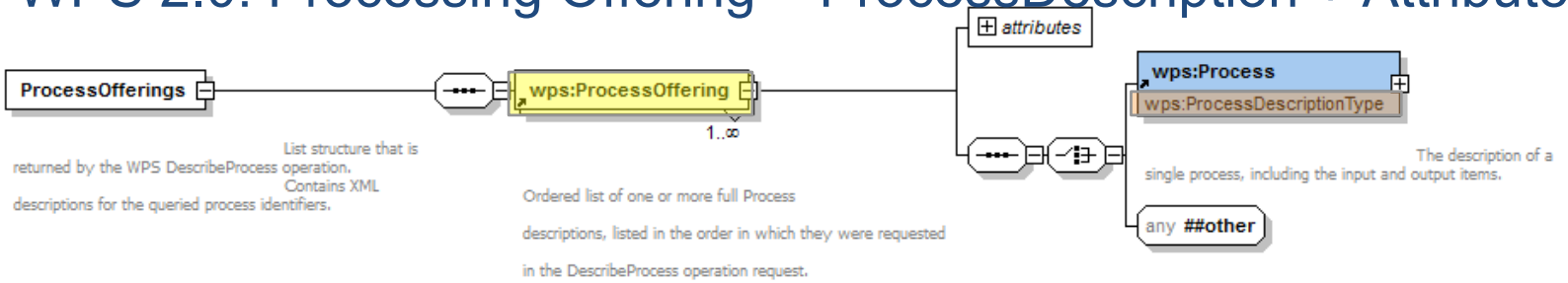
New WPS-T Schemas



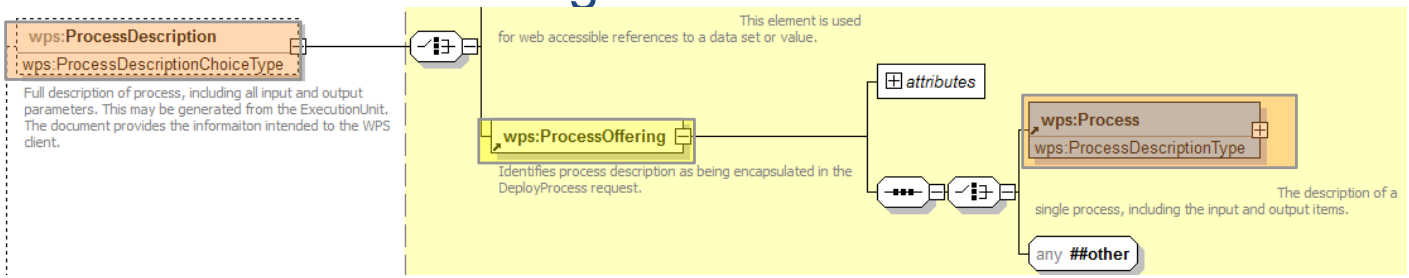
Includes all required elements for deploying an application package

Remaining Issue

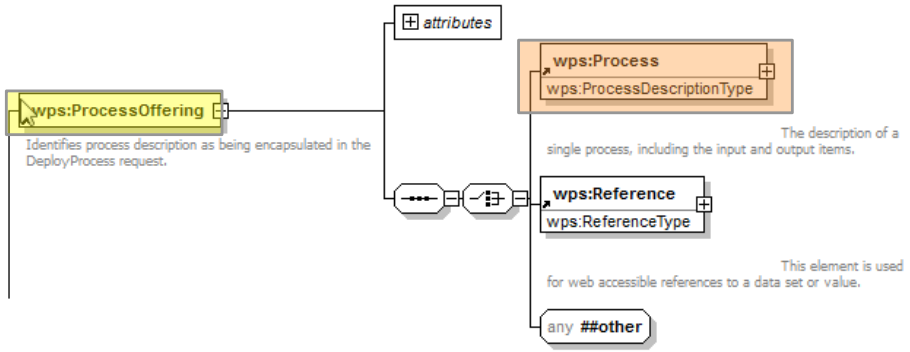
- WPS 2.0: Processing Offering = ProcessDescription + Attributes



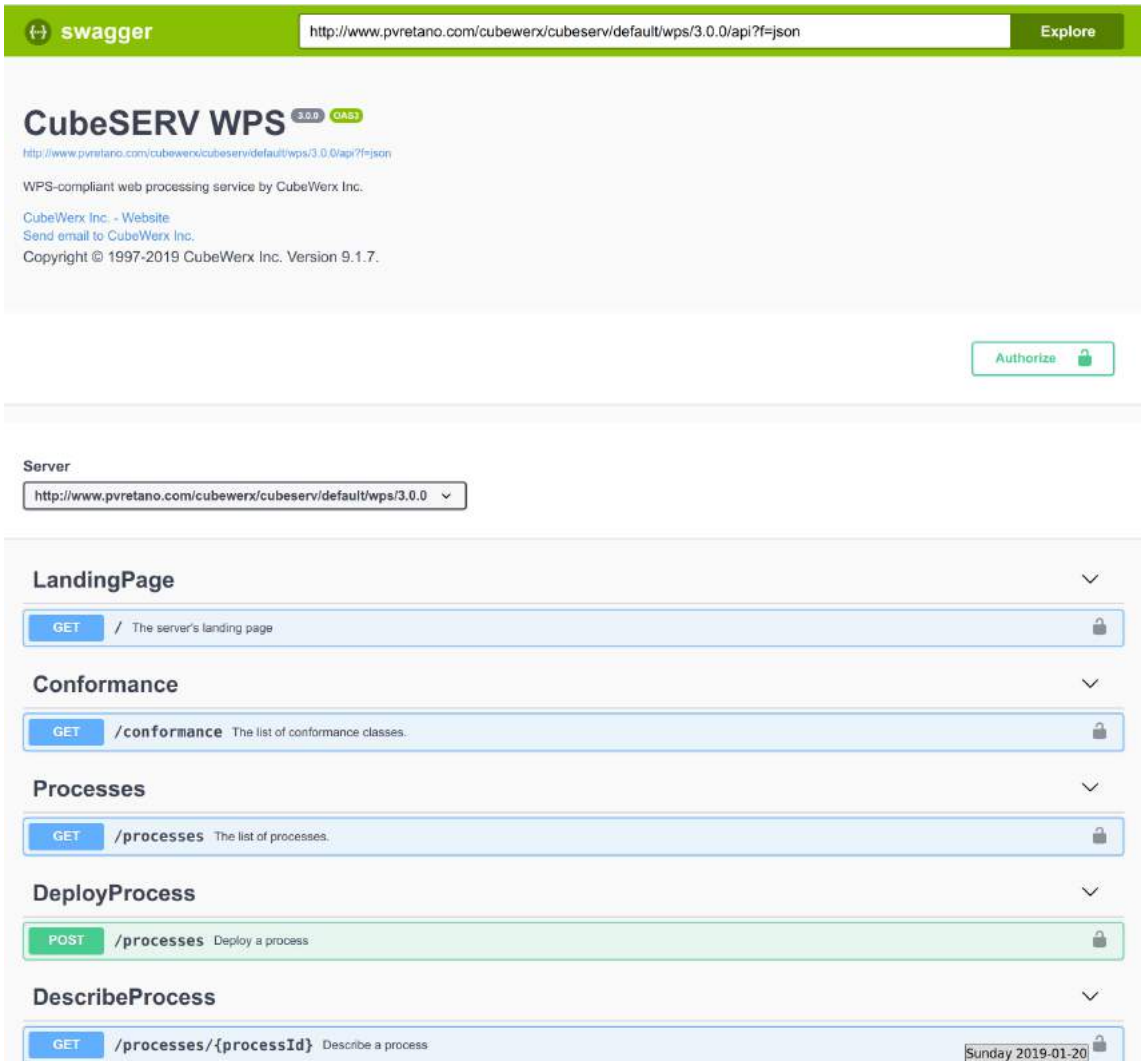
- Testbed-14: Confusing structure



- Recommendation:



REST-JSON API



- Based on work already being done by the WPS SWG to define a REST API
- Based on the NextGen service pattern defined by WFS 3.0
- The API is described using OpenAPI so it is developer and tool friendly

REST-JSON API - Discovery

CubeWerx

Resource/Path	HTTP Method	Purpose
/	GET	The landing page provides links to the API definition, the Conformance statements and the metadata about the processes offered by this API
/api	GET	Get's the server's OpenAPI document
/conformance	GET	Lists all requirements classes specified in the standard (WPS REST/JSON Binding Core) to which the server conforms

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REST-JSON API - Processes

CubeWerx

Resource/Path	HTTP Method	Purpose
/processes	GET	Retrieve available processes
	POST	Deploy a process
/processes/{id}	GET	Retrieve a process description
	DELETE	Undeploy a process
/processes/{id}/quotations	GET	Retrieve the list of quotation ids for a given process
	POST	Request a quotation for a given process
/processes/{id}/quotations/{quotationID}	GET	Retrieve quotation information
	POST	Execute a quoted process

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REST-JSON API - Jobs

CubeWerx

Resource/Path	HTTP Method	Purpose
/processes/{id}/jobs	GET	Retrieve the list of jobs for a process
	POST	Execute a process
/processes/{id}/jobs/{jobID}	GET	Retrieve the status of a job
	DELETE	Dismiss a job
/processes/{id}/jobs/{jobID}/result	GET	Retrieve the result(s) of a job

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REST-JSON API – Quotation

CubeWerx

Resource/Path	HTTP Method	Purpose
/quotations	GET	Retrieve the list of all quotation ids
/quotations/{quotationID}	GET	Retrieve quotation information
	POST	Execute a quoted process
/bills	GET	Retrieve the list of all bill identifiers
/bills/{billID}	GET	Retrieve bill information

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REST-JSON API – Access Control

CubeWerx

Resource/Path	HTTP Method	Purpose
/processes/{id}/visibility	GET	Retrieve the visibility status for a process
	PUT	Change the visibility status for a process

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Quotation & Billing

- EMS
  - The server keeps in memory a mapping between the EMS generated *JobId* and one or more subsequents ADES *jobIDs*. The same mechanism is applied for quotations and bills.
  - When receiving a request, if multiple ADES are involved, all ADES quotations are merged in one single quotation
- ADES
  - Minimalistic approach: the estimated time and price are calculated based on a ratio of input files' size.
  - On successful quotation request, the quotation response is stored with the Execute request within the ADES database.
  - The quotation has a validity period. An execution request based on the quotation outside of the validity period is refused.
  - Bill is provided as a link sent within the results response.

CONCLUSION/ACHIEVEMENTS

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Conclusion/Achievements

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- 5 different companies working together in the OGC manner, i.e. consensus-based, to:
  - Propose and write-down a standard Application Package format (D008 – "Application Package" ER)
  - Propose a WPS-T JSON/REST API - partly developed in coordination with the WPS 2.0 SWG - and write-down best practices and experiences about the EMS & ADES, two essential components of a EP (D009 – "EMS & ADES Best Practices and Results" ER)
- 1 client, 3 different EMS and 3 different ADES implementations able to interact in a standardized and interoperable way:
  - Using the proposed AP format
  - Using the proposed WPS-T REST/JSON API
  - Integrating several different TEPs & MEPs, authN/authZ, catalogue in flow
- With the support of the OGC, brought ESA closer to the goal of standardizing parts of the very complex EP ecosystem

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- ATOS CVC Romania
- Participants:
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  - CubeWerx: Peter Vretanos
  - Geomatys: Jérôme Gasperi, Guilhem Legal, Vincent Heurteaux
  - Solenix: Paulo Sacramento, Dan Robinson
  - Spacebel: Patrick Jacques, Christophe Noël, Yves Coene

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