OGC API Hackathon 2019 Engineering Report

Table of Contents

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Chapter 1. Subject

The subject of this Engineering Report (ER) is a hackathon event that was held from June 20th to 21st, 2019 to advance the development of OGC Application Programming Interface (API) specifications. An API is a standard set of documented and supported functions and procedures that expose the capabilities or data of an operating system, application or service to other applications (adapted from ISO/IEC TR 13066-2:2016). The OGC API Hackathon 2019, as the event was called, was hosted by the Geovation Hub in London, United Kingdom. The event was sponsored by the European Space Agency (ESA) and the Ordnance Survey.

Chapter 2. Executive Summary

Several technologies and practices have emerged over the past decade that have presented new opportunities for geospatial software developers. Amongst those technologies are Web Application Programming Interfaces (APIs). In order to leverage the capabilities offered by these technologies, the OGC has initiated a body of work to develop draft standards for OGC APIs. At the February 2019 OGC Technical Committee (TC) meeting in Singapore, the TC took a decision to hold a hackathon to help advance many of the draft OGC API standards.

The hackathon was held from June 20th to 21st, 2019, hosted by the Geovation Hub in London, United Kingdom. The European Space Agency (ESA), Ordnance Survey and Geovation sponsored the event. The hackathon was also supported by the US National Geospatial Intelligence Agency (NGA). The goal of the hackathon was to advance the development of OGC API specifications, with the aim of the hackathon being to provide an environment and an opportunity for the geospatial community to achieve this goal. The following objectives were set for the hackathon:

- Develop, deploy and test services/clients that support OGC APIs
- Suggest improvements for a common core
- Define rules/guidance that can be documented
- Validate work that has been completed to date
- Contribute to the GitHub repositories of the draft standards

More than 70 individuals participated in the event. The participants represented 60 organizations; 41 of those organizations are OGC members; one of the organizations is an OGC Alliance Partner and the remaining 18 organizations are non-members. Working collaboratively, the participants formed teams around the draft standards.

During the two-day hackathon, the participants developed, deployed and tested a variety of implementations of OGC APIs. These implementations were from different organizations, including private, public and academic organizations. Suggestions for improvements were made, and in some cases, editors of the standards were able to update the draft standards during the hackathon. Improvements to the common core were discussed, and where possible, agreed on. The work that had previously been done was validated through development and testing. Where the previous work was invalid, suggestions for improvements were identified. Requirements and recommendations were discussed and documented as rules and guidance in the Github repositories of the draft standards. This Engineering Report therefore concludes that the hackathon achieved its goal.

One of the key findings of the hackathon was that the draft OGC API standards are implementable. This was evidenced by the implementations developed by many of the participating organizations at the hackathon. Another key finding is that the 'building-block' principle, adopted by the different draft standards, allows for a common core to be specified. This was evidenced in the use of common capabilities such as `/collection` paths and support for bounding box (BBOX) queries.

It is envisaged that the output of the hackathon will be instrumental to the evolution of OGC web service standards to a modern API-based approach, setting the course for open geospatial standards for the next decade. The output should lead to a solid, common core and advancement of a whole

new generation of OGC standards that are flexible in modern IT environments. This does not mean that existing OGC web service standards will fade away. Instead, it means that a new suite of OGC standards will give developers and users the option of leveraging capabilities offered by Web APIs.

2.1. Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

Contacts

Name	Organization	Role
Gobe Hobona	Open Geospatial Consortium	Editor
Scott Simmons	Open Geospatial Consortium	Contributor
Michael Gordon	Ordnance Survey	Contributor
Simon Green	Ordnance Survey	Contributor
Clemens Portele	interactive instruments GmbH	Contributor
Jorge Samuel Mendes de Jesus	ISRIC - World Soil Information	Contributor
Peter Baumann	rasdaman GmbH	Contributor
Francesco Bartoli	Geobeyond	Contributor
Dirk Stenger	lat/lon GmbH	Contributor
Chuck Heazel	Heazeltech LLC	Contributor
Matthias Mohr	University of Münster	Contributor
Robin Houtmeyers	Hexagon Geospatial	Contributor
Jonathan Moules	GeoSeer	Contributor
Gérald Fenoy	GeoLabs	Contributor
Brad Hards	Sigma Bravo	Contributor
Chris Little	Met Office	Contributor
Yves Coene	Spacebel	Contributor
Adam Branscomb	Esri UK	Contributor
Adam Martin	Esri	Contributor
Joan Maso	CREAF	Contributor
Stephan Meißl	EOX	Contributor
Tom Kralidis	Open Source Geospatial Foundation (OSGeo)	Contributor
Alexander Jacob	Eurac Research	Contributor
Brian Osborn	CACI	Contributor
Robert St. John	CACI	Contributor

Name	Organization	Role
TBA	TBA	Contributor
TBA	TBA	Contributor
TBA	TBA	Contributor
TBA	TBA	Contributor

NOTE Role = Editor and/or Contributor

2.2. Foreword

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Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

Chapter 3. References

The following normative documents are referenced in this document.

NOTE: Only normative standards are referenced here, e.g. OGC, ISO or other SDO standards. All other references are listed in the bibliography. Example:

- OGC: OGC 06-121r9, OGC® Web Services Common Standard [https://portal.opengeospatial.org/files/?artifact_id=38867&version=2]
- OGC: OGC 17-069r2, OGC API - Features - Part 1: Core, Version 1.0.0-draft.2 (release candidate) [http://docs.opengeospatial.org/DRAFTS/17-069r2.html]
- OpenAPI Initiative: OpenAPI Specification 3.0.2 [https://github.com/OAI/OpenAPI-Specification/blob/master/versions/3.0.2.md]
- OGC: OGC 09-146r6, OGC® Coverage Implementation Schema, version 1.1, 2017 [http://docs.opengeospatial.org/is/09-146r6/09-146r6.html]
- OGC: OGC Web Coverage Service (WCS) 2.1 Interface Standard - Core, 2018 [http://docs.opengeospatial.org/is/17-089r1/17-089r1.html]
- OGC: OGC 14-065r2, OGC® WPS 2.0.2 Interface Standard Corrigendum 2, 2018 [http://docs.opengeospatial.org/is/14-065/14-065.html]
- OGC: OGC OGC 07-057r7, OpenGIS® Web Map Tile Service Implementation Standard, 2010 [http://portal.opengeospatial.org/files/?artifact_id=35326]
- OGC 09-025r2, OGC® Web Feature Service 2.0 Interface Standard – With Corrigendum, 2014 [http://docs.opengeospatial.org/is/09-025r2/09-025r2.html]

Chapter 4. Terms and definitions

For the purposes of this report, the definitions specified in Clause 4 of the OWS Common Implementation Standard OGC 06-121r9 [https://portal.opengeospatial.org/files/?artifact_id=38867&version=2] shall apply. In addition, the following terms and definitions apply.

- **application programming interface**

  standard set of documented and supported functions and procedures that expose the capabilities or data of an operating system, application or service to other applications (adapted from ISO/IEC TR 13066-2:2016)

- **feature**

  abstraction of real world phenomena (source: ISO 19101-1:2014)

- **OpenAPI definition | OpenAPI document**

  a document (or set of documents) that defines or describes an API and conforms to the OpenAPI Specification [derived from the OpenAPI Specification]

- **Web API**

  API using an architectural style that is founded on the technologies of the Web [derived from the W3C Data on the Web Best Practices]

  NOTE Best Practice 24: Use Web Standards as the foundation of APIs [https://www.w3.org/TR/dwbp/#APIHttpVerbs] in the W3C Data on the Web Best Practices provides more detail.

- **commit**

  As a noun, a commit is a single point in the Git history that represents a "revision" or "version" [derived from https://git-scm.com/docs/gitglossary].

- **coverage**

  feature that acts as a function to return values from its range for any direct position within its spatiotemporal domain, as defined in OGC Abstract Topic 6 (OGC 07-011).

- **Regular grid**

  grid whose grid lines have a constant distance along each grid axis

- **process**

  A process p is a function that for each input returns a corresponding output

  $$p: X \rightarrow Y$$

  where X denotes the domain of arguments x and Y denotes the co-domain of values y. Within the Web Processing Service (WPS) standard, process arguments are referred to as process inputs and result values are referred to as process outputs. Processes that have no process inputs represent value generators that deliver constant or random process outputs.

- **service**

  distinct part of the functionality that is provided by an entity through interfaces (source: ISO/IEC

TR 14252)

- **operation**

  specification of a transformation or query that an object may be called to execute (source: ISO 19119)

- **request**

  invocation of an operation by a client

- **response**

  result of an operation, returned from a server to a client

4.1. Abbreviated terms

- API Application Programming Interface
- CRS Coordinate Reference System
- GML Geography Markup Language
- HTML Hypertext Markup Language
- HTTP Hypertext Transfer Protocol
- JSON Java Script Object Notation
- WCS Web Coverage Service
- WFS Web Feature Service
- WMTS Web Map Tile Service
- OWS OGC Web Services
- REST Representational State Transfer
- XML Extensible Markup Language

Chapter 5. Overview

Section 5 introduces the OGC API Hackathon by describing the challenge, the scenario adopted, and the infrastructure used by the participants. The section also presents overviews of the datasets and services identified to support participants during the Hackathon. The section also presents a list of the organizations represented by the participants.

Section 6 describes each of the OGC API specifications that were involved in the hackathon.

Section 7 presents the solution architecture developed in this hackathon. The section identifies the client and service implementations of the OGC API specifications.

Sections 8 and 9 document the results and provide a summary of the main findings, as well as discussing the experiences and lessons learnt.

Appendix A provides reports from each participating organisation, covering their motivation for participating, a description of their implementation of the OGC API specifications, alternative approaches, their experiences, impressions and recommendations.

Chapter 6. Introduction

The development of OGC API specifications is not a new activity within the Consortium, as OGC members and staff have been investigating OpenAPI (and its commercial equivalent, Swagger) in a concentrated effort since 2016. This effort was the result of a recognition that although the existing OGC web service standards are in effect web APIs, there are a number approaches adopted by modern web API frameworks that would require a fairly fundamental change in underlying design.

Two documents really provided the initial energy to get serious about redesign: the OGC Open Geospatial APIs White Paper, edited by George Percivall cite:[OGC16_019r4], and the Spatial Data on the Web Best Practices, jointly developed by OGC and the World Wide Web Consortium (W3C) cite:[OGC15_107]. These documents highlighted how geospatial data should be more native to the web. Further, OGC staff were working on “implementer-friendly” views of OGC standards and experimented with an OpenAPI definition for the Web Map Tile Service (WMTS).

But perhaps the most important impact was the leap of the OGC Web Feature Service (WFS) and Filter Encoding Service (FES) Standards Working Group (SWG) that rebuilt the WFS standard with an integrated OpenAPI definition as core to description of how to build against the standard. The work on WFS, which has resulted in the OGC API - Features specification (formerly called WFS 3.0), benefited from a two-day Hackathon held in 2018. Since then, other OGC web service SWGs have begun to independently develop API specifications based on their relevant OGC web service standards.

Numerous discussions occurred at OGC quarterly Technical Committee (TC) Meetings to consider those elements being developed in each SWG which should be common to all web API standards. These discussions came to a head at the February 2019 TC Meeting in Singapore, where a series of working group meetings and common sessions for the whole TC Membership reinforced the desire to work on a common framework for many OGC web standards and to develop a nomenclature for labeling these standards. Thus, the pattern “OGC API - [resource]” was coined. The discussions in Singapore also resulted in the planning of the OGC API Hackathon to define and test common elements from Coverages, Map Tiles, and Processing standards work using foundational material from the Features work.

The OGC API Hackathon 2019 was hosted by the Geovation Hub in London, United Kingdom, from June 20th to 21st, 2019. The hackathon was sponsored by the European Space Agency (ESA), Ordnance Survey and Geovation. The hackathon was also supported by the US National Geospatial Intelligence Agency (NGA). The **goal** of the hackathon was to advance the development of OGC API specifications. The aim of the hackathon was to provide an environment and an opportunity for the geospatial community to achieve this goal.

The objectives of the hackathon were set out as to:

- develop, deploy and test services/clients that support OGC APIs
- suggest improvements for a common core
- define rules/guidance that can be documented
- validate work that has been completed to date
- contribute to the GitHub repositories

6.1. Overview of the Challenge

The challenge of the Hackathon was to define and test common elements from Coverages, Map Tiles, and Processing standards work using foundational material from the Features work. The magnitude of this challenge was reflected by the fact that the OGC API specifications for Coverages, Map Tiles, and Processing were all at different stages of development. Therefore the Hackathon had to advance the development of all of the specifications to a stage where common elements across all of the specifications could be identified.

6.2. Scenario

NOTE	This section is a working draft.

To facilitate the development of the OGC API specifications, the scenario presented in this section was provided as a reference for the teams. The scenario is based on flood risk management and is motivated by recents events such as the 2018 floods that affected parts of Europe (including the United Kingdom, Italy, France, Spain and Portugal) cite:[WikipediaEUFloods] and the 2019 floods that affected parts of the United States cite:[WikipediaUSFloods]. The scenario draws from the OGC's Disasters Interoperability Concept Development Study (CDS) which assessed geospatial Web services across the disaster domain, defining the core components of National Spatial Data Infrastructure (SDI) architecture for disasters (Disasters SDI), and defining use cases and scenarios for future implementations as part of a follow-on pilot phase cite:[Idol2018].

Risk mitigation is one of the phases in the 'life cycle' of disaster management cite:[Idol2018], which includes the steps shown in Figure 1. *Mitigation* refers to taking sustained actions to minimise or completely eliminate the long-term risk from hazards and their effects to individuals and property. *Preparedness* refers to building the emergency management capabilities to respond effectively to any hazard, as well as to recover from the hazard. *Response* refers to conducting emergency operations that reduce the hazard to acceptable levels (or eliminate it entirely) in order to save lives, through evacuation of potential victims, and provision of food, water, medical care and shelter to those affected by the disaster. *Recovery* refers to the rebuilding of communities that have been affected by a disaster so that those communities, as well as their governments, can return to normality and function on their own. A more detailed discussion on disaster management can be found in the OGC Development of Disaster Spatial Data Infrastructures for Disaster Resilience Engineering Report cite:[Idol2018].

Figure 1. Disaster management cycle

As part of Government flood risk management policy, Local Authorities have to carry out a preliminary flood risk analysis. Using satellite imagery, flood risk data, along with asset information, vulnerable property information and topographic data, Local Authorities carry out analysis to improve resilience and promote a more efficient use of resource.

A Local Authority is tasked with identifying at-risk residential properties in order to assist in flood prevention and amelioration. By carrying out this task, the Local Authority aims to reduce the number of residential properties affected by floods, as well as to decrease the economic and social costs associated with such devastating events. The Geospatial Specialists at the Local Authority embark on the steps presented in Table 1 in order to carry out the task.

Table 1. Steps in the flood risk management scenario

Step	Description	Notes
1	Receive satellite imagery, digital terrain model, Flood Risk Zone, address, and topographic data	
2	Overlay flood assets such as culverts, levees etc.	
3	Combine multiple datasets together.	
4	Data analysis to assess/quantify flood risk.	A number of hydrology approaches may be applied e.g. run-off modelling
5	Identify at risk properties and possible remediation strategies.	

Step	Description	Notes
6	Execute cost-benefit analysis to determine priorities.	
7	Commission work for on-the-ground implementation. This may be carried out by internal or external teams.	
8	Impact of remediation work assessed by external engineering consultant.	

The illustration in Figure 2 shows the Area of Interest (AOI) that was selected to facilitate prototyping, demonstration and briefings. The AOI covered the region of Carmarthenshire, Wales and focused on the town of Carmarthen. The region was the site of significant flooding in October 2018 and hence provided an appropriate location to based the flood-based scenario adopted for the Hackathon.

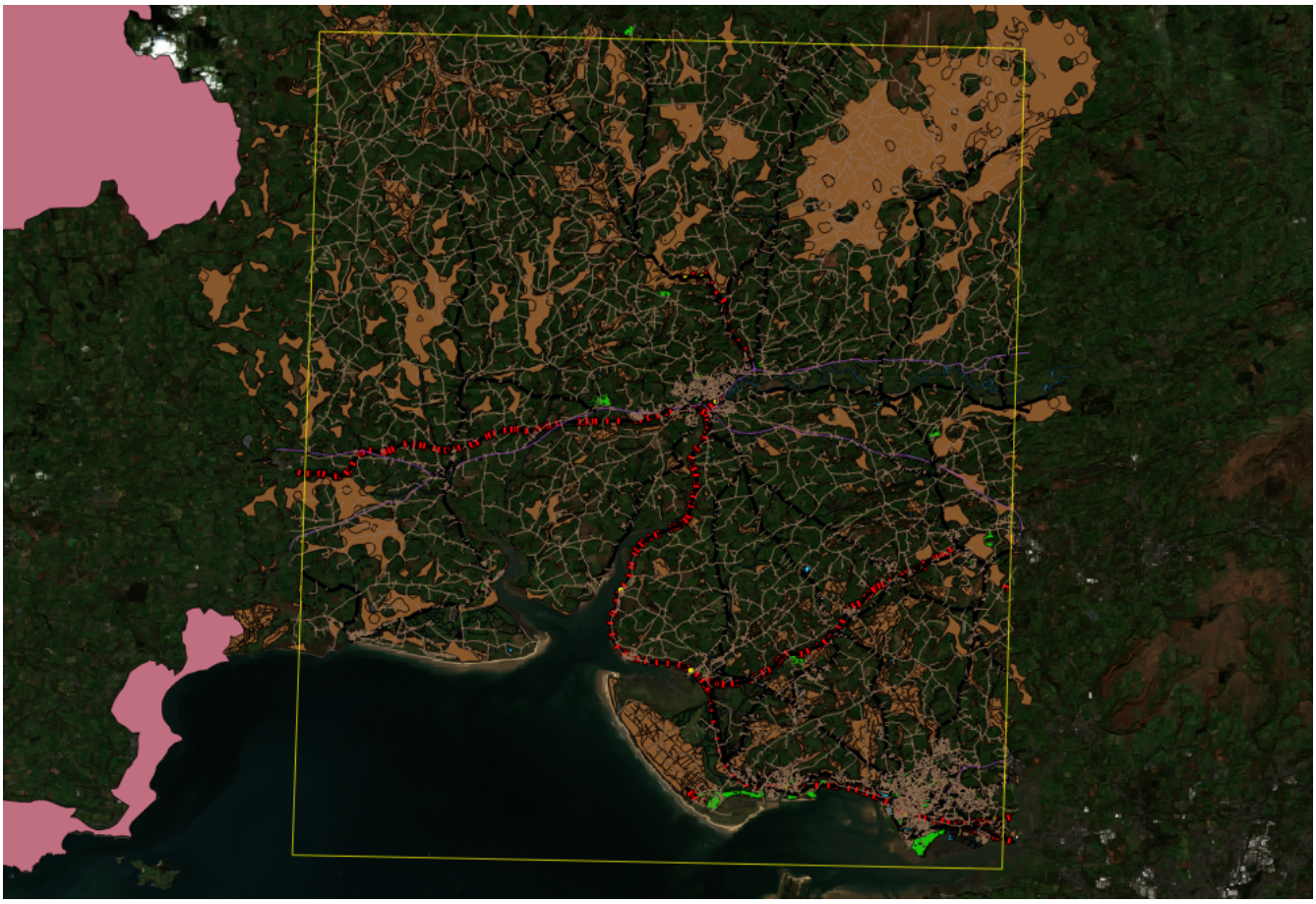

Figure 2. Area-of-Interest (Contains OS data © Crown copyright and database right 2019; Satellite image: ESA Copyright)

Whereas the Time-Of-Interest (TOI) was October 2018, the AOI had the polygonal bounds in World Geodetic System 1984 (WGS84) coordinates:

```
-4.09247619415462,51.6507504017036
-4.59606172257991,51.6468710002251
-4.59750580025958,52.0105126182078
-4.09303085864973,52.0127870676365
-4.09247619415462,51.6507504017036
```

6.3. What was provided

6.3.1. Supporting Datasets

The following datasets were identified as relevant to the scenario, and thus recommended for testing implementations of the specifications.

- ESA Sentinel Data: The Sentinels are a family of missions developed by ESA for Corpenicus, the European Union's Earth Observation programme. The data supplied to the OGC API Hackathon included imagery from the Sentinel-2 mission. Launched on 23 June 2015, the Sentinel-2 mission is a polar-orbiting, multispectral high-resolution imaging mission for land monitoring to support emergency services, imagery of vegetation, soil and water cover, inland waterways and coastal areas cite:[ESACopernicus1]. The Sentinel imagery was supplied by Sinergise, the providers of sentinelhub.com cite:[Sinergise2019].
- UK Met Office DataPoint: DataPoint is a freely available service that offers meteorological feeds for use by professionals, the scientific community, and developers. It is an unsupported service, with a primary goal of facilitating research, development and innovation cite:[MetOffice2019].
- UK Met Office Atmospheric Deterministic and Probabilistic Forecasts: This dataset includes atmospheric deterministic and probabilistic forecasts provided as downloadable gridded data cite:[MetOffice2019b]. The data includes 2km deterministic high-resolution atmospheric data for the UK and 10km deterministic high-resolution atmospheric data for the Globe. There is also data from the Global and Regional Ensemble Prediction System.
- Ordnance Survey - OS Open Zoomstack: This dataset provides a single, customisable map of Great Britain to be used at national and local levels. The dataset is available in OGC GeoPackage format. The dataset includes vector data at a variety of scales, from a whole-country view to a street-level view (1:10,000) cite:[OrdnanceSurvey2019z].
- Meteorological Service of Canada Datamart: A variety of raw meteorological data types and forecast data provided by the Meteorological Service of Canada (MSC). It is aimed at specialized users with good meteorological and Information Technology knowledge. The datasets are available through direct download from an HTTP server, as well as through a Web Map Service (WMS) cite:[MSC2019].

6.3.2. Supporting Services

The following datasets were identified as relevant to the scenario, and thus recommended for testing implementations of the specifications.

- Meteorological Service of Canada Geospatial web services: This service provides access to the MSC's open data, including raw numerical weather prediction (NWP) model data layers and the

weather radar mosaic. The service provides meteorological layers through a Web Map Service (WMS) interface to enable end-users to display meteorological data within their own tools, on interactive web maps and in mobile apps cite:[MSC2019b].

- National Oceanic and Atmospheric Administration (NOAA) National Weather Service Data as OGC Web Services: These web services provide meteorological data covering the United States, through interfaces that conform to the Web Map Service (WMS), Web Feature Service (WFS) and Web Coverage Service (WCS) standards of the OGC cite:[NOAA2019].

6.3.3. Deployment Infrastructure

Participants were advised to bring their own laptops to the hackathon. To support testing, the following infrastructure options were available to participants:

- Participants could deploy services into their own computers.
- Participants could deploy services into their own Cloud infrastructure.
- By prior arrangement, participants could deploy services into Ordnance Survey-sponsored Cloud infrastructure.

Ordnance Survey-sponsored Cloud infrastructure

A survey was emailed to each Hackathon participant prior to the event. Based on the results of the survey, four virtual machines were created by Ordnance Survey for use during the Hackathon by the nine users who replied specifying a need to use Azure based architecture. An illustration of the configuration of the infrastructure is presented in Figure 3.

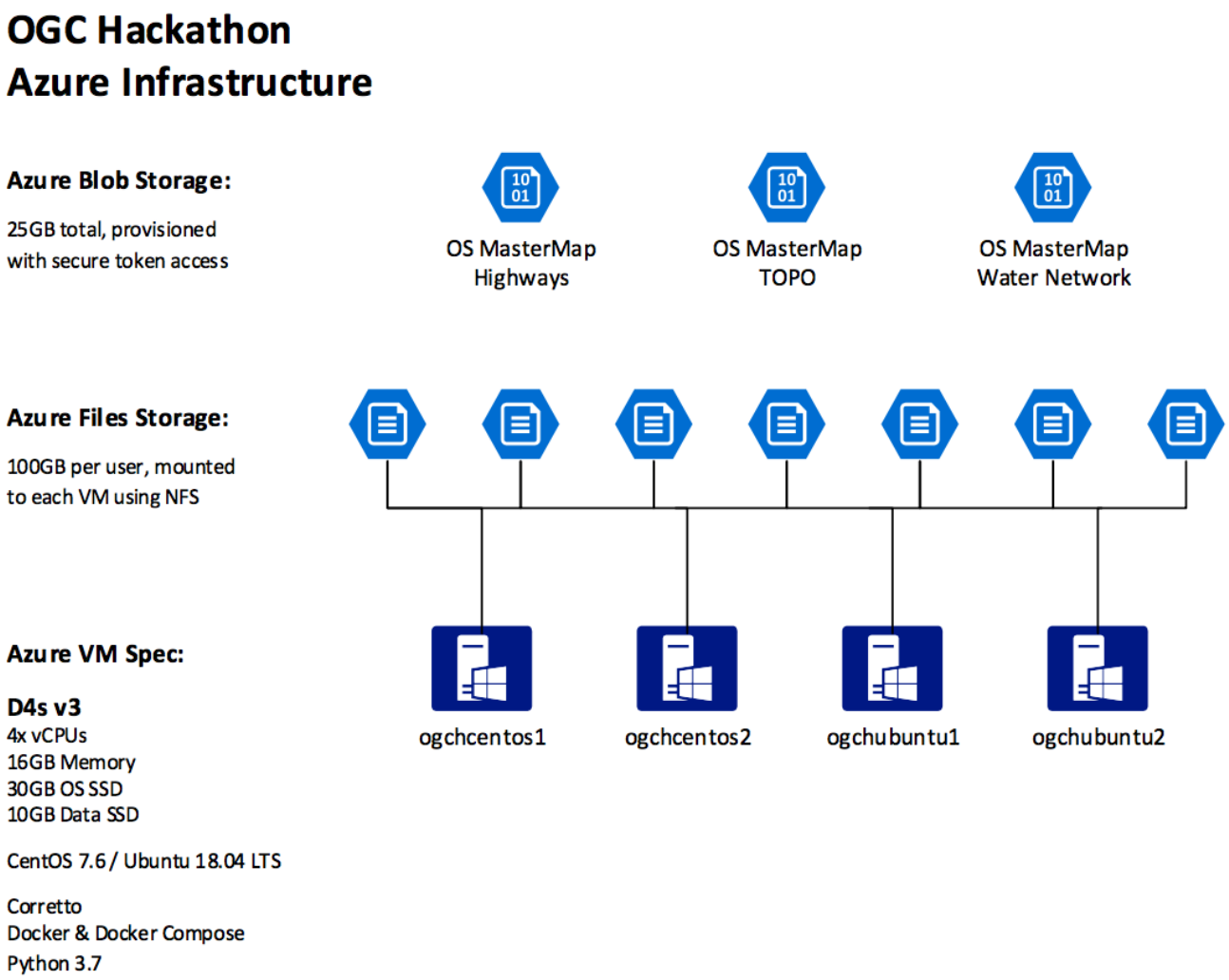

Figure 3. OGC Hackathon Azure Infrastructure sponsored by Ordnance Survey

Pairs of servers were configured with the CentOS 7.6 and Ubuntu 18.04 Long Term Support (LTS) operating systems to meet the requirements specified within the survey. Each of the nine users was given their own 100GB Azure File share, mounted across to each virtual machine with Network File System (NFS) to enable cross-server working.

Each server was installed with a similar set of software: Corretto, Docker, Docker Compose & Python 3.7.

In addition, Ordnance Survey provided three cut-down datasets for OS MasterMap (Highways, TOPO & Water Networks) covering the areas of interest being used during the Hackathon. Access to these datasets was made available using secure tokens.

6.4. Hackathon Participants

The Hackathon was sponsored by the European Space Agency (ESA) and the Ordnance Survey. Table 2 lists organizations that participated in the Hackathon.

Table 2. Technology Integration Experiments (TIE) for OGC APIs

Organization Name	OGC Membership
52°North GmbH	Member

Organization Name	OGC Membership
akouas	Non-member
ARC	Non-member
Arup	Non-member
blockdore	Non-member
British Antarctic Survey	Member
CREAF	Member
CubeWerx Inc.	Member
Deimos Space UK	Member
District Government Cologne - Geobasis NRW	Non-member
Defence Science and Technology Laboratory (Dstl)	Member
Duisburg Essen university	Non-member
Ecere Corporation	Member
ECMWF	Member
El Toro	Non-member
EOS Data Analytics	Non-member
EOX IT Services GmbH	Member
Esri UK	Member
Eurac Research	Non-member
European Space Agency (ESA)	Member
Geobeyond	Non-member
GeoCat B.V.	Member
GeoLabs	Non-member
GeoSeer	Non-member
GeoSolutions	Member
Geovation	Member
Heazeltech	Member
Helyx SIS	Member
Hexagon	Member
Infinity Corporation Limited	Non-member
interactive instruments GmbH	Member
ISRIC - World Soil Information	Member
Jet Propulsion Laboratory (JPL)	Member
JRC, European Commission	Member
Land Information New Zealand	Member

Organization Name	OGC Membership
Landcare Research, New Zealand	Member
lat/lon GmbH	Member
Met Office	Member
Meteorological Service of Canada	Member
National Aeronautics and Space Administration (NASA)	Member
National Geospatial Intelligence Agency (NGA)	Member
National Land Survey of Finland	Member
Natural Resources Canada	Member
NOAA/NWS	Member
Ordnance Survey	Member
OSGeo	OGC Alliance Partner
Princeton University	Non-member
Princeton University Library	Non-member
Quick Caption	Non-member
rasdaman GmbH	Member
Secure Dimensions	Member
Sigma Bravo	Non-member
Sinergise	Non-member
Solenix	Member
Spacebel s.a.	Member
Strategic Alliance Consulting Inc	Member
University of Birmingham	
University of Münster	Member
University of Notre Dame	Member
WebGeoDataVore	Non-member
West University of Timisoara	Member

Chapter 7. OGC API Specifications

This chapter describes each of the draft OGC API specifications ahead of the Hackathon. The section presents an overview of each specification and is not intended to be a substitute for reading the complete specification.

7.1. OGC API - Common

The OGC API - Common specification documents the set of common practices and shared requirements that have emerged from the development of Resource Oriented Architectures and Web APIs within the OGC. The specification serves as a common foundation upon which all OGC APIs will be built. As such, the OGC API - Common standard serves as the "OWS Common" standard for OGC Resource Oriented APIs. Consistent with the architecture of the Web, this specification uses a resource architecture that conforms to principles of Representational State Transfer (REST). The specification establishes a common pattern that is based on OpenAPI [https://www.openapis.org/].

In addition to identifying core resources, the OGC API - Common specification goes on to specify HTTP status codes that may be supported by an OGC API, as well as how to handle web caching, coordinate reference systems and encodings. The specification also describes how to handle common parameters such as bounding boxes and date-time constraints.

The following subsection presents a summary of the core resources.

7.1.1. Key Resources

A summary of the paths offered by the OGC API - Common specification is presented below:

- Path = /
  - Returns landing page
- Path = /api
  - Returns API Description document (OpenAPI)
- Path = /conformance
  - Returns a set of conformance class URIs.
- Path = /collections
  - Returns metadata describing the collections accessible through this API
- Path = /collections/{collectionId} **Returns metadata describing the collection identified by {collectionId} *Path = /collections/{collectionId}/items
  - Returns --- TBD. This may be where Common leaves off and resource specific standards take over.

7.2. OGC API - Features

The OGC API - Features specification offers the capability to create, modify and query spatial data on the Web. This standard specifies requirements and recommendations for APIs that want to

follow a standard way of sharing feature data. The specification is a multi-part document. The Core part of the specification describes the mandatory capabilities that every implementing service has to support and is restricted to read-access to spatial data. Additional capabilities that address specific needs will be specified in additional parts. Envisaged future capabilities include, for example, support for creating and modifying data, more complex data models, richer queries, and additional coordinate reference systems. This specification builds on the Web Feature Service (WFS) standard and has previously been referred to as WFS 3.0.

7.2.1. Key Resources

A summary of the paths offered by the OGC API - Features specification is presented below:

- Path = /
  - Returns the landing page of this API (inherited from OGC API - Common)
- Path = /conformance
  - Returns information about standards that this API conforms to (inherited from OGC API - Common)
- Path = /collections
  - Returns a description of the feature collections in the dataset (inherited from OGC API - Common)
- Path = /collections/{collectionId}
  - Returns a description of the {collectionId} feature collection (inherited from OGC API - Common)
- Path = /collections/{collectionId}/items
  - Returns features of feature collection {collectionId}
- Path = /collections/{collectionId}/items/{featureId}
  - Returns a feature

Support for HTML and JSON/GeoJSON as encodings is recommended for all resources. The specification includes conformance classes for GML (Simple Features profile), too.

7.3. OGC API - Processes

The OGC API - Processes specification provides defines how a client application can request the execution of a process, how the inputs to that process can be provided, and how the output from the process is handled. The specification allows for the wrapping of computational tasks into an executable process that can be invoked by a client application. Examples of computational processes that can be supported by implementations of this specification include raster algebra, geometry buffering, constructive area geometry, routing and several others. This specification builds on the Web Processing Service (WPS) standard.

7.3.1. Key Resources

A summary of the paths offered by the OGC API - Processes specification is presented below:

- Path = /
  - Returns landing page (inherited from OGC API - Common)
- Path = /api
  - Returns API Description document (OpenAPI) (inherited from OGC API - Common)
- Path = /conformance
  - Returns a set of conformance class URIs. (inherited from OGC API - Common)
- Path = /processes
  - Returns available processes
- Path = /processes/{id}/
  - Returns a process description
- Path = /processes/{id}/jobs
  - Returns the list of jobs for a process.
- Path = /processes/{id}/jobs/{jobID}
  - Returns the status of a job
- Path = /processes/{id}/jobs/{jobID}/result
  - Returns the result(s) of a job

7.4. OGC API - Map Tiles

The OGC API - Map Tiles specification defines an OGC standard for a Web Map Tile API that can serve map tiles of spatially referenced data using tile images with predefined content, extent, and resolution. The specification describes the discovery and query operations of an API that provides access to Map Tiles in a manner independent of the underlying data store. The discovery operations allow the API to be interrogated to determine its capabilities and retrieve metadata about the organisation and distribution of tiles. The query operations allow tiles to be retrieved from the underlying data store based upon simple selection criteria, defined by the client. This specification builds on the Web Map Tile Service (WMTS) standard.

7.4.1. Key Resources

A summary of the paths offered by the OGC API - Processes specification is presented below:

- Path = /
  - Returns landing page (inherited from OGC API - Common)
- Path = /conformance
  - Returns a set of conformance class URIs. (inherited from OGC API - Common)
- Path = /collections
  - Returns metadata describing the collections accessible through this API (inherited from OGC API - Common)
- Path = /collections/{collectionId}

    - Returns metadata describing the collection identified by {collectionId}
- Path = /collections/{collectionId}/queryables
    - Returns the queryable properties of the feature collection
- Path = /collections/{collectionId}/items
    - Returns features of the feature collection
- Path = /collections/{collectionId}/items/{featureId}
    - Returns a feature
- Path = /tileMatrixSet
    - Returns all available tile matrix sets (tiling schemes)
- Path = /tileMatrixSet/{tileMatrixSetId}
    - Returns a tiling scheme by id
- Path = /tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}
    - Returns a tile of the dataset
- Path = /collections/{collectionId}/tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}
    - Returns a tile of the collection with or without style
- Path = /tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}/info
    - Returns information on a point of a tile with or without style
- Path = /collections/{collectionId}/tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}/info
    - Returns information of a point in a tile of the collection with or without style
- Path = /tiles/{tileMatrixSetId}
    - Returns tiles from several collections.
- Path = /collections/{collectionId}/tiles/{tileMatrixSetId}
    - Returns tiles of a collection
- Path = /map
    - Returns a map of collections with or without style
- Path = /collections/{collectionId}/map
    - Returns a maps from the collection with or without style
- Path = /map/info
    - Returns information about a map of the collection with or without style
- Path = /collections/{collectionId}/map/info
    - Returns information about a map from the collection with or without style

7.5. OGC API - Coverages

The OGC API - Coverages specification defines a Web API for accessing coverages that are modelled according to the Coverage Implementation Schema (CIS) 1.1 [http://docs.opengeospatial.org/is/09-146r6/09-

146r6.html]. Coverages are represented by some binary or ASCII serialization, specified by some data (encoding) format. Arguably the most popular type of coverage is that of a gridded coverage. Gridded coverages have a grid as their domain set describing the direct positions in multi-dimensional coordinate space, depending on the type of grid. Satellite imagery is typically modelled as a gridded coverage, for example. The OGC API - Coverages specification builds on the Web Coverage Service (WCS) standard.

7.5.1. Key Resources

A summary of the paths offered by the OGC API - Coverages specification is presented below:

- Path = /
  - Returns landing page (inherited from OGC API - Common)
- Path = /api
  - Returns API Description document (OpenAPI) (inherited from OGC API - Common)
- Path = /conformance
  - Returns a set of conformance class URIs. (inherited from OGC API - Common)
- Path = /collections
  - Returns metadata describing the collections accessible through this API (inherited from OGC API - Common)
- Path = /collections/{collectionId}
  - Returns metadata describing the collection identified by {collectionId}, in particular: a list of the identifiers of its members
- Path = /collections/{collectionId}/coverages
  - Returns metadata about each coverage in the collection
- Path = /collections/{collectionId}/coverages/{coverageID}
  - Returns the coverage itself, in some encoding - either ASCII (XML, JSON, RDF, etc.) or binary (GeoTIFF, NetCDF, etc.) or multipart (such as MIME, zip, etc.) as defined in OGC CIS 1.x
- Path = /collections/{collectionId}/coverages/{coverageID}/metadata
  - Returns the metadata associated with the coverage identified by {coverageId}, as defined in OGC CIS
- Path = /collections/{collectionId}/coverages/{coverageID}/domainset
  - Returns the domain set of the coverage identified by {coverageId}, as defined in OGC CIS
- Path = /collections/{collectionId}/coverages/{coverageID}/rangetype
  - Returns the range type of the coverage identified by {coverageId}, as defined in OGC CIS based on SWE Common DataRecords

Chapter 8. Architecture

The focus of the hackathon was on development of the OGC API - Common, the OGC API - Features, OGC API – Processes, the OGC API – Coverages and the OGC API – Map Tiles standards. Implementations of these specifications were deployed in the Hackathon infrastructure in order to build a solution with the architecture shown in Figure 4. As shown on the illustration, the architecture adopted a multi-tier approach that included one or more implementations of each OGC API specification deployed on the wider Internet (e.g. in participants' own Cloud environments), as well as some implementations deployed in the Ordnance Survey's Cloud which is hosted on Microsoft Azure.

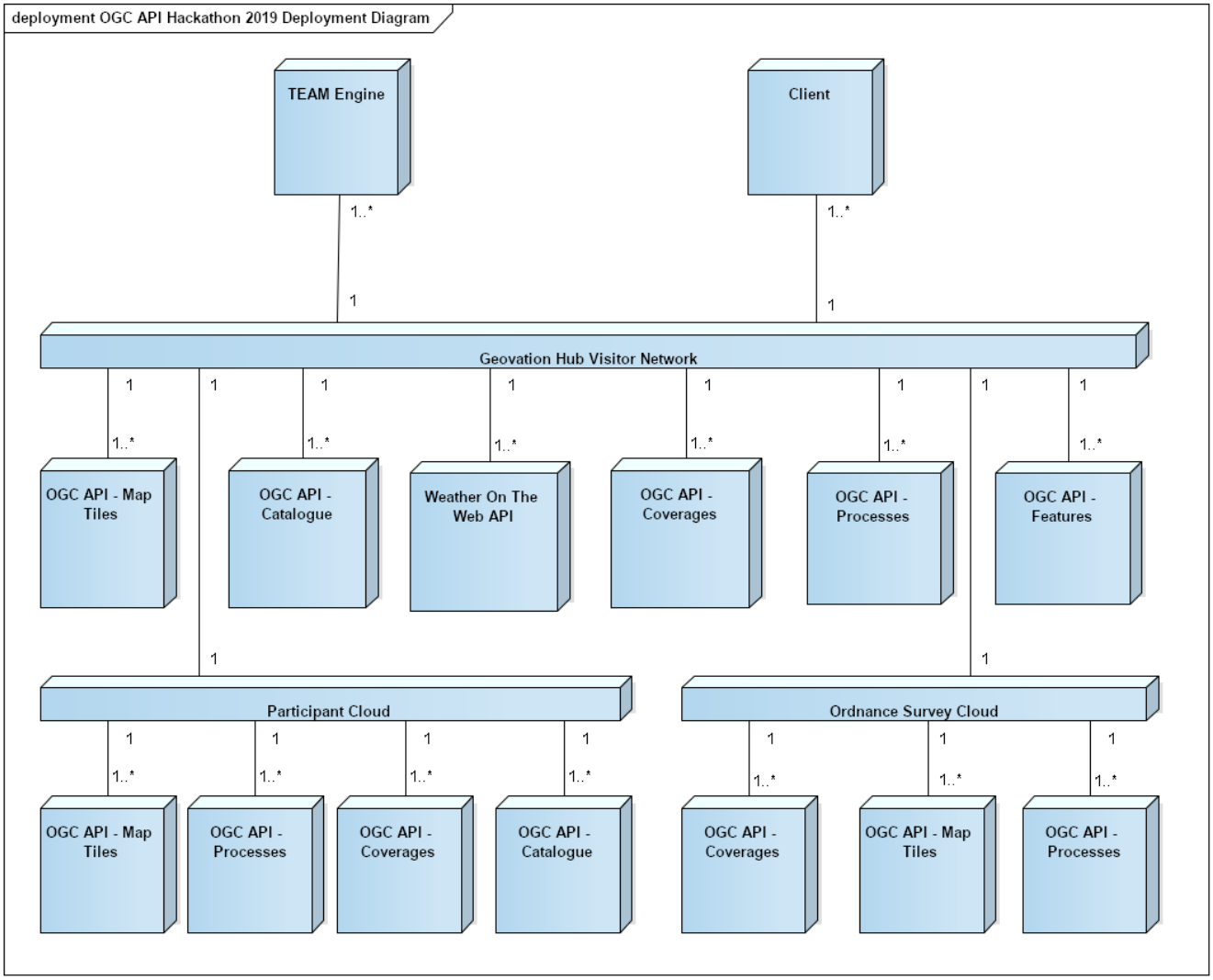

Figure 4. Solution Architecture of the OGC API Hackathon

The OGC API - Common specification documents the set of common practices and shared requirements that have emerged from the development of Resource Oriented Architectures and Web APIs within the OGC. The specification serves as a common foundation upon which all OGC APIs will be built. The OGC API - Processes specification defines how a client application can request the execution of a process, how the inputs to that process can be provided, and how the output from the process is handled. The OGC API - Map Tiles specification defines an OGC standard for a Web Map Tile API that can serve map tiles of spatially referenced data using tile images with predefined content, extent, and resolution. The OGC API - Coverages specification defines a Web API for accessing coverages that are modelled according to the Coverage Implementation Schema (CIS)

1.1 [http://docs.opengeospatial.org/is/09-146r6/09-146r6.html]. The hackathon also sought to maintain consistency between the aforementioned specifications and the OGC API - Features specification. The OGC API - Features specification offers the capability to create, modify and query geospatial feature data on the Web.

8.1. Service Implementations

8.1.1. pygeoapi

pygeoapi is a Python server implementation of the emerging OGC API specifications. Early versions of this software implemented the OGC API - Features specification (formerly WFS 3.0). Recent versions of the software have included support for both the OGC API - Features and the OGC API - Processes specifications. Support for these specifications makes it possible publish feature data and geospatial processes. As the name suggests the software is built using the Python programming language and is supported by a developer toolchain that includes Docker and Git/Github.

8.1.2. 52°North JavaPS

The 52°North JavaPS product is an open source implementation of both the Web Processing Service (WPS) standard and the OGC API - Processes specification. JavaPS enables the deployment of geospatial processes on the Web in a way that conforms to OGC standards. The software is built using the Java programming language and is supported by a developer toolchain that includes Maven and Git/Github. The software features a pluggable architecture for processes and data encodings that is based on the 52°North Iceland [https://wiki.52north.org/SensorWeb/Iceland] project which represents a generic Java framework for OGC Web Services. By virtue of being based on the Iceland project, JavaPS provides components that are associated with processing geospatial data, for example request objects, response objects, decoders, encoders, parsers.

8.1.3. Esri

Esri produce both an installable product (ArcGIS Enterprise) and SaaS product (ArcGIS Online) which support adopted OGC specifications. ArcGIS Enterprise as a server implements WMS, WMTS, WCS2, WPS, WFS2, KML, Geopackage etc as well as other de-facto standards. ArcGIS Online as a server implements WMTS, WFS2 as well as other de-facto standards. Until the OGC API standards are stable and formally adopted, it is not feasible to implement them in the released products. Therefore for the purposes of the Hackathon and further R&D, Esri have implemented the OGC-API tiles as a facade on to ArcGIS Online tiled services. Technically this is currently implemented as a node.js server running in Microsoft Azure. https://ogc-tiles-esri-server.azurewebsites.net

8.1.4. rasdaman

rasdaman ("raster data manager") is a flexible, scalable datacube engine with location-transparent federation capabilities. Open-source rasdaman is available from www.rasdaman.org. Being WCS reference implementation rasdaman supports OGC WMS, WCS, and WCPS (the OGC datacube analytics standard). For experimentation with the emerging OGC OpenAPI interface for coverages a rasdaman server has been made available on Amazon with an OpenAPI facade to WCS; access has been demonstrated with EURAC and Sinergise OpenAPI clients.

8.1.5. ldproxy

ldproxy is an implementation of the OGC API family of standards, based on the W3C/OGC Spatial Data on the Web Best Practices. It is written in Java (Source Code [https://github.com/interactive-instruments/ldproxy]) and is typically deployed using docker (DockerHub [https://hub.docker.com/r/iide/ldproxy/]).

The software originally started in 2015 as a Web API for feature data based on WFS 2.0 capabilities. In addition to the JSON/XML encodings, an emphasis is placed on an intuitive HTML representation.

The current version supports WFS 2.0 instances as well as PostgreSQL/PostGIS databases as backends. It implements all conformance classes and recommendations of "OGC API - Features - Part 1: Core" plus a number of experimental OGC API Features extensions (CRS support, /items path, property selection, geometry simplification, transactions, dynamic links, and more). ldproxy also has draft implementations for additional resource types (Tiles, Styles).

8.1.6. Helyx SIS

The Helyx team implemented a WPS 3.0 style API with the primary work completed in the OGC Routing API Pilot, which is currently on-going. The focus of the component implementation was to produce a schemaless collections endpoint to act as a storage location for data production processes. This could be typical OGC processes in a WPS sent, or with could be in the style of a WFS endpoint.

An advantage of the schemaless (and in the future, potentially serverless) approach is the efficiency of the hashing procedure enabling many KVPs to be entered even on a low spec machine. Additionally, this approach has the potential to be made production ready quickly due to the simplicity of the implementation requirements. A future possibility for this piece of work is to implement it using Hazelcast, as it backs up KVPs to a NoSQL database therefore caching the requests and increasing performance accordingly.

8.1.7. TBA

TBA

8.2. Client Implementations

8.2.1. OpenSphere OGC API Plugin

OpenSphere [https://github.com/ngageoint/opensphere] is a pluggable, single-page, GIS web application that supports both 2D and 3D views. It supports hooking up to many common servers and formats such as ArcGIS, Geoserver (and other OGC WMS/WFS services), XYZ, TMS, KML, GeoJSON, Shapefiles and CSVs. Other features include animation of both raster and vector data, import and export of various formats, and saving files and layers between sessions. Sigma Bravo extended OpenSphere to support OGC API - Features and OGC API - Map Tiles.

8.2.2. Hexagon LuciadLightspeed

LuciadLightspeed provides a foundation for advanced geospatial analytics applications. It allows users to create high performance command & control and location intelligence applications with clean design implementation and rapid application development. A desktop client application was implemented using LuciadLightspeed and configured to interface services implementing the OGC API - Map Tiles specification.

8.2.3. Solenix WPS Demo Client

The Solenix WPS Demo client is an adaptation of the OGC Testbed 14 client, accounting for some of the changes introduced with the OGC API - Processing.

The client application runs from a web browser.

8.2.4. Esri OGC API-Tiles Demo Client

The Esri client application is a simple Leaflet application which connects to the Esri OGC API-Tiles server implementation for testing purposes.

8.2.5. Sinergise OGC Coverages Demo Client

The Sinergise OGC Coverages Demo Client is a single-page Javascript application, using Leaflet.js to show the data from different backends. Support for two different backends was implemented, Rasdaman and EOX IT Services. The frontend is available at http://webdev.sentinel-hub.com/ogc-hackathon/index.html (view source for additional info).

8.2.6. Helyx SIS Demonstration Clients

Helyx produced two clients as part of the hackathon, one standalone web client and one QGIS client.

Standalone Web Client

The purpose of this client was to enable a *walkthough* of the OGC API to discover processes. The client was able to identify the inputs and outputs of each process, request inputs from the user, execute the WPS and display the result. The purpose of this was to demonstrate the possibilities of clients if OGC APIs were all built to the same specification. If this was the case then clients could likely be universal. Discovery of the processes is shown in below

[homepage] | *images/homepage.png*

Figure 5. Web client homepage

QGIS Client

The QGIS client performs a similar function to the web client, except it is designed and built in the QGIS plugin environment. The client walks through the API and identifies processes and parameters to automatically populate the GUI for each process therefore providing the user with well-defined inputs. A full implementation of the QGIS client is currently being produced as part of

the OGC Open Routing API Pilot, a screen shot can be found Figure 6.

[compute routes 2] | *images/compute_routes_2.png*

Figure 6. QGIS Client

8.2.7. TBA

TBA

8.3. Validation Implementations

8.3.1. TEAM Engine

TEAM Engine (Test, Evaluation, And Measurement Engine) is a Java-based application for testing web services and other information resources. It executes test suites developed using the popular TestNG framework, OGC Compliance Test Language (CTL) scripts, and possibly other JVM-friendly languages. It is lightweight and easy to run from the command-line or as a web application. TEAM Engine can be used to test almost any type of service or information resource. It is the official test harness used by the Open Geospatial Consortium's (OGC) compliance program [http://cite.opengeospatial.org/]. Visit the project documentation website [http://opengeospatial.github.io/teamengine/] for more information.

Currently, there is a test suite available to verify "OGC API - Features" service implementations. The test suite is written in Java using the TestNG framework and source code is publicly available [https://github.com/opengeospatial/ets-wfs30]. Also, there is a public installation of the test suite on OGC CITE Beta environment [http://cite.opengeospatial.org/te2/].

Chapter 9. Results

This section describes what occurred and presents results from the Hackathon.

9.1. What occurred

9.1.1. Processes

The decision to hold the OGC API Hackathon was made by the TC at the 2019 TC meeting in Singapore. Following this decision, OGC staff engaged a number of potential sponsors from the OGC membership. Having identified sponsors and hosts, a series of teleconferences were held for planning the event. These teleconferences discussed venue logistics, computing infrastructure, data, scenarios, catering and other topics. A Gantt chart of the planning and execution of the hackathon is shown in Figure 7.

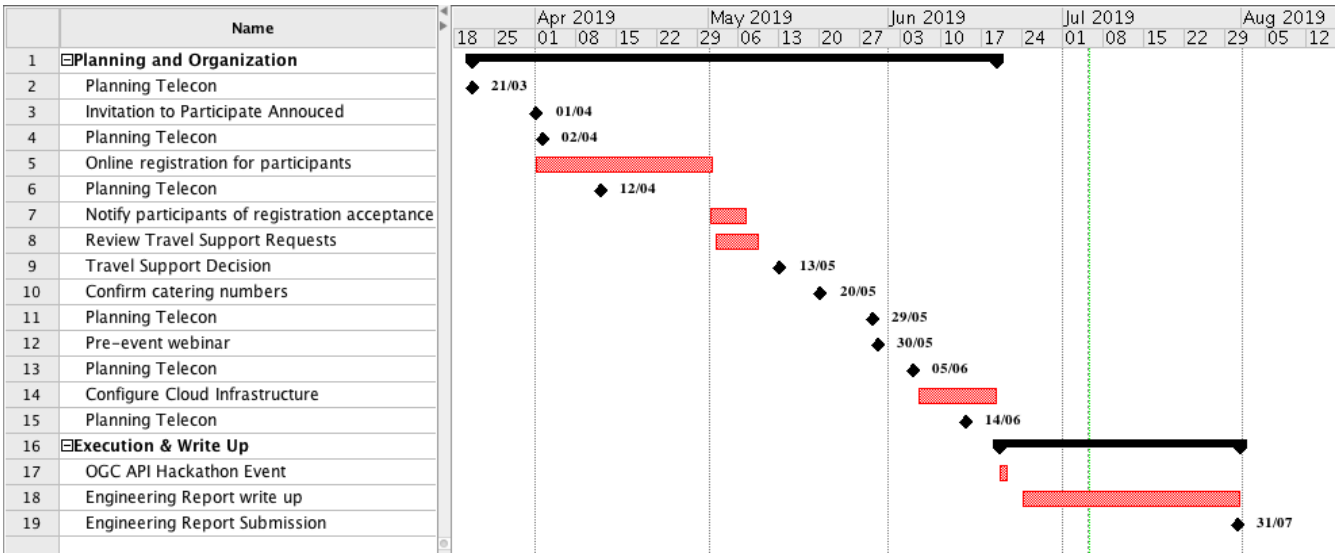

Figure 7. A Gantt chart of the planning and execution of the hackathon

During the hackathon, the process involved alternation between briefings, discussions and coding. On the first day of the hackathon, three back-briefs were held, that is one in the morning, another in the afternoon and another in the evening. These briefings provided an opportunity for issues to be discussed across teams. Agreements and resolutions from the discussions triggered by the briefings were then fed back into the team-specific work.

The agenda for the hackathon is presented below.

Agenda

Day 1 - Thursday 20th June, 2019

- 09:00hrs - Welcome note (Geovation Hub Staff)
- 09:15hrs - Goals and objectives (OGC DKM & SWG Chairs)
- 09:30hrs - Introduction to the Draft Specifications (Common, Features, Map Tiles, Processes, Coverages)
- 11:00hrs – Split into teams by specification

- 11:10hrs – Team-based work starts [define the problem/scope]
- 12:30hrs - Lunch
- 13:30hrs - Resume [come up with multiple options]
- 17:00hrs - Early Dinner
- 18:00hrs - Resume [select the preferred option]
- 20:00hrs - Back-briefs from each team
- 21:00hrs - Adjourn

Day 2 - Friday 21st June, 2019

- 08:00hrs - Goals and objectives (OGC DKM & SWG Chairs)
- 08:30hrs - Resume team-based work [implement the preferred option]
- 12:00hrs - Third back-briefs from each team ["alignment report" to brief on any deviation from Core as provided at start]
- 12:30hrs - Working Lunch [complete implementation of the preferred option]
- 13:30hrs – Joint work on Common or Resume team-based work [implement the preferred option]
- 14:30hrs – Show & Tell (Demonstration of clients accessing services)
- 15:30hrs - Final back-briefs
- 16:30hrs - Closing note (OGC COO)
- 17:00hrs - Close

9.1.2. Organization

By the event date, 76 individuals had been registered to participate in-person and 35 participants had been registered to participate remotely. The participants represented 60 organizations, 41 of those organizations are OGC members, one of the organizations is an OGC Alliance Partner and the remaining 18 organizations are non-members. The proportion of OGC members to alliance partners and non-members is illustrated in Figure 8.

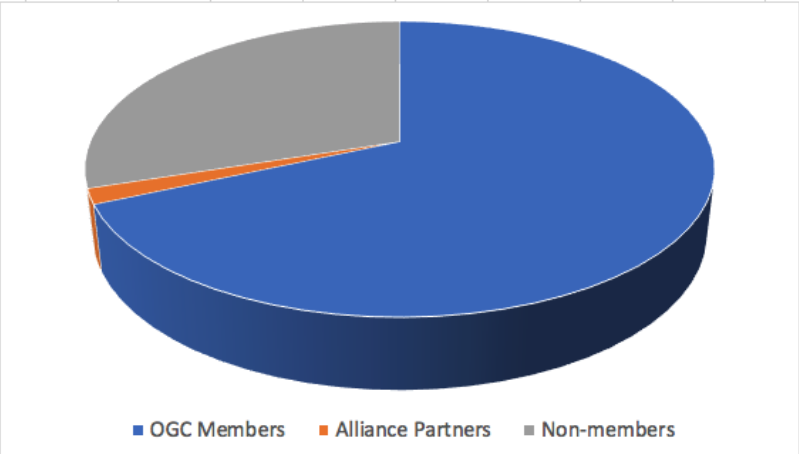

Figure 8. OGC membership of participating organizations

A questionnaire sent out just before the hackathon to collect information about which OGC API specifications the participants would focus on received 27 responses. The spread of responses to the hackathon is shown in Figure 9.

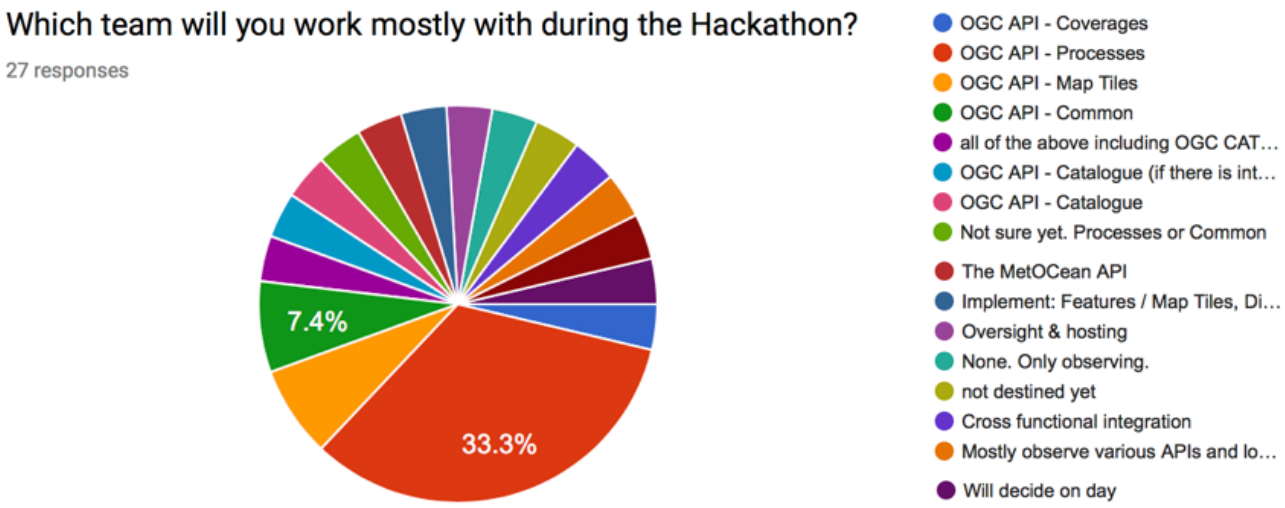

Figure 9. Participants' interests

The hackathon was therefore organized around teams based on the OGC API specifications. Participants interested in APIs other than those for coverages, processes, and map tiles, were asked to contribute to the work on advancing the OGC API - Common specification. This would help ensure that the OGC API - Common specification provides an appropriate a base for all future OGC APIs.

9.1.3. Technology

The client and service applications were bound together through interfaces conforming to the OGC APIs for Map Tiles, Processes, Features, Catalogues, and Coverages. The client applications included software from Hexagon, Helyx, OpenSphere, Esri, Solenix, EURAC and Sinergise. The service applications included software from 52 North, CubeWerx, Esri, Helyx, pygeoapi, Geoserver, Spacebel, West University of Timisoara, rasdaman, and interactive instruments. The variety of software implementations suggests that the OGC API specifications widely implementable and do not depend on any single vendor's technology.

As discussed in Architecture, the software products that were deployed by the aforementioned organizations included:

- pygeoapi
- 52°North JavaPS
- Esri prototype facade on to ArcGIS Online tiled services
- rasdaman
- OpenSphere OGC API Plugin
- Hexagon LuciadLightspeed
- Solenix WPS Demo Client
- Esri OGC API-Tiles Demo Client

- ldproxy
- Helyx server, web clients and QGIS Desktop client

The deployed technologies includes software implemented in C, C++ , Python, Java, and NodeJS. Some of the deployed technologies include Python adapters to software implemented in C++. This variety of programming languages shows that the OGC API specifications are independent of any programming language.

9.1.4. Information

Communication

A key aspect of executing a hackathon is the communication within and between the participating teams. A number of communication tools were used within the OGC API Hackathon to facilitate communication.

- OGC Portal: Used for event planning.
- Gitter: Used for communication relating to technical information, due to its close integration with Github.
- Github: Used for logging issues and sharing documents (including the engineering report) across teams.
- OGC Mailing list: Used for sharing administrative information with all participants ahead of the hackathon.
- Gotomeeting: Used for the pre-event webinar and for teleconferencing with remote participants during the hackathon.
- Microsoft Teams: Used by the Ordnance Survey for supporting participants that had requested access to the Ordnance Survey Cloud.

Knowledge Capture

Github played a key role in the documentation and sharing of knowledge during the hackathon. Github is a development environment built on top of Git - a distributed version control and source code management (SCM) system. In addition to providing a repository for the draft OGC API specifications, Github also provided the following useful capabilities:

- Statistics
  - Commits
  - Additions and deletions
- Previews of differences between files and their revisions
- Access control
- Wiki
- Notifications of requests for changes and accepted changes

NOTE	A commit is a single point in the Git history that represents a "revision" or "version".

The various teams involved in the hackathon used the Github repositories of their relevant OGC API specifications to log issues that were identified during discussions. Note that the hackathon took place at the end of the week, and thus some of the participants were only able to log issues at the beginning of the week after the hackathon. Figure 10 presents a graph of the total number of issues logged in Github repositories on the lead up to the hackathon event, during the event and the week after the event. The effect of the hackathon is clearly visible from the 'spike' in the number of issues logged during the two days of the hackathon event (i.e. June 20th & 21st).

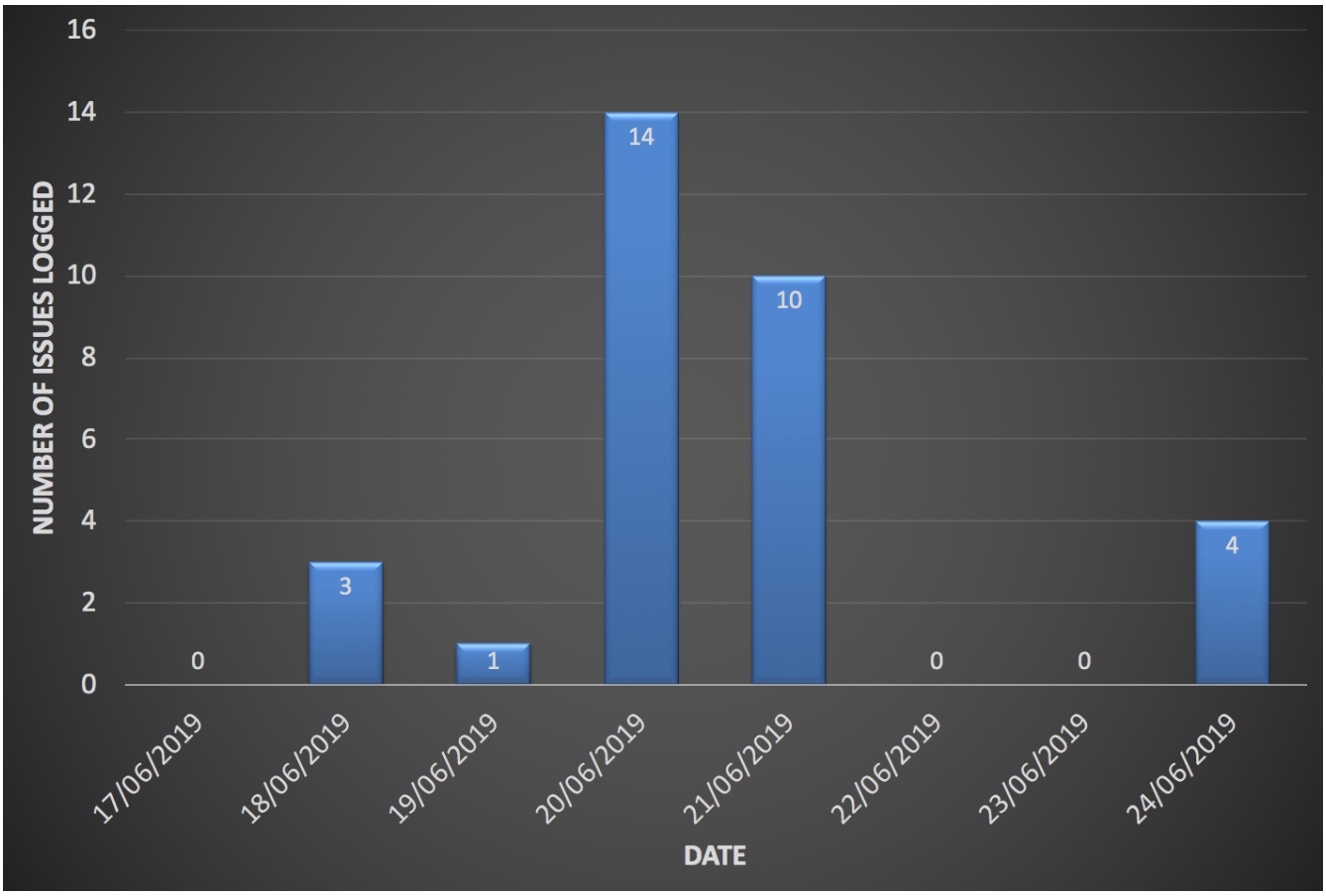

Figure 10. The total number of issues logged in Github repositories for Processes, Map Tiles, Common and Coverages

Changes to the OGC API specifications were made on the lead up to the hackathon, and during the event. Figure 11 presents the total number of commits in Github repositories for OGC APIs on the lead up to the hackathon event, during the event and the week after the event. The commits represent more than 4600 additions and 3200 deletions to the draft API specifications. The number of additions and deletions was determined from the commits made to Github repositories for Processes, Map Tiles, Common and Coverages.

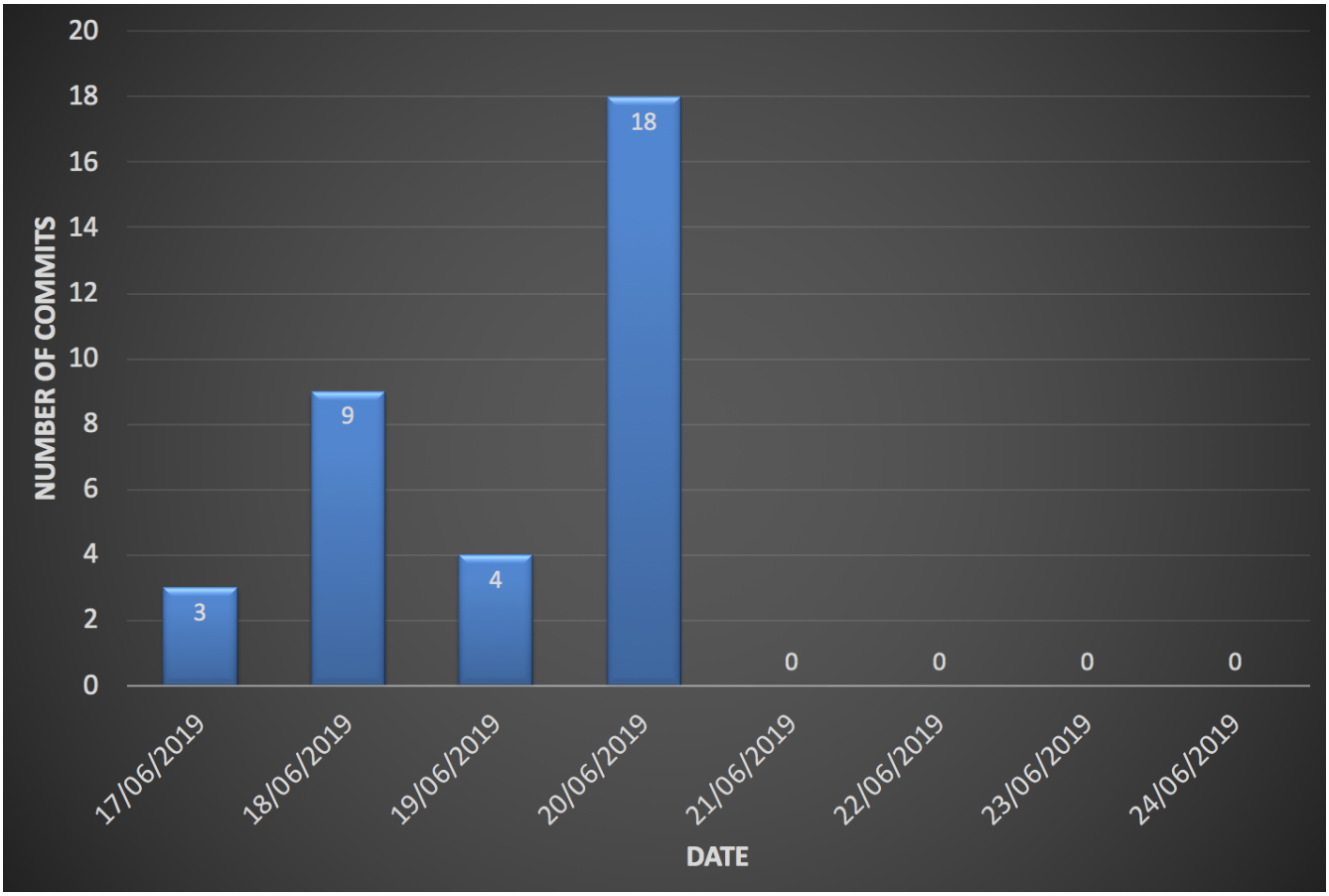

Figure 11. The total number of commits made to Github repositories for Processes, Map Tiles, Common and Coverages

NOTE All changes were controlled and vetted by the editors of the OGC API specifications.

It should be noted that although the hackathon resulted in additions and deletions to the draft API specifications, the outputs of the hackathon are subject to vetting and approval processes of the relevant OGC Standards Working Groups. Therefore there is always the possibility that the Standards Working Groups may reject all of the outputs of the hackathon. To an extent, such an outcome is mitigated by the participation of several members of the Standards Working Group in the hackathon. Further, appointing the editors of the OGC API specifications as the Team Leads of the hackathon appeared to improve the likelihood of acceptance of changes made during the hackathon.

9.2. OGC API - Processes

The participants made an observation that some attributes for referenceValue were missing. As a result, changes were made to add attributes for identifying the MIME type, schema and encoding in a referenceValue object. These changes were needed for providing input in a specific format or returning output in a specific format.

There was a suggestion [https://github.com/opengeospatial/wps-rest-binding/issues/42] to add ows:additionalProperties and ows:context to metadata. It was observed that ows:additionalParameters allows a service to provide key value pairs metadata information. It was also observed that Testbed 13 and testbed 14 had demonstrated the utility of such a capability. As a result, the hackathon participants committed changes to the OGC API - Process specification adding

the definition of additionalParameters.

There was also a discussion [https://github.com/opengeospatial/wps-rest-binding/issues/37] about whether process output arrays are fully supported. The participants observed that currently the output-value-cardinality [http://www.opengis.net/spec/WPS/2.0/req/conceptual-model/process/output-value-cardinality] requirement limits cardinality of the output to one. A number of workarounds were suggested including returning a list of outputs, returning an archive (zip), returning a Metalink, or returning Multipart/mixed responses. The participants concluded that a solution would need to handle all kind of outputs, including outputs by reference, as well as binary files.

There was a discussion [https://github.com/opengeospatial/wps-rest-binding/issues/30] about how to specify synchronous execution OGC API Hackathon. The options identified included i) Either use a query parameter or a HTTP header to specify the execution mode, ii) Return a result object, iii) Do not return a header with the location (as there technically is no location, i.e. its a temp. This issue was also related to the broader issue of how to choose between synchronous and asynchronous mode for job creation. The participants observed that indeed the WPS 2.0 specification has a jobID in the the status object, and therefore the OGC API - Processes specification should also include a jobID into the statusInfo object.

There was a suggestion [https://github.com/opengeospatial/wps-rest-binding/issues/31] for an extension supporting triggers according to job status. In particular the suggestion was for the user/client to be able to specify triggers for conditions like: `onSuccess` a Url to be triggered upon process completion, or `onFail` a URL to be triggered on process failure, `progressUpdate` a URL to be triggered by the job while progressing and should contain progress status (eg. proccent of job completion). Participants considered whether such a capability might be more appropriate as an extension, perhaps associated with a pub/sub notification capability.

There was a suggestion [https://github.com/opengeospatial/wps-rest-binding/issues/32] to add the exception information to the status information at GET `/processes/{id}/jobs/{jobID}` and remove the GET `/processes/{id}/jobs/{jobID}/exception` endpoint. The participants considered whether an HTTP 201 code should be returned with POST /processes/{id}/jobs. The participants resolved that allowing for plural form results could address this issue, for example `processes/{processId}/jobs/{jobId}/results/{resultId}`. Use of an HTTP 201 code was however inconclusive.

9.3. OGC API - Map Tiles

The participants identified three roots for API building blocks, namely the root of the service, collection ID, and collection ID combined the coverage ID. A need to combine these root paths with maps and tiles was identified. There was an observation made that if the roots are combined with maps and tiles, there is an opportunity to provide much more information through data tiles such as vector tiles or coverage tiles. There was also an observation made that if a style and style id are concatenated with the path then the API would be able to combine data tiles with portrayals of the information. There was a third alternative identified, which is the concatenation of both the aforementioned approaches.

These paths have specific query parameters associated with them. Participants observed that such a capability may not be fully supported by OpenAPI 3.0.

There was a discussion about whether the response for maps should return raster or vector maps. Related to this was whether a map was at the same level as a collection. There was agreement that maps are not at the same level as collections.

There was a suggestion [https://github.com/opengeospatial/OGC-API-Map-Tiles/issues/12] to normalize the case used by attributes of the tileMatrix construct. Before the hackathon some of the attribute names where in UpperCamelCase whereas others were in lowerCamelCase. Normalizing the attribute names would ensure consistency of naming and thus make it easier for developers to implement.

There was also an observation [https://github.com/opengeospatial/OGC-API-Map-Tiles/issues/13] made that there is a need to determine where metadata fields supported by WMS could be applied in the OGC API - Map Tiles standard. The metadata fields supported by the WMS standard include: Name, Title, Abstract, KeywordList, Style, CRS, EX_GeographicBoundingBox, BoundingBox, Dimension, Attribution, AuthorityURL, Identifier, MetadataURL, DataURL, FeatureListURL, MinScaleDenominator, MaxScaleDenominator, queryable, cascaded, opaque, noSubsets, fixedWidth, and fixedHeight.

The participants observed [https://github.com/opengeospatial/OGC-API-Map-Tiles/issues/14] that the extents and bounding box classes used by the OGC API - Map Tiles specification have been defined in different ways. The extent class defines a bounding extent as an array of numbers indicating bounding coordinates, whereas the boundingBox class defines the bounding coordinates as separate attributes for the lower and upper corner coordinates.

9.4. OGC API - Coverages

The participants agreed that OGC API - Coverages should inherit from OGC API - Common as much as possible. This meant that wherever a requirement is specified in OGC API - Common, if it is applicable to coverages, the OGC API - Coverages specification would reference the requirement in the OGC API - Common specification.

The participants agreed that a request for the coverages path would return a list of all of the coverage identifiers included in the collection.

There was also agreement that a request for the coverage description would only return the essential information instead of the complete metadata associated with the coverage.

There was discussion about how to support bounding box (BBOX) filters on multidimensional coverages. The participants expressed the need to inherit the BBOX and time parameters from OGC API - Common, however also they also observed that there would be a need to identify a CRS for height. One of the suggestions was for each axis to have a separate coverage filter. The participants concluded that there is currently no construct in the Core part of the OGC API - Common specification that supports filtering of coverages.

The was discussion about the retrieval of coverages. The OGC API - Coverages specification was updated to allow for different ways for getting the coverages individually. Since not every format is suitable for transferring all of the coverage information, participants identified different ways for getting the different types of coverages. It was also noted that for applications that do not want to use collections, they can just use the `coverages/{coverageid}` path.

There was a discussion about whether parameters, values and URL bases were case sensitive. This issue was observed to be applicable to all of the specifications. There was a suggestion that the OGC API - Common specification should specify a rule for case sensitivity and that that rule should be consistent with the RFC.

9.5. OGC API - Common

There was a discussion about whether OGC API - Common should support the CRS:84 coordinate system (WGS84) by default. The participants observed that the collectionInfo metadata (returned for each collection) allows one to specify the CRS supported by the collection. The client can specify one of the other CRS if they do not support the default. For coverages, the default CRS was observed to be the native CRS. The participants concluded that there will be a default CRS for the API and the OGC API - Common specification should have complete control over the CRS and the default CRS should not constrain the resource.

The participants discussed what role version numbers would play within an OGC API, recognising that the current suite of OGC web service standards require implementations to indicate the supported versions as a query parameter. The participants determined that the version of the standard would be reflected in the conformance class. Each conformance class would be made uniquely identifiable and any change to that conformance class would relate in the creation of a new conformance class. It would therefore not be necessary to indicate the version on the standard on the path or the query parameters of an implementation of the OGC APIs. In addition, it should be the API that includes a version in its path, but not the OGC API paths as these are just sub-resources of the API and many APIs will include other resources not specified by OGC API standards.

The participants observed that there is a need for a CRS that is based on CRS:84 but that includes ellipsoidal height. EPSG:4979 and EPSG:4327 were suggested as a possible basis for such a CRS, but these use latitude/longitude as the axis order. It was agreed to discuss the issue of a height or elevation CRS with the WFS/FES SWG and the CRS DWG at the OGC TC meeting in Leuven. The WFS/FES SWG passed a motion at the OGC TC meeting in Leuven, the week after the hackathon, proposing a new CRS named CRS84h that would be based on CRS:84 and include an additional axis for ellipsoidal height.

There was a discussion on whether the API definition resource should be mandatory at path `/api` across all OGC API specifications. Earlier in the hackathon it was observed that some of the OpenAPI examples included the `/api` resource whereas others did not. Participants supporting the addition of `/api` as a mandatory path in the OpenAPI definitions pointed out that the resource would ensure that the API definition is always a complete representation of the server implementation. In contrast, participants supporting the optional use of the `/api` resource pointed out that the API definition can already be found through the use of the `rel="service"` link provided by the landing page and that clients do not need a resource for the OpenAPI definition in the OpeNAPI definition as they already have it. It was therefore agreed that there would be no requirement for providing the API definition at path `/api` or to include it in the API definition itself.

9.6. Technology Integration Experiments (TIE)

Several Technology Integration Experiments (TIE) were completed during the Hackathon. Table 3 shows the services and client applications that were deployed and bound together during the

hackathon. The table also identifies the OGC APIs that were implemented to achieve the integration.

Table 3. Technology Integration Experiments (TIE) for OGC APIs

Services\ Client	**Hexagon**	**Helyx**	**SigmaBravo**	**Esri**	**Solenix**	**EURAC**	**Sinergise**	**GeoPackage/Map Cache**
52 North		Processes			Processes			
CubeWerx		Processes			Processes			
Esri	Map Tiles		Map Tiles	Map Tiles				
Helyx		Processes						
pygeoapi			Features		Processes			Features
Geoserver			Features					
Spacebel			Features, Catalogue		Processes			
West University of Timisoara		Processes			Processes			
rasdaman						Coverages	Coverages	
MAGE								Features
ldproxy								Features

NOTE Services on rows and Clients on columns

Chapter 10. Findings

10.1. Key Findings

One of the key findings of the hackathon was that the draft OGC API standards are implementable. This was evidenced by the implementations developed by many of the participating organizations at the hackathon.

Another key finding is that the 'building-block' principle, adopted by the different draft standards, allows for a common core to be specified. This was evidenced in the use of common capabilities such as `/collection` paths and support for bounding box (BBOX) queries.

Additional findings are presented in the following subsections.

10.2. Experiences

The first objective of the hackathon was to develop, deploy and test services/clients that support OGC APIs. The hackathon participants were able to develop and deploy services and clients during the hackathon, as documented in Table 3. The participants were also able to successfully bind together many of the services with client applications provided by other participants, using OGC APIs. This confirms that the first objective of the hackathon was fully met.

A second objective of the hackathon was to suggest improvements for a common core. Some of the discussions around the OGC API - Common specification included default support for the CRS:84 coordinate system and the role of version numbers. The discussion that began shortly before the hackathon on the need for a new CRS that adds ellipsoidal height to CRS:84 has resulted on a proposal being passed by the WFS/FES SWG. Further, the discussion on the role of the `/api` resource has resulted in consensus between the various SWGs that the API definition does not have to be resource inside the API at path `/api`. These discussions and the resolutions resulting from them confirm that the second objective of the hackathon was also met.

A third objective of the hackathon was to define rules/guidance that can be documented. Several edits to the OGC API specifications were made on the lead up to the hackathon, and during the event. These edits included additions and deletions of some of the rules and guidance in the specifications, as well as improvements to some of the existing rules and guidance. More than 4600 additions and 3200 deletions to the draft API specifications as an immediate result of the hackathon, thereby confirming that the third objective of the hackathon was also met.

A fourth objective of the hackathon was to validate work that has been completed to date. The successful implementation, by multiple different organisations, of the OGC API specifications supported the validation of the prior work (i.e. the approach taken for the various OGC API specifications). The hackathon also provided the opportunity to invalidate or rethink specific aspects of some of the specifications. The fact that the different specifications extended the OGC API - Common specification, supports the view that the approach taken for organizing and structuring the OGC API specifications was validated by the hackathon. This confirms that the fourth objective of the hackathon was also met.

A fifth objective of the hackathon was to contribute to the GitHub repositories. Figure 11 presents

the total number of commits made to Github repositories for OGC APIs for Processes, Map Tiles, Common and Coverages. Figure 10 presents the total number of issues made to Github repositories for OGC APIs for Processes, Map Tiles, Common and Coverages. The commits and issues from the lead up to the hackathon and during the hackathon confirm that the fifth objective of the hackathon was also met.

This subsection has reflected on all of the objectives of the hackathon and confirmed that they were all met. The next section identifies lessons learnt from holding the hackathon.

10.3. Lessons learnt

10.3.1. Duration of the hackathon

Two of the participants expressed concerns that the duration of the hackathon was rather short. There was a suggestion that a minimum three days may have been more appropriate. To an extent, the approach taken to incrementally ramp up towards the hackathon date addressed some of these concerns. However, it is accepted that a three-day hackathon could have led to more outputs. A three-day hackathon could cover the following, for example:

- Day 1: Discussions and revisions to the draft standards
- Day 2: Implementation of the draft standards
- Day 3: Design and implementation of Executable Test Suites of the draft standards

10.3.2. Scheduling of the hackathon

It cannot be ignored that the scheduling of the hackathon during the week preceding the OGC TC meeting in nearby Leuven made it possible for some of the participants to travel to both events. This aspects of the scheduling made a difference for participants that had travelled from abroad. In some cases however the scheduling meant that some interested parties could not attend the hackathon due to its proximity, in scheduling, to the TC meeting. Overall however the proximity to the TC meeting proved to be helpful.

10.3.3. Motivation to participate

In some hackathons prizes are awarded, ranging from a few hundred to a million dollars [https://techcrunch.com/2013/11/21/two-harvard-university-alum-win-salesforce-1m-hackathon-prize-at-dreamforce-for-mobile-service-to-create-reports] (USD). In organizing the OGC API Hackathon, OGC staff considered the goal of the hackathon was in relation to the likely motivation of participants. Given that the goal of the hackathon was to advance the OGC API specification, collaboration between different organizations became a key consideration. A decision was therefore made to offer travel support to any participants that applied for such support, instead of offering a competition prize. A review of the motivation for various participants to take part in the hackathon supported this devision. Below are some examples of the motivation of some of the participants to participate, extracted from Implementations of OGC APIs:

- "Evolution of the OGC specifications to a modern, developer-friendly API is essential"
- "We wanted to participate in this hackathon event in order to understand well the intent and

orientation of OGC APIs, as well as to align as much as possible the implementations, in order to make them compatible"

- "To get more information about the direction followed by the working groups for the different standards, as well as to get answers to some questions we have got about the OGC API - Processes specification specifically"
- "To help solve the discoverability problem…to facilitate making life easier for finding data through the new OGC API specifications"
- "To share [our] expertise as a long-term implementer and user, to support the advancements of OGC standards related to map tiles, coverages and processes"
- "We would like the implemented APIs to be consistent with, and conform to any OGC API standards"

The sample of statements presented above suggests that the advancement of open standards, on its own, can be useful as a motivator for participation. In situations where collaboration across organisations is not a key consideration, a competitive hackathon offering prizes would be appropriate.

10.4. What are the next steps?

TBA

Appendix A: Implementations of OGC APIs

A.1. 52°North GmbH

52°North is an open international network of research, industry and public administration organizations that partner in a collaborative process of Geomatics Research & Development. All software developed within the 52N R&D process is published under an open source license.

A.1.1. Motivation to Participate

One of 52°North's is core topics is Web-based processing of geospatial data. Currently, 52°North leads the development of the OGC API - Processes within the OGC Web Processing Service 2.0 Standards Working Group. We aimed to use the hackathon:

- to get feedback from developers from inside and outside the OGC,
- to find any blocking issues,
- to test our implementation of the Executable Test Suite for the API,
- to discuss the relationship with the OGC API - Common specification.

A.1.2. Implemented Solution

52°North implemented and deployed an instance of the 52°North JavaPS software, which is an implementation of the OGC Web Processing Service (WPS) standard and the OGC API - Processes specification. A screenshot of the deployed service is shown in Figure 12. The software was configured to offer an interface that conforms to the OGC API - Processes specification.

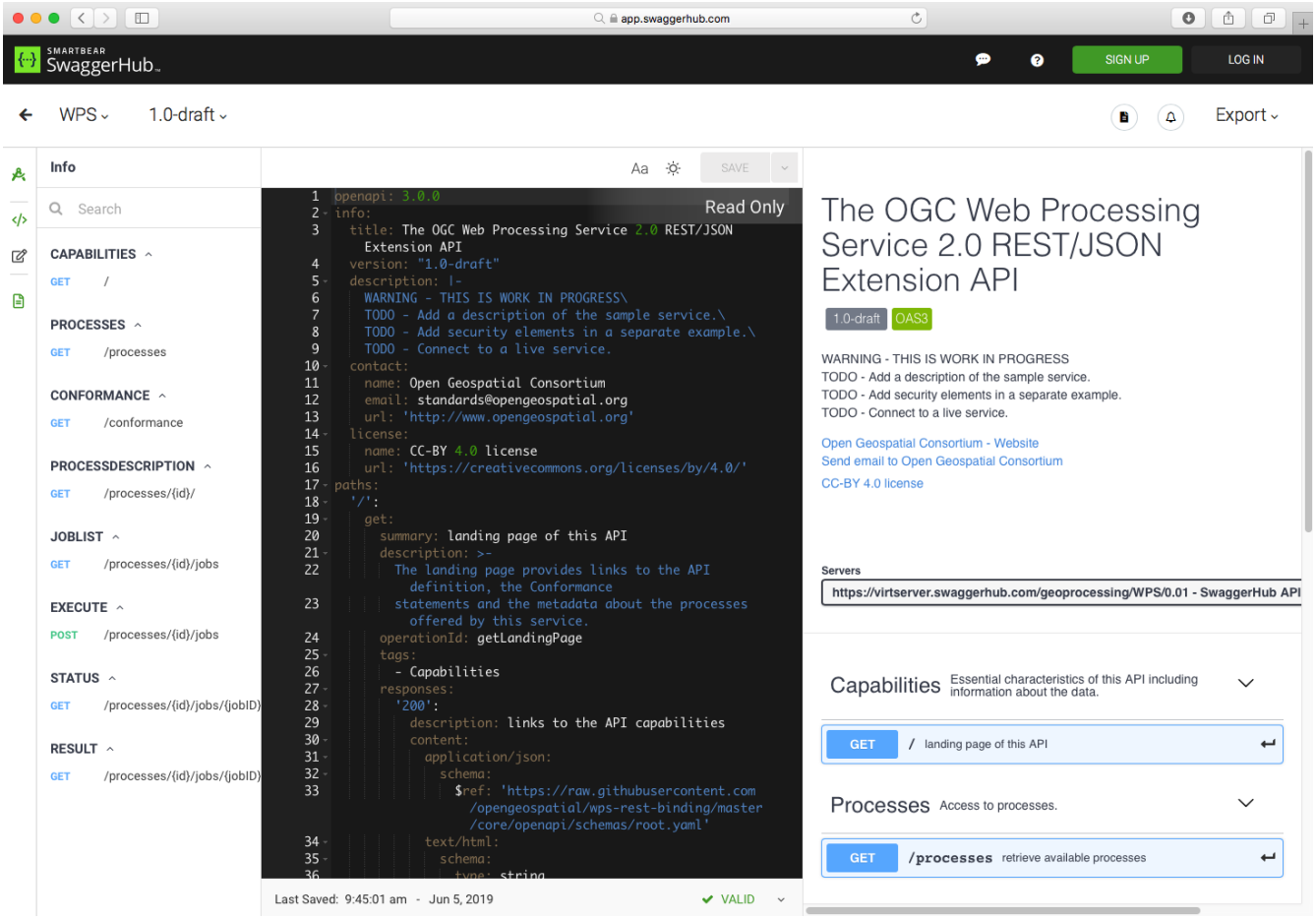

Figure 12. Swagger Hub page of the OGC API - Processes implementation deployed by 52°North GmbH

The implementation is available at http://geoprocessing.demo.52north.org:8080/javaps/rest/

Figure 13 shows a simple user interface to submit new processing jobs.

```
URL:
http://geoprocessing.demo.52north.org:8080/javaps/rest/processes/org.n52.wps.server.algorithm.SimpleBuffer
```

Figure 13. User interface to submit new processing jobs to the 52°North javaPS

A.1.3. Proposed Alternatives

The following points were discussed:

Align the API to the WPS 2.0 standard

The OGC API - Processes has its origins in a Public Engineering Report (ER) of the OGC Testbed 12 from 2016. This ER described a REST/JSON binding for WPS 2.0. The JSON schemas were very closely aligned to the WPS 2.0 XML schemas. Since 2016 the JSON schemas were modified, more specifically simplified. This simplification was seen as undesirable by the hackathon attendees. Therefore, the JSON schemas will be aligned with the WPS 2.0 XML schemas again.

Example of JSON schema not aligned: Status info

WPS 2.0 XML StatusInfo element

```
<?xml version="1.0" encoding="UTF-8"?>
<wps:StatusInfo
    xmlns:wps="http://www.opengis.net/wps/2.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.opengis.net/wps/2.0 ../wps.xsd">

    <wps:JobID>FB6DD4B0-A2BB-11E3-A5E2-0800200C9A66</wps:JobID>
    <wps:Status>Accepted</wps:Status>
    <wps:EstimatedCompletion>2014-12-24T23:00:00Z</wps:EstimatedCompletion>
    <wps:NextPoll>2014-12-24T16:00:00Z</wps:NextPoll>
    <wps:PercentCompleted>30</wps:PercentCompleted>
</wps:StatusInfo>
```

Corresponding JSON element

```
{
  "status": "accepted",
  "message": "Process started",
  "progress": 0,
  "links": [
    {
      "href": "http://processing.example.org/processes/EchoProcess/jobs/81574318-1eb1-
4d7c-af61-4b3fbcf33c4f",
      "rel": "self",
      "type": "application/json",
      "title": "this document"
    }
  ]
}
```

Proposed changes:

- Add element containing JobID
- Add element containing EstimatedCompletion
- Add element containing NextPoll

Another example would be to re-introduce nested inputs to the JSON schema, see this issue: https://github.com/opengeospatial/wps-rest-binding/issues/33

Other discussion points

Other discussion points concerned extensions to the API, e.g., an extension that enables specifying callbacks for asynchronous execution or a transactional extension.

Also, the possibility was discussed to use JSON schema for the process description, instead of using a Swagger/OpenAPI specification.

In a related discussion, the idea came up to use only OpenAPI to describe WPS, i.e., discard most of

the JSON schemas and only use certain building blocks to define a WPS. This approach will be followed in the OGC Routing Pilot [http://www.opengeospatial.org/projects/initiatives/routingpilot]. The results will be discussed at the OGC TC/PC meeting in September.

All discussions are captured in the GitHub issues section: https://github.com/opengeospatial/wps-rest-binding/issues/

A.1.4. Experiences with OGC API Specifications

52°North uses the OGC API - Processes in a variety of projects and we think it performs well. The API was and is also heavilly used by other participants e.g. in the OGC Testbeds. The JSON is lightweight and we think that it is better readable than the XML. The links in the JSON let the users/clients easilly find the relevant resources, e.g. from the list of processes to a single process description to the job submission. The HTML encoding also increases usability, e.g., letting the user quickly submit example jobs via a lightweight HTML POST client.

A.1.5. Other Impressions & Recommendations

The hackathon was very well organized and it was good to see so many people interested in the API development. We would recommend to hold similar hackathons more regularly in order to get developers from outside the OGC involved in the standardization process early. The OGC API - Processes now has several implementations and we got valuable comments. This gives us a fresh impuls to continue the work on the API and to eventually finalize it.

A.2. akouas

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A.2.1. Motivation to Participate

TBA

A.2.2. Implemented Solution

TBA

A.2.3. Proposed Alternatives

TBA

A.2.4. Experiences with OGC API Specifications

TBA

A.2.5. Other Impressions & Recommendations

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A.3. ARC

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A.3.1. Motivation to Participate

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A.3.2. Implemented Solution

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A.3.3. Proposed Alternatives

TBA

A.3.4. Experiences with OGC API Specifications

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A.3.5. Other Impressions & Recommendations

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A.4. Arup

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A.4.1. Motivation to Participate

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A.4.2. Implemented Solution

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A.4.3. Proposed Alternatives

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A.4.4. Experiences with OGC API Specifications

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A.4.5. Other Impressions & Recommendations

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A.5. blockdore

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A.5.1. Motivation to Participate

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A.5.2. Implemented Solution

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A.5.3. Proposed Alternatives

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A.5.4. Experiences with OGC API Specifications

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A.5.5. Other Impressions & Recommendations

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A.6. British Antarctic Survey

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A.6.1. Motivation to Participate

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A.6.2. Implemented Solution

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A.6.3. Proposed Alternatives

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A.6.4. Experiences with OGC API Specifications

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A.6.5. Other Impressions & Recommendations

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A.7. CREAF

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A.7.1. Motivation to Participate

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A.7.2. Implemented Solution

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A.7.3. Proposed Alternatives

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A.7.4. Experiences with OGC API Specifications

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A.7.5. Other Impressions & Recommendations

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A.8. CubeWerx Inc.

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A.8.1. Motivation to Participate

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A.8.2. Implemented Solution

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A.8.3. Proposed Alternatives

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A.8.4. Experiences with OGC API Specifications

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A.8.5. Other Impressions & Recommendations

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A.9. Deimos Space UK

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A.9.1. Motivation to Participate

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A.9.2. Implemented Solution

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A.9.3. Proposed Alternatives

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A.9.4. Experiences with OGC API Specifications

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A.9.5. Other Impressions & Recommendations

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A.10. Cologne Government Regional Office - Geobasis NRW

Division 7 of the Cologne Government Regional Office is North Rhine-Westphalia's central service for geographic reference data and top-quality geo-products and services. Division 7 has statewide responsibility for collecting, storing, handling and making available basic topographic geodata. The basic geodata provided by Division 7 (coordinates, elevations, property boundaries, size and use of real estate, topographic information etc.) are needed for a wide range of purposes including planning, construction projects, transport and the supply of basic community services, nature conservation and environmental protection, valuation of real property, real estate transactions and mortgage borrowing. Against a background of rapid technological progress and changing environmental awareness, the division's services are now in demand from new sections of the community. Rather than chiefly asking for analogue data such as maps, plans and lists, users increasingly prefer digital information which they can integrate into existing databases.

A.10.1. Motivation to Participate

The motivation for Geobasis NRW was to implement OGC specification for Map Tiles in their application TIM-online 2.0 and to getting more information about the work in working groups.

A.10.2. Implemented Solution

During the OGC API Hackathon event in London, Geobasis NRW implemented the OGC API for Map

Tiles by using the web service provided by ESRI (https://ogc-tiles-esri-server.azurewebsites.net/api/).

Before the OGC API Hackathon, Geobasis NRW implemented the OGC API for Features by using ldproxy (https://www.ldproxy.nrw.de/). Have a look on the functionality:

- Extras / Verwaltungseinheit
- Extras / Flurstück
- Extras / Gebäude

Implementation available: https://www.tim-online.nrw.de/ogc-hackathon/

A.10.3. Proposed Alternatives

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A.10.4. Experiences with OGC API Specifications

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A.10.5. Other Impressions & Recommendations

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A.11. Dstl

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A.11.1. Motivation to Participate

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A.11.2. Implemented Solution

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A.11.3. Proposed Alternatives

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A.11.4. Experiences with OGC API Specifications

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A.11.5. Other Impressions & Recommendations

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A.12. Duisburg Essen university

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A.12.1. Motivation to Participate

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A.12.2. Implemented Solution

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A.12.3. Proposed Alternatives

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A.12.4. Experiences with OGC API Specifications

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A.12.5. Other Impressions & Recommendations

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A.13. Ecere Corporation

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A.13.1. Motivation to Participate

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A.13.2. Implemented Solution

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A.13.3. Proposed Alternatives

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A.13.4. Experiences with OGC API Specifications

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A.13.5. Other Impressions & Recommendations

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A.14. ECMWF

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A.14.1. Motivation to Participate

TBA

A.14.2. Implemented Solution

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A.14.3. Proposed Alternatives

TBA

A.14.4. Experiences with OGC API Specifications

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A.14.5. Other Impressions & Recommendations

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A.15. El Toro

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A.15.1. Motivation to Participate

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A.15.2. Implemented Solution

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A.15.3. Proposed Alternatives

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A.15.4. Experiences with OGC API Specifications

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A.15.5. Other Impressions & Recommendations

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A.16. EOS Data Analytics

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A.16.1. Motivation to Participate

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A.16.2. Implemented Solution

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A.16.3. Proposed Alternatives

TBA

A.16.4. Experiences with OGC API Specifications

TBA

A.16.5. Other Impressions & Recommendations

TBA

A.17. EOX IT Services GmbH

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A.17.1. Motivation to Participate

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A.17.2. Implemented Solution

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A.17.3. Proposed Alternatives

TBA

A.17.4. Experiences with OGC API Specifications

TBA

A.17.5. Other Impressions & Recommendations

TBA

A.18. European Space Agency (ESA)

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A.18.1. Motivation to Participate

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A.18.2. Implemented Solution

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A.18.3. Proposed Alternatives

TBA

A.18.4. Experiences with OGC API Specifications

TBA

A.18.5. Other Impressions & Recommendations

TBA

A.19. Esri UK

Esri is a provider of Geographic Information Systems (GIS) software and solutions to a wide range of organizations. Esri software has been deployed in more than 350,000 organizations, including large cities and many national governments. Esri make ArcGIS mapping and analytics software.

A.19.1. Motivation to Participate

Evolution of the OGC specifications to a modern, developer-friendly API is essential.

A.19.2. Implemented Solution

To date Esri have not implemented any of the new draft OGC API standards in their released software. They have however been working on various R&D prototypes of server and client.

A.19.3. Proposed Alternatives

TBA

A.19.4. Experiences with OGC API Specifications

Esri has been involved in the OGC since its inception, and has widely implemented many other OGC standards in both server and client software. After each ArcGIS product release, the latest core OGC standards with compliance tests are reviewed. Currently, 133 ArcGIS products (multiple versions)

have received compliance certifications across 338 OGC implementations.

A.19.5. Other Impressions & Recommendations

TBA

A.20. Eurac Research

Eurac Research (http://www.eurac.edu) is a private not-for-profit research centre established in 1992 with headquarters in Bolzano. Its 430 staff members, united by shared values of passion for their work and an unwavering commitment to quality, have the opportunity to work in a multicultural environment thanks to a wide diversity of nationalities represented among its team. This diversity, of gender and nationality, ensures a positive environment that enables respect and an understanding of different cultural patterns. Eurac Research is internally organized in 11 Research Institutes, supported by 11 Service Departments, performing research activities in different fields from issues related to minority rights protection, federal, regional and local governmental trends and the efficient management of public administrations to studies on renewable energies, promotion of sustainable development and the protection of natural resources. The contributing body for this hackathon is the Institute for Earth Observation (http://www.eurac.edu/en/research/mountains/remsen/Pages/default.aspx) with its research groups for Advanced Computing for Earth Observation (http://www.eurac.edu/en/research/mountains/remsen/researchfields/Pages/Technology-for-Environmental-Monitoring.aspx). The purpose of the Institute is the advanced analysis of Earth Observation (EO) data and their integration into products and services tackling most relevant environmental issues in mountain areas.

The Group for Advanced Computing for Earth Observation focuses on research in the field of Big Data science for developing and implementing novel technology and methodology for handling and analysis of big earth observation data as well as management and processing of earth observation data for the Institute for Earth Observation.

Participating from Eurac Research: Alexander Jacob - Research Group Leader - Advanced Computing for Earth Observation (alexander.jacob@eurac.edu [mailto:alexander.jacob@eurac.edu])

A.20.1. Motivation to Participate

Eurac Research is actively contributing to openEO (https://openeo.org/) an open source innovative aiming to federate EO cloud service providers by developing a standardised interface together with back-end and client implementations. This allows users to approach diverse EO data infrastructures, using source code with the same processing commands. Eurac Research develops a back-end driver (https://github.com/Open-EO/openeo-wcps-driver) towards high level interfaces for data cubes via OGC standard WC(P)S and contributes further with the implementation of a use case for operational snow monitoring using openEO.

Since much of the development of OGC API specifications is moving in a similar direction, Eurac Research wanted to participate in the hackathon event in order to improve their understanding of the purpose and orientation of OGC API specifications, as well as to align the implementations as much as possible, in order to make them compatible. Currently several pieces of the openEO API are very similar to the OGC API, since Eurac Research were from the start of the development also

looking at what was happening inside the OGC. The RESTful approach of WFS-3, now known as OGC API - Features, was specifically of great interest to Eurac Research. Another related initiative that Eurac Research is monitoring and following is the development of the Spatial Temporal Asset Catalogue (STAC) of the Radiant Earth Foundation (https://github.com/radiantearth/stac-spec).

A.20.2. Implemented Solution

During the hackathon event in London, Eurac Research participated in the further development of the OGC API - Coverages specification on the first day and then developed a number of back-end implementations. Alexander also implemented the latest agreed-on specification on the second day of the hackathon. The implementation was based on the Web Coverage Processing Service (WCPS) and is available at: http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/.

This solution is based on the aforementioned openEO WCPS driver and has adopted some new REST endpoints considering the OGC API - Coverages specification. In particular:

- /collections
  - lists all available collections within server. For this hackathon two collections have been hard-coded for demonstration purposes only: http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/collections
- /collections/{collectionid}
  - lists all available coverages in collections specified within server, including most essential metadata like spatial and temporal extent of all coverages: http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/collections/Sentinel-2
- /collections/{collectionid}/coverages
  - currently identical to /collections/{collectionid}: http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/collections/Sentinel-2/coverages
- /collections/{collectionid}/coverages/{coverageid}
  - this endpoint is supposed to deliver the actual coverage in its native format or a specified format and subset via query parameters. In the current implementation however it is just delivering the metadata: http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/collections/Sentinel-2/coverages/openEO_S2_32632_20m_L2A
- /coverages
  - lists all available coverages, independently of whether they belong to collections or not. This listing includes most essential metadata like spatial and temporal extent of all coverages: http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/coverages/
- /coverages/{coverageid}
  - this endpoint gives actual access to the data included in a coverage. The following examples demonstrates also how query parameters can be used to limit to a specific subset along all available dimensions of the coverage and how a specific output format can be specified: http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/coverages/openEO_S2_32632_60m_L2A&format=json&subset=E(399960,419960)&subset=N(5090220,5100220)&subset=DATE(%222018-06-04%22). Available query parameters are:

- format
  - available formats are listed at http://saocompute.eurac.edu/openEO_WCPS_Driver/openeo/output_formats
- subset
  - works just like the original subset from WCS 2

The existing driver works on top of an installation of Rasdaman community edition, exposing both the already existing WCS 2 and its WCPS 1 extension.

A.20.3. Proposed Alternatives

Alexander proposed the direct use of the path `/collections/{collectionid}/{coverageid}` instead of the path `/collections/{collectionid}/coverages`. The reason being that if collections can have different types of collections e.g. a feature collection and a coverage collection, it may be more appropriate that this information is delivered in the metadata of the collection with a type field.

A.20.4. Experiences with OGC API Specifications

The overall impression of the Hackathon was, for Alexander, that there still needs to be more integration between the different OGC API specifications. The goal should not be to just "restify" the existing standards, but to create a new well-defined suite of functionality that takes the current state of available data and technology into account. Most importantly the data available today is multidimensional, covering at least 3 or more dimensions that should be considered everywhere in the API. Secondly, in order to make actual use of the enormous amount of data available today, one cannot simply download the data an then process everything on the client-side. Processing should be performed as much as possible, where the data is, in order to avoid unnecessary copies, and unnecessary delay due to long Input/Output times. Finally processing should be as flexible as possible and allow for chaining of arbitrary functions or operations in order to allow a user to achieve whatever he wants with the data. Here, Alexander urges OGC to look into how processing is designed in openEO (https://open-eo.github.io/openeo-api/v/0.4.1/index.html) with its concept of a graph representation of workflows, that can contain any number of processes chained into arbitrarily complex graphs including even user-defined functions, when necessary processes are not natively supported by a given back-end implementation.

A.20.5. Other Impressions & Recommendations

The concept of collections of coverages needs to be further specified more precisely. In particular it needs to be discussed and decided if collections should have the same projection and underlying grid, or if they can have arbitrary projections and grids. In the latter case a defined behavior should be decided of how to access a collection as opposed to an individual coverage. Questions like how are we mosaicking and integrating data from coverages on-the-fly when belonging to same collections, need to be answered. Are re-sampling methods, blending and mosaicking decided implicitly by the back-end implementation or can those be selected by query parameters or other means as well? How do we deal with multi-temporal (or arbitrary n-dimensional) mosaicking and resampling?

A.21. Geobeyond

Geobeyond is a geospatial software and solutions provider. Geobeyond is involved in the development of the GeoNode open source toolkit. GeoNode is a web-based application and platform for developing solutions for spatial data infrastructures (SDI). Francesco Bartoli represented Geobeyond at the hackathon.

A.21.1. Motivation to Participate

Geobeyond was motivated to participate in the hackathon by:

- the potential to port the GEE-Bridge API [https://github.com/francbartoli/gee-bridge] to OGC API - Commons and OGC API - Processes.
- discussion within the community on how to handle WPS remote processes and process chaining (local and remote).
- the need to understand and find a way to implement several specifications together for the new GeoNode API 4.0 which will be driven by the API-first approach and totally based on the OpenAPI v3 specification.
- alignment with the CSW community about the new OpenAPI based specification.

A.21.2. Implemented Solution

During the hackathon, Geobeyond implemented a draft GeoNode API [https://github.com/geobeyond/geonode-api/tree/processes] based on:

- OGC API - Processes specification which could provide a generic solution for algorithms as functions.
  - Implemented interface with out-of-the-box validation for jobs and result as modeled in the WPS REST Binding
  - Support of asynchronous processing and jobs persistence
  - Deploy ready for containers to Docker Swarm

This starting point will be the base building block to add more specifications to the next GeoNode 4.0 in order to be a reference implementation with at least the following OGC standards:

- OGC API - Commons standard
- OGC API - Features standard
- OGC API – Coverages standard
- OGC API – Map Tiles standard

A.21.3. Proposed Alternatives

The following considerations of alternative approaches were identified by Geobeyond:

- Process chaining and consequently workflows should be part of the perimeter of the

specification or can be an abstract concept within GeoNode?

- Processing from cloud infrastructure (Google Earth Engine, IBM Geoscope, etc) have to be considered remote or local? Sort of WPS Cascading?

A.21.4. Experiences with OGC API Specifications

Geobeyond has experience with the following OGC API Specifications:

- Basic experience with OGC API - Features
- Basic experience with OGC API - Commons and OGC API - Processes

A.21.5. Other Impressions & Recommendations

The event has been pretty much useful and productive and the expectations are to see this kind of developer oriented meetings organized more frequently.

A.22. GeoCat B.V.

Established in the Netherlands in 2007, GeoCat (https://www.geocat.net) offers cutting-edge products that make publishing geospatial data on the internet or cloud easier and more efficient. GeoCat customized software and services help our customers succeed with Spatial Data Infrastructures (SDI) and geospatial-enabled technologies. GeoCat is committed to sustainable applications with following the principles of free and open-source software and open standards.

GeoCat has an established reputation with our products and services supporting the National Spatial Data Infrastructures for The Netherlands, Switzerland, Norway, Sweden, Finland, Denmark, Scotland, The European Environment Agency, Eurostat and many others.

A.22.1. Motivation to Participate

GeoCat active support of the OGC with a demonstrated commitment to OGC standards both in our participation in standards development and shipped implementations. Committed to SDI standards, especially with geospatial catalogues, GeoCat has implemented a wide range of OGC standards. GeoCat participated in the GeoNovum testbed for spatial data on the web, from which results were contributed to the final report of the OGC/W3C best practice for spatial data on the web report. This report was taken as the foundation for the OGC API developments. We believe enabling OGC standards to connect to web domain standards enlarges the audience of spatial data, and allows the spatial community to benefit from the latest web domain research and innovations.

There is a number of focus areas for GeoCat, especially related to GeoNetwork (https://www.geonetwork-opensource.org), in such events:

- We're looking forward to participating in the next generation of UML, YAML & RDF models for spatial data and cartography and how they are exchanged in the scope of OGC API's.
- To collect experience and contribute the discussion to implement support for OAPI Catalog, OAPI Tiles and OAPI Features specifications.
- Research how existing client tooling (QGIS, OpenLayers, PowerBI, Talend) can benefit from OGC

API standards

- Enable crawling by search engines (and humans) of OGC API's, preferably using (extensions to) common ontologies, such as schema.org, dcat, etc.

A.22.2. Implemented Solution

- GeoCat contributes to the pygeoapi (https://pygeoapi.io) project, focussing on dataset discovery.
- GeoCat is evaluating how to integrate OAPI Catalog into the GeoNetwork catalog product.
- GeoCat completed a pilot to introduce an OAPI Features client into GeoNetwork.

A.22.3. Experiences with OGC API Specifications

GeoCat has been constantly an active supporter of OGC and OGC standards, including recent efforts on WFS 3.0.

A.22.4. Other Impressions & Recommendations

GeoCat recognized the group's admirable motivation towards creating standards that easy to understand and are developer-friendly.

We recognized valid remarks on the OGC API being very strict around the Collections concept. This was especially apparent with the OGG API Process where a collections driven approach was markedly less intuitive than an Open API approach.

These discussions are beneficial and lead to a strong standardization process.

A.23. GeoLabs

GeoLabs (http://www.geolabs.fr) is a world-wide provider of geospatial management solutions based on open source technologies. GeoLabs is involved in the development of numerous open source geospatial projects, as well as providing Software-as-a-Service (SaaS) and Platform-as-a-Service (PaaS) solutions for geospatial data. GeoLabs has developed MapMint (mapmint.com), a complete web based web mapping infrastructure, participated in the development of geoportail.fr, and the development of Senegal's National Cadastre. Further, GeoLabs provides commercial cloud-based GIS services, and contributes in numerous open source projects.

A.23.1. Motivation to Participate

The motivation for GeoLabs was to get more information about the direction followed by the working groups for the different standards, as well as to get answers to some questions that GeoLabs had about the OGC API - Processes specification. Indeed, GeoLabs implemented part of the OGC API - Processes specification before attending the hackathon and encountered some issues in trying to mimic the different options available in WPS 2.0. The hackathon therefore provided an opportunity for GeoLabs to discuss and share experiences with participants from other organizations.

A.23.2. Implemented Solution

GeoLabs came to the hackathon with the ZOO-Project implementation demonstration swagger interface available at: https://demo.mapmint.com/swagger-ui/dist/ for interacting with two instances based on the OGC API - Processes specification. The instances are available at: http://demo.mapmint.com/WPS2/ and http://demo.mapmint.com/WPS3/ (where the former is using the model available on the wps-rest-binding [https://github.com/opengeospatial/wps-rest-binding] repository and the latter one is based on the tests GeoLabs made to change the wps-rest-binding, in order to make it fit the current WPS 2.0 definitions).

This implementation of the OGC API - Processes specification is based on the one available at http://www.zoo-project.org with some modifications. It is based on an implementation that is able to offer access to libraries and applications such as GDAL, OGR, GEOS, PROJ, the Orfeo ToolBox (https://www.orfeo-toolbox.org/) and the SAGA-GIS application. The demonstration includes numerous services available to be run using the implementation of the OGC API - Processes specification.

A.23.3. Proposed Alternatives

TBA

A.23.4. Experiences with OGC API Specifications

TBA

A.23.5. Other Impressions & Recommendations

TBA

A.24. GeoSeer

GeoSeer is a search engine for OGC Services. At the time of writing it has just shy of 200,000 such services in its index, making their data easily and freely searchable.

A.24.1. Motivation to Participate

The Motivation behind creating GeoSeer was to help solve the discoverability problem. End users often find it difficult to find the services or data that exists. GeoSeer's participation was an extension of this seeking to facilitate making life easier for finding data through the new OGC API specifications, or at least to ensure it did not get even harder. In fact, the team behind GeoSeer suggests that discovery is one of the aspects that could be improved in current OGC services and should be getting more consideration in the new OGC API specifications.

A.24.2. Implemented Solution

N/A

A.24.3. Proposed Alternatives

N/A

A.24.4. Experiences with OGC API Specifications

For GeoSeer, the OGC API specifications all seem quite interesting, though the concept of "collections" took some getting used to and remains somewhat confusing. This suggests that collections may not be as intuitive as could be desired and users may struggle with the concept.

In relation to discoverability:

Good

- The HTML reports that are created are good for improving discoverability with mainstream search engines.
- The OGC API specifications are easily parsable.

Issues

A number of potential discoverability issues with the current specifications were identified by GeoSeer. The issues include:

- The specifications do not include "keywords" currently. Ideally this should be mandatory in core to facilitate discovery. While popular search engines may not currently use this field, that does not mean they and/or others would not in the future. GeoSeer does use this field for indexing, and many current OGC Web Services have this set with meaningful keywords by their deployers. GeoSeer would suggest having it both at the root level (to indicate the type of "service"), and at the /collections level for each collection. This would improve discoverability.
- There may be too much reliance on extensions. Many deployers will NOT install extensions even if they should. For example, the data for services that claim to be compliant to Implementing Rules of the European Union's INSPIRE directive shows that only around half of the services actually have the INSPIRE ExtendedCapabilities. And that is for something that INSPIRE says is mandatory. An extension for "discovery" would therefore not provide its peak usefulness unless its components were in core.
- The "Title", and "Description", fields are both optional in the Common, Features and Map Tiles specifications. These fields should be mandatory. If they are not they will not be there for many services and that will make them considerably less discoverable. It will also significantly reduce usability with desktop GIS (imagine selecting a feature collection when none of them have these…).
- There should be a mandatory Bounding Box (BBOX) in WGS84, required for each collection, in the OGC API - Common specification. This will facilitate discovery of spatial data - "WHERE" being critical to such data. There are many thousands of "tree" datasets out there for instance, how can a user otherwise know where the data is without this? Some wording to allow exclusion for non-spatial datasets could be incorporated. This could be in addition to a native BBOX defined by the extensions as necessary.
- Metadata URLs should be included too. While GeoSeer were no big fan of external metadata

documents, many large organizations find them extremely important and they are used a fair percentage on current services. A consistent way to specify them would make access to this information automatically easier.

- GeoSeer would like to highlight that if something is not explicitly specified in the OGC API specifications and instead relies on the deployer deciding what/how to implement it (as has been suggested with Keywords), this obviates much of the benefit of a standard. Even **with** standards, developers end up finding many different ways to do things! Without standards the number of ways to do things just makes life extremely difficult for anyone who wishes to automate access to services. It is advisable not to rely on the deployers/implementers being consistent.

Many of the above would also make it easier for end-users who are accessing these services via a desktop client like QGIS/ArcGIS. Without title/description information in a JSON format it will be impossible for such a user to know what they want without opening stuff in parallel web-browser; hardly easy.

A.24.5. Other Impressions & Recommendations

TBA

A.25. GeoSolutions

TBA

A.25.1. Motivation to Participate

TBA

A.25.2. Implemented Solution

TBA

A.25.3. Proposed Alternatives

TBA

A.25.4. Experiences with OGC API Specifications

TBA

A.25.5. Other Impressions & Recommendations

TBA

A.26. Geovation

TBA

A.26.1. Motivation to Participate

TBA

A.26.2. Implemented Solution

TBA

A.26.3. Proposed Alternatives

TBA

A.26.4. Experiences with OGC API Specifications

TBA

A.26.5. Other Impressions & Recommendations

TBA

A.27. Heazeltech

TBA

A.27.1. Motivation to Participate

TBA

A.27.2. Implemented Solution

TBA

A.27.3. Proposed Alternatives

TBA

A.27.4. Experiences with OGC API Specifications

TBA

A.27.5. Other Impressions & Recommendations

TBA

A.28. Helyx SIS

Helyx SIS is a professional services company that specialises in the provision of information management and information exploitation, as well as the provision of geospatial information

services and solutions. Amongst its professional services and on-site support, Helyx also undertakes innovation and applied research for customers.

A.28.1. Motivation to Participate

As well as being an active participant on multiple OGC initiatives, e.g. Testbeds and Pilots, Helyx is also a provider of services to various government departments that are also members of the OGC.

A.28.2. Implemented Solution

Helyx prototyped an implementation of a routing profile of the OGC API - Processes specification. Much of the work going in the hackathon was done as part of the OGC Open Routing API Pilot. This initiative is focused specifically on routing as an application with use cases including online, offline and hybrid connectivity. Additionally, the routing engines in the Pilot are required to support parameters that include; shortest distance, shortest time and algorithms such as the *traveling salesman* problem. The solution provided a good use case of the OGC API specification including contributing to the debate in the WPS SWG, which is concerned with the role of WPS in the OGC API. In addition to the server side solution, Helyx also produced two different clients; a web based JavaScript client and a QGIS Client built using the QGIS plugin architecture.

A.28.3. Proposed Alternatives

No proposed alternatives.

A.28.4. Experiences with OGC API Specifications

Helyx has implemented and used several OGC Services in the web services suite and also have implementations for:

- WFS 3.0
- WPS 3.0 (OGC API)

Our experience with WFS have been largely positive as much of our work has focused on the security aspects of data services. OGC API or WPS has been more challenging as there is a discussion going on within OGC regarding the purpose or utility of the WPS specification. There are currently two schools of thought about WPS within the OGC:

1. Use the OpenAPI specification to do Processing
2. Create a facade within OpenAPI to make processing service *look like* WPS 2.

Each of their approaches have their advantages, option 1 is more flexible, looser and does not impose any well-defined paths or parameters. This means that generic clients are more likely to be able to recognise the *pure* OpenAPI specification. Option 2 is useful as it reflects the calls done as part of WPS 2 and REST bindings can be created accordingly. The trade off between the two has yet to be resolved.

A.28.5. Other Impressions & Recommendations

It appears as though the entire suite of OGC standards will eventually transition to OpenAPI and JSON schemas, although this is far from defined. Perhaps a wider consideration is what this new approach means for architectures in both the OGC overall operating picture and by those utilising GOC standards as part of their own architectures.

A.29. Hexagon

Hexagon is a provider of sensor, software and autonomous solutions that work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications. Hexagon technologies are helping to shape urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future. Hexagon Geospatial creates solutions that visualize location intelligence, bridging the divide between the geospatial and operational worlds.

A.29.1. Motivation to Participate

Hexagon Geospatial has been an active supporter of OGC and OGC standards for many years. Next to implementing a wide range of OGC standards, Hexagon Geospatial have ample experience in applying OGC standards within industry solutions for a variety of domains, such as Aviation, Defense & Intelligence, Maritime, Transportation, Mining or Disaster Management. By being part of many testbeds and interoperability experiments over the past decade and contributing numerous software components and engineering reports, Hexagon Geospatial also learned that cooperation with other people on real-world use cases is an excellent way of testing and improving specifications. Hexagon Geospatial is motivated to share its expertise as a long-term implementer and user to support the advancements of OGC standards related to map tiles, coverages and processes.

A.29.2. Implemented Solution

A desktop Java-based client was implemented by Hexagon Geospatial to experiment with the OGC API - Map Tiles specification. The client retrieved data from the server provided by Esri UK, accessing the maps using the tile-based approach.

Interesting about the client implementation is that it started from `/collections/{collectionId}` and used the provided metadata to look up the appropriate tile matrix set from `/tileMatrixSets/{tileMatrixSetId}`. Now that the tile structure was known, the client used `/collections/{collectionId}/tiles/{styleId}/{tileMatrixSetId}/⋯` to get the actual tile data. Note that the specification was still evolving and there was no `map/` before `{styleId}/` yet.

The implementation showed that the necessary metadata is available to access the map tiles generically.

Figure 14 shows the client accessing a map tiles collection from the server. The tiles are shown in the native CRS of the tile matrix set.

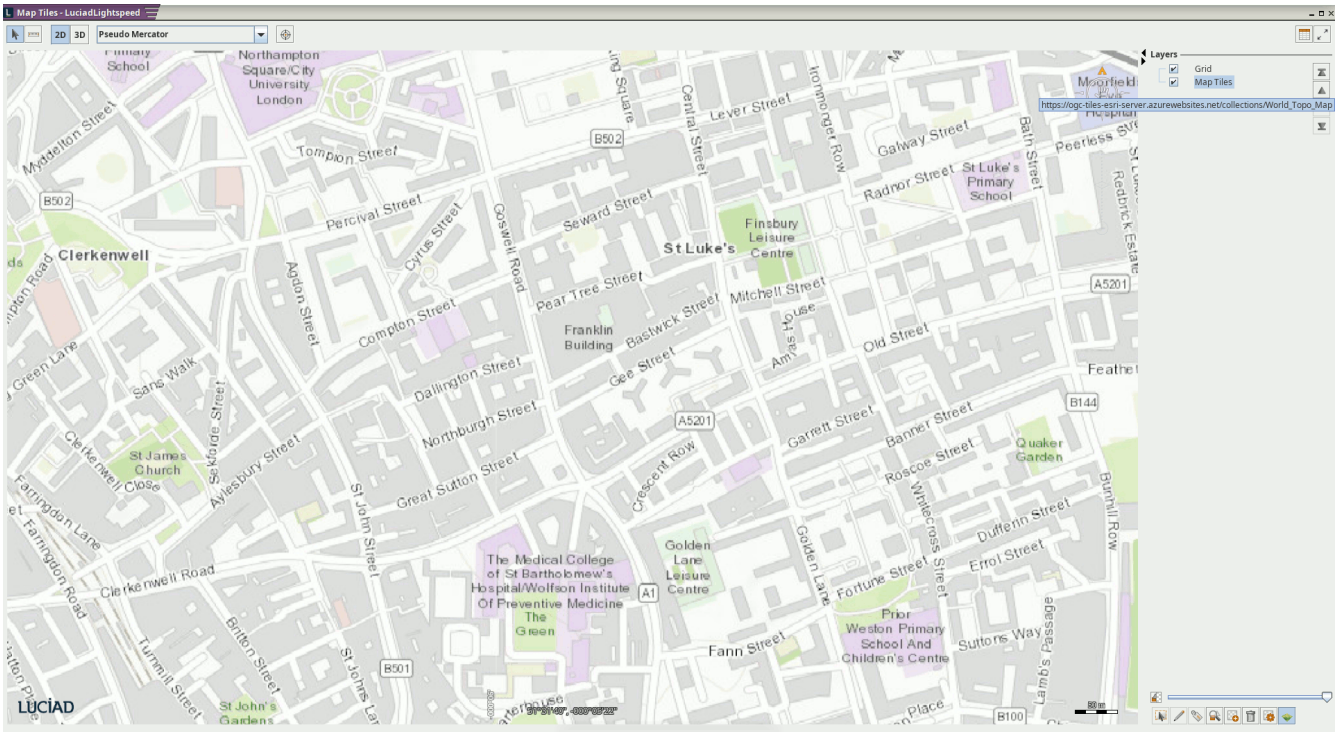

Figure 14. Hexagon client showing map tiles using native CRS of the tile matrix set

Figure 15 shows the client accessing a map tiles collection from the server. The tiles are requested in their native CRS, but reprojected onto a 3D globe.

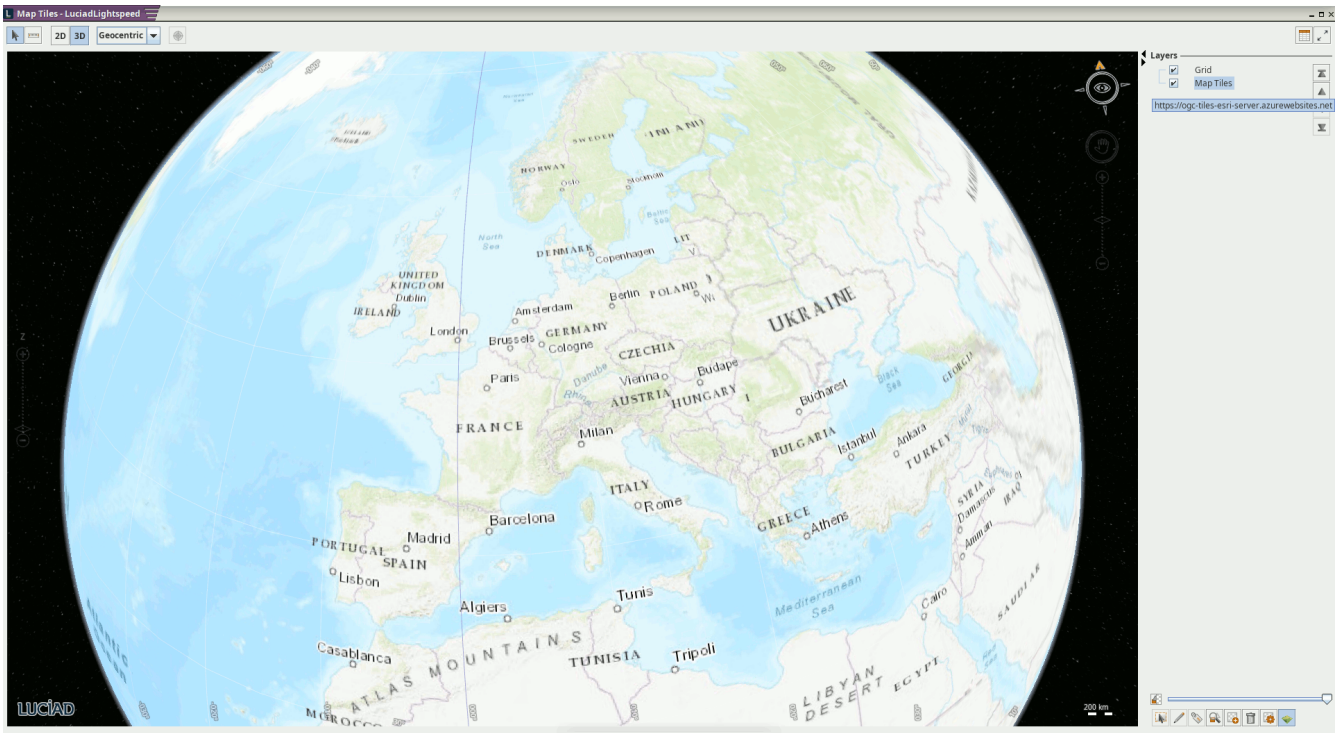

Figure 15. Hexagon client showing map tiles projected onto 3D globe

A.29.3. Proposed Alternatives

A number of questions were raised in relation to consistency and duplication in various parts of the metadata in the API.

Hexagon Geospatial participated in the discussions about composition of the tiling scheme on top of

collections or maps.

It was noted that there seems to be an opportunity for having more concepts in the Common API. Specifically, it seems that *extent* could be included.

When generating a map depicting multiple collections, the request will probably get quite complex. Perhaps it is useful to think of such a map as a composition of multiple single-collection maps. The multiple-collection map request could perhaps refer to multiple single-collection maps?

A.29.4. Experiences with OGC API Specifications

The Hexagon Geospatial product portfolios applied OGC standards from the start and currently implements more than a dozen OGC standards and candidate standards, including implementations of WFS, WMS, WCS, WMTS, WPS, CSW, GeoPackage, Filter Encoding, SLD / SE, GML, KML, 3D Tiles and NetCDF.

A.29.5. Other Impressions & Recommendations

Hexagon Geospatial sees as a positive development that OGC is trying to make the APIs more easily consumable by users. However, and perhaps specifically to the Map Tiles specification, the variety of use cases and access patterns still leads to considerable complexity, for instance by having request parameters related to parts of the URL path.

Hexagon Geospatial believe the hackathon was useful to get a feel for the practicality of the proposed APIs. However, when each group goes off to work on their specification separately, it is easy for the APIs to start diverging. It would be good to have a convergence phase where ideas from the various group are compared and commonalities can be extracted for the Common API.

A.30. Infinity Corporation Limited

TBA

A.30.1. Motivation to Participate

TBA

A.30.2. Implemented Solution

TBA

A.30.3. Proposed Alternatives

TBA

A.30.4. Experiences with OGC API Specifications

TBA

A.30.5. Other Impressions & Recommendations

TBA

A.31. interactive instruments GmbH

interactive instruments has been a strong supporter of the current OGC API activities in OGC and ISO/TC 211 from the beginning. We have also contributed to the W3C/OGC Spatial Data on the Web Best Practices and started developing ldproxy [https://github.com/interactive-instruments/ldproxy] as an open source Web API for feature data based on WFS 2.0 capabilities in 2015 in the Geonovum "Spatial Data on the Web" testbed [http://geo4web-testbed.github.io/topic4/].

Our XtraServer [https://www.interactive-instruments.de/en/xtraserver/] software is an OGC reference implementation for WFS 1.1/2.0, GML 3.2, and WMS 1.1/1.3.

A.31.1. Motivation to Participate

- We are the main editor of "OGC API - Features - Part 1: Core" (formerly known as WFS 3.0). Before the hackathon, most of the open issues raised since the first draft release (April 2018) had been resolved and the draft standard was close to being submitted for approval votes in the OGC and ISO Technical Committees. As the draft of OGC API Common is largely a subset of that draft standard, the OGC members asked OGC to organise the hackathon to verify that the "common" part is extensible for other resource types.
- Build on the good experience with the WFS 3.0 hackathon [http://www.opengeospatial.org/blog/2764] to accelerate specification development with a focus on developer feedback and a "code first" approach.
- Be available for questions on OGC API, in particular OGC API Features.
- Understand and discuss resource types for Maps and Tiles. In OGC Testbed 14 and the OGC Vector Tiles Pilot, experimental extensions have been implemented in ldproxy. This work is continuing in OGC Testbed 15 in the Open Portrayal Framework task [https://portal.opengeospatial.org/files/?artifact_id=82290#Portrayal].
- In ongoing work in the OGC Open Routing API Pilot [https://portal.opengeospatial.org/files/82559] we raised some questions about the approach taken by OGC API Processes (see the draft API documentation [https://app.swaggerhub.com/apis/cportele/wps-routing-api/1.0.0] and the related GitHub issue [https://github.com/opengeospatial/RoutingAPIPilot/issues/1]. The goal was to discuss the topic with developers of OGC API Processes.
- Work on upgrading ldproxy to the latest draft of OGC API Features.

A.31.2. Implemented Solution

At the start of the hackathon ldproxy implemented the first draft release of OGC API Features (draft.1 from April 2018 [https://rawcdn.githack.com/opengeospatial/WFS_FES/3.0.0-draft.1/docs/17-069.html]) plus several extensions (CRS, `/items` path, property selection, geometry simplification, transactions, dynamic links, etc.) as well as other resource types (tiles, styles).

Example services:

- Open Data in North-Rhine Westphalia, Germany [https://www.ldproxy.nrw.de/]
- OGC Vector Tiles Pilot implementation [https://services.interactive-instruments.de/vtp/daraa]

Most of the time at the hackathon has been spent answering questions and discussing various approaches. Some progress was made in updating ldproxy to the latest draft of "OGC API - Features - Part 1: Core". The updates were tested and included in our OGC Testbed 15 implementation [https://services.interactive-instruments.de/t15/daraa].

A.31.3. Proposed Alternatives

Features

Two issues were raised in OGC API Features as a result of discussions at or related to the hackathon.

- FeatureCollection (xml) schema and streaming [https://github.com/opengeospatial/WFS_FES/issues/234]
- Endpoint `/api` missing from OpenAPI specification [https://github.com/opengeospatial/WFS_FES/issues/236]

Both issues were resolved and addressed in the release candidate of OGC API - Features - Part 1: Core [http://docs.opengeospatial.org/DRAFTS/17-069r2.html].

Note that the second issue is relevant for a future OGC API Common.

Common

In the discussions about Common several aspects were raised where coverage collections differ from feature collections. No issues were identified that would require a change in Features, but the specification of the OGC API Common conformance classes will need to take the different resource requirements into account.

Processes

As mentioned in the motivation section, one goal was to discuss the design of OGC API Processes with developers of the specification. The discussion took place on the second day.

The following topics were discussed:

- "Process" and "Job" are not the resources a developer would expect in a dedicated API for a process, for example, a routing API.
- The process description defines an OGC-specific schema language while OpenAPI already uses a schema language (JSON Schema). As a result, a developer has to understand the JSON schema of the OGC-specific schema language first (defined in the OpenAPI definition) to understand the input and output schemas of the routing process (from the response to `/processes/{processId}`).
- This extra layer of information also results in a more complex and verbose representation of a job definition in the OGC API Processes variant.

An important aspect in this is that the OGC API standards are intended to be easier to use (than the current OGC Web Services standards), including for those that are not geo-experts. Web APIs implementing at least the core parts of the OGC API standards should be useable by developers that

are not familiar with OGC standards and that do not have a comprehensive toolset supporting all kinds of OGC standards.

With this in mind, one option for moving WPS into the OGC API family could be to mainly specify guidance and patterns for API building blocks for processing geospatial data. I.e., building blocks how to implement asynchronous or synchronous processes, simple notifications using webhooks, more advanced notifications using MQTT or AsyncAPI, how to specify input and output schemas of processes, etc. Where OpenAPI is used, the inputs and outputs of the processes should be described using JSON Schema.

In the discussion we identified some aspects of the current WPS standard that might also lead to an OGC API standard. For example:

- One of the motivations for the WPS-specific process descriptions was to limit the schema complexity that WPS-implementations have to support. One approach could be to specify a simple JSON Schema profile for OGC API processing resources that would be based on the existing WPS standard. Since this would be an OGC standard, a key part of this would be spatial and temporal components. I.e., existing WPS implementations would become backends for the rapid implementation of processing resources that follow the OGC API guidance.
- Another capability that needs more thoughts is WPS-T, i.e., the capability to deploy new processing resources. With the uptake of virtualization, containerization, cloud infrastructures, etc. it is obvious, however, that this is more a general IT topic than an OGC topic as there is nothing "geospatial" about deploying a new container on a server.

In the discussion there was consensus that such an approach could be a way forward for supporting standards-based processing of geospatial data in Web APIs. It was agreed to continue the discussion in the OGC WPS Standards Working Group.

Catalogues / Records and STAC

A break-out also discussed an OGC API approach for catalogues and records ("CAT4.0") [https://github.com/opengeospatial/CAT4.0]. interactive instruments supports this activity and joined the group working on a charter for such an OGC API standard since it is not restricted to metadata records, but explicitly includes other types of records, too, for example, for publishing code lists.

STAC and OGC API Features started in parallel and aligned common aspects during the WFS 3.0 hackathon [http://www.opengeospatial.org/blog/2764] in March 2018, which was co-located with a STAC sprint and basically a joint event. With part 1 of OGC API Features becoming stable, the focus of the Features group in OGC will move towards commonly requested extensions. Some of those are also under discussion in STAC - and important for the CAT4.0 activity. Examples include more query capabilities and transactions. The goal would be to keep the specifications aligned, where we have the same requirements.

There was agreement in discussions to have a common web-meeting in a few weeks to start the discussion and potentially another joint hackathon/sprint event later.

A.31.4. Experiences with OGC API Specifications

- Main editor of "OGC API - Features - Part 1: Core"

- Co-chair of WFS SWG and the ISO 19168-1 project
- Developer of the ldproxy software
- Use of ldproxy and WFS 3.0 / OGC API in various projects
- Work in OGC initiatives Testbed-14, Vector Tiles Pilot, Testbed-15, Open Routing API Pilot on OGC API / OpenAPI topics
- Use of Swagger (version 2.0) in implementations for several years

A.31.5. Other Impressions & Recommendations

The hackathon was very helpful to broaden the OGC API discussions and to confirm the approach taken by OGC API Features. The event was very well organized and the location was excellent.

Such two or three day implementation-driven "specification sprints" are an excellent mechanism for moving draft OGC standards that follow the same open process as OGC API Features forward.

A.32. ISRIC - World Soil Information

TBA

A.32.1. Motivation to Participate

TBA

A.32.2. Implemented Solution

TBA

A.32.3. Proposed Alternatives

TBA

A.32.4. Experiences with OGC API Specifications

TBA

A.32.5. Other Impressions & Recommendations

TBA

A.33. Jacobs University

The Large-Scale Scientific Information Systems Research Group [https://www.jacobs-university.de/lsis] at Jacobs University [https://www.jacobs-university.de/] is researching on flexible, user-oriented, scalable services on massive multi-dimensional arrays, aka "datacubes". Among its results are 160+ publications [http://kahlua.eecs.jacobs-university.de/~lsis/publications.php] on the topic, the pioneer Array DBMS, rasdaman [http://www.rasdaman.org], and a series of OGC and ISO datacube standards

[http://kahlua.eecs.jacobs-university.de/~lsis/Standards/]; the OGC WCS suite meantime is implemented by a large, growing number of open-source and proprietary raster service tools [http://external.opengeospatial.org/twiki_public/CoveragesDWG/WebHome#Known_Implementations].

A.33.1. Motivation to Participate

Being tightly engaged in coverage standardization since many years it was important to accompany development of new APIs for coverages to ensure proper use of the coverage concept, to contribute an implementation based on rasdaman, and also to give assistance to other implementers in coverage concepts.

A.33.2. Implemented Solution

The rasdaman engine, which suppors GET/KVP, POST/XML, and SOAP protocol bindings for coverage services, was extended with an experimental facade translating OpenAPI requests into standard WCS requests.

A.33.3. Proposed Alternatives

No alternatives are proposed, but more rigorous definitions are strongly encouraged, also to spot and resolve current issues - see below for details.

A.33.4. Experiences with OGC API Specifications

OpenAPI, as used by OGC, represents a minimalistic style aiming at providing all functionality squeezed into URL syntax. Naturally, there are strong limitations in expressiveness and syntactic elegance. Additionally, even basic concepts are not defined clearly, see issues in the OAPI Coverages repo [https://github.com/opengeospatial/ogc_api_coverages]:

- 1 [https://github.com/opengeospatial/ogc_api_coverages/issues/1]: OpenAPI basics: what does "/" mean? (closed while not resolved),
- 3 [https://github.com/opengeospatial/ogc_api_coverages/issues/3]: Path syntax (closed while not resolved)
- 19 [https://github.com/opengeospatial/ogc_api_coverages/issues/19]: identifier syntax for OAPI Common

Additional issues include

- Ontology links, CRSs as per OGC-NA and other objects are usually expressed as URLs, too. Using them - i.e., "URL in URL" - is awkward. Not co tonsider "URL in RUL in RUL" for which there are use cases indeed.
- mixed use of path components - in the URL /collections/{collectionId}/coverages/{coverageID}/rangetype the path component "collections" is a fixed keyword; "{collectionid} is an identifier in the service offering, whereby the pair "collection and "collectionid" always must appear (i) at that position in the path and (ii) in that sequence; "rangeType" is a function that extracts part of a coverage. Hence, a path component can be a keyword, an identifier, or a function. In case of a function, in the case of "rangetype" the function input is the left-hand side, but it is not clear that this is always so. Additional parameters are only possible in the query part, and this query part constitutes one single pool of arguments where it needs extra effort to disentangle what parameter belongs to what

function.

- there is a one-level collection concept, ie: every service must offer a collection of items, which cannot contain other collections. It remains unclear why variable-depth collections are not supported (although they have been discussed).
- Harmonization is addressed explicitly by bringing four important groups together, which is a precious step. However, currently this is more on syntactic level than on the semantics. Example: OpenAPI Features insist on keeping their coordinate lists which maintains the old, well-known problem of coordinate ambiguity and subsequent discussions about x/y versus y/x sequence; this bad practice is continued with height/depth now: h/x/y versus x/y/h etc. The OGC coverage standards do not have this problem because with each coordinate the axis is mentioned explicitly, hence despite arbitrary sequence of th parameters the semantics always is unambiguous. Further, Features continue separate treatment - syntactically and semantically - of (horizontal) space and time, bypassing the experience in spatio-temporal handling in Coverages.

A.33.5. Other Impressions & Recommendations

It is strongly recommended to pursue two "housekeeping" tasks before groups may have established their own interpretations:

- establish a clear correspondence between WCS Core and additionally all extensions (discussion has started about range subetting, for example). This will constitute an easy guidance on how to proceed with considering further functionality, as well as the mechanics of each functionality (which has been elaborated over 10+ years by coverage stakeholders from all sort of domains), and (iii) speed up implementation as service implementers just need to provide facades to their existing frontends, rather than establishing a parallel silo.
- establish a clear semantics for the basics of OpenAPI use in OGC - a task for OpenAPI Common, actually.

A.34. Jet Propulsion Laboratory

TBA

A.34.1. Motivation to Participate

TBA

A.34.2. Implemented Solution

TBA

A.34.3. Proposed Alternatives

TBA

A.34.4. Experiences with OGC API Specifications

TBA

A.34.5. Other Impressions & Recommendations

TBA

A.35. JRC, European Commission

TBA

A.35.1. Motivation to Participate

TBA

A.35.2. Implemented Solution

TBA

A.35.3. Proposed Alternatives

TBA

A.35.4. Experiences with OGC API Specifications

TBA

A.35.5. Other Impressions & Recommendations

TBA

A.36. Landcare Research, New Zealand

TBA

A.36.1. Motivation to Participate

TBA

A.36.2. Implemented Solution

TBA

A.36.3. Proposed Alternatives

TBA

A.36.4. Experiences with OGC API Specifications

TBA

A.36.5. Other Impressions & Recommendations

TBA

A.37. Land Information New Zealand

TBA

A.37.1. Motivation to Participate

TBA

A.37.2. Implemented Solution

TBA

A.37.3. Proposed Alternatives

TBA

A.37.4. Experiences with OGC API Specifications

TBA

A.37.5. Other Impressions & Recommendations

TBA

A.38. lat/lon GmbH

lat/lon GmbH has provided services in the field of space-related and state-of-the-art internet-supported information systems for more than 10 years. The services range from software development and consulting to training and workshops. An interdisciplinary team consisting of geographers, computer scientists, and management scientists links the technical know-how to the necessary and creative experience. lat/lon GmbH has been a member of the OGC from the beginning and is actively involved in the development of spatial data infrastructures in the local sector, for example, at a state level or a federal level. The aspiration of lat/lon GmbH is a coherent and interoperable infrastructure for the administration and exchange of spatial data and information.

A.38.1. Motivation to Participate

lat/lon GmbH is involved in the OGC Compliance and Interoperability Testing (CITE) program, in the capacity of "Lead Compliance Tools". Thus, there is a high interest in advancing the OGC test suites

to be capable of testing the different OGC API specifications. During OGC Testbed-14, lat/lon GmbH developed a WFS 3.0, now called "OGC API - Features", test suite. This test suite represents a good base for other OGC API test suites. So, one major motivation is to investigate and evaluate the need for and technical preconditions of other OGC API test suites. Also, lat/lon GmbH is interested in whether there is demand for an executable test suite for the OGC API - Common specification and whether the WFS 3.0 test suite can be used as a base for a test suite based on the OGC API - Common specification.

In general, lat/lon GmbH is highly interested in further development of all OGC API specifications and provides input to discussions e.g. through GitHub issue trackers.

A.38.2. Implemented Solution

lat/lon GmbH advanced the OGC WFS 3.0 test suite [https://github.com/opengeospatial/ets-wfs30], now "OGC API - Features", by working on open bugs and tasks. Also, the test suite was used by other participants to evaluate other participant's service implementations and to find weaknesses in the test suite itself.

A.38.3. Proposed Alternatives

There were discussions trying to answer the question about technical preconditions of other OGC API test suites. Also, the need for an OGC API Common test suite was discussed [https://github.com/opengeospatial/ets-wfs30/issues/67].

A.38.4. Experiences with OGC API Specifications

As OGC API specifications are closer to well-known IT standards, it is easier for non-geospatial developers to understand and work with the APIs. In addition, the JSON and HTML encodings enable users with less advanced technical skills to use the APIs. Especially, the HTML encoding might become interesting for non-technical users enabling even more users to work with OGC APIs.

A.38.5. Other Impressions & Recommendations

The atmosphere at OGC API Hackathon was very friendly leading to productive work. Especially, the discussions about OGC API - Common and at which degree common content might be shared between all OGC API specifications helped a lot to generate a common understanding of OGC APIs and to bring all specifications forward. This hopefully leads to homogeneous OGC API specifications following the same pattern.

Thus, the hackathon was very helpful at this early stage as it will have an impact on specifications itself. Future hackathons might help to continue creating homogeneous specifications already proven in practice.

A.39. Meteorological Service of Canada

The Meteorological Service of Canada (MSC) is the national meteorological agency of Canada. It is a division of Environment and Climate Change Canada. The MSC primarily provides public meteorological information, weather forecasts, and warnings of severe weather and other

environmental hazards.

A.39.1. Motivation to Participate

TBA

A.39.2. Implemented Solution

The MSC implemented and deployed an instance of pygeoapi - a Python server implementation of the emerging OGC API specifications. A screenshot of the landing page of the deployed service is shown in Figure 16. The software was configured to offer an interface that conforms to the OGC API - Features and OGC API - Processes specifications.

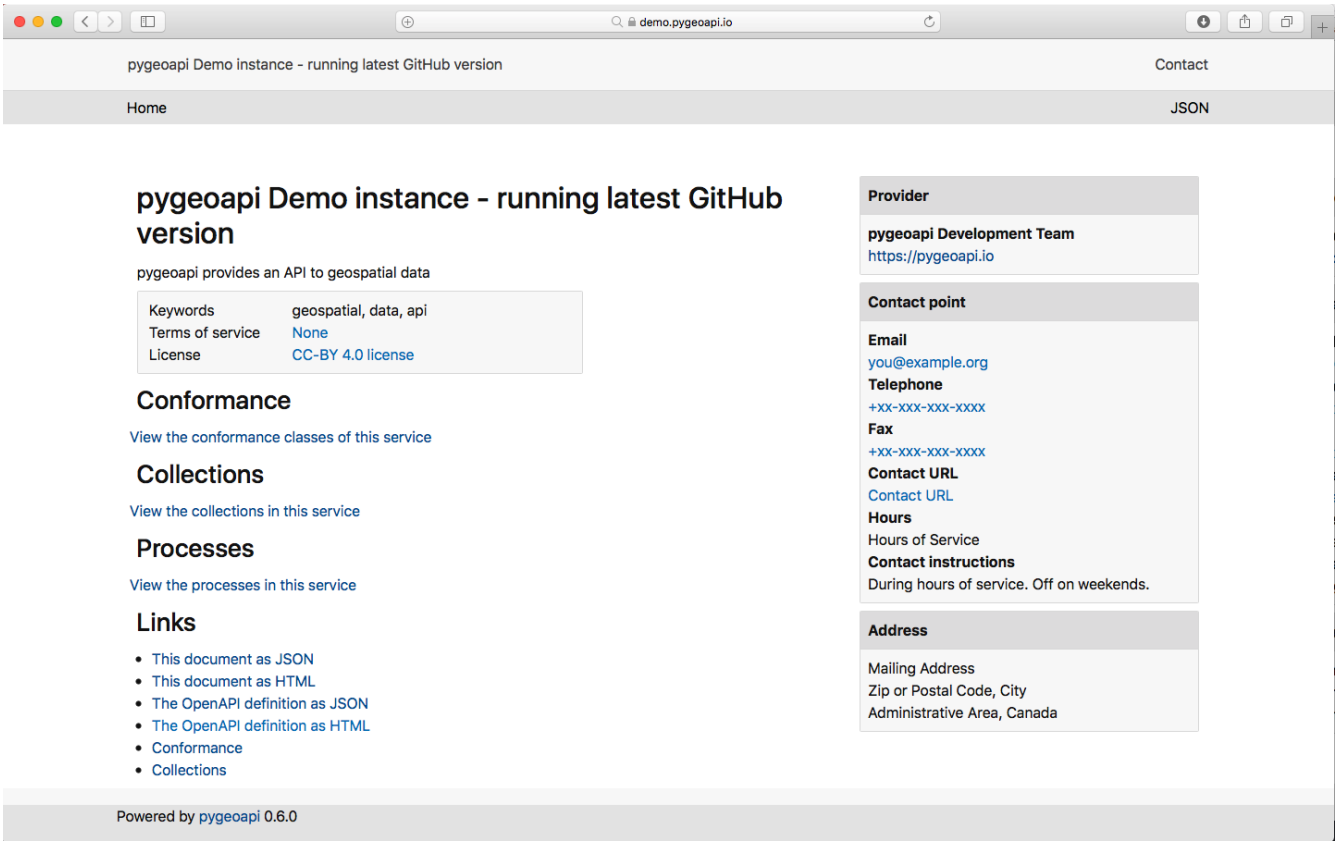

Figure 16. The landing page of the pygeoapi instance deployed by the Meteorological Service of Canada

A screenshot of the OpenAPI page of the deployed service is shown in Figure 17.

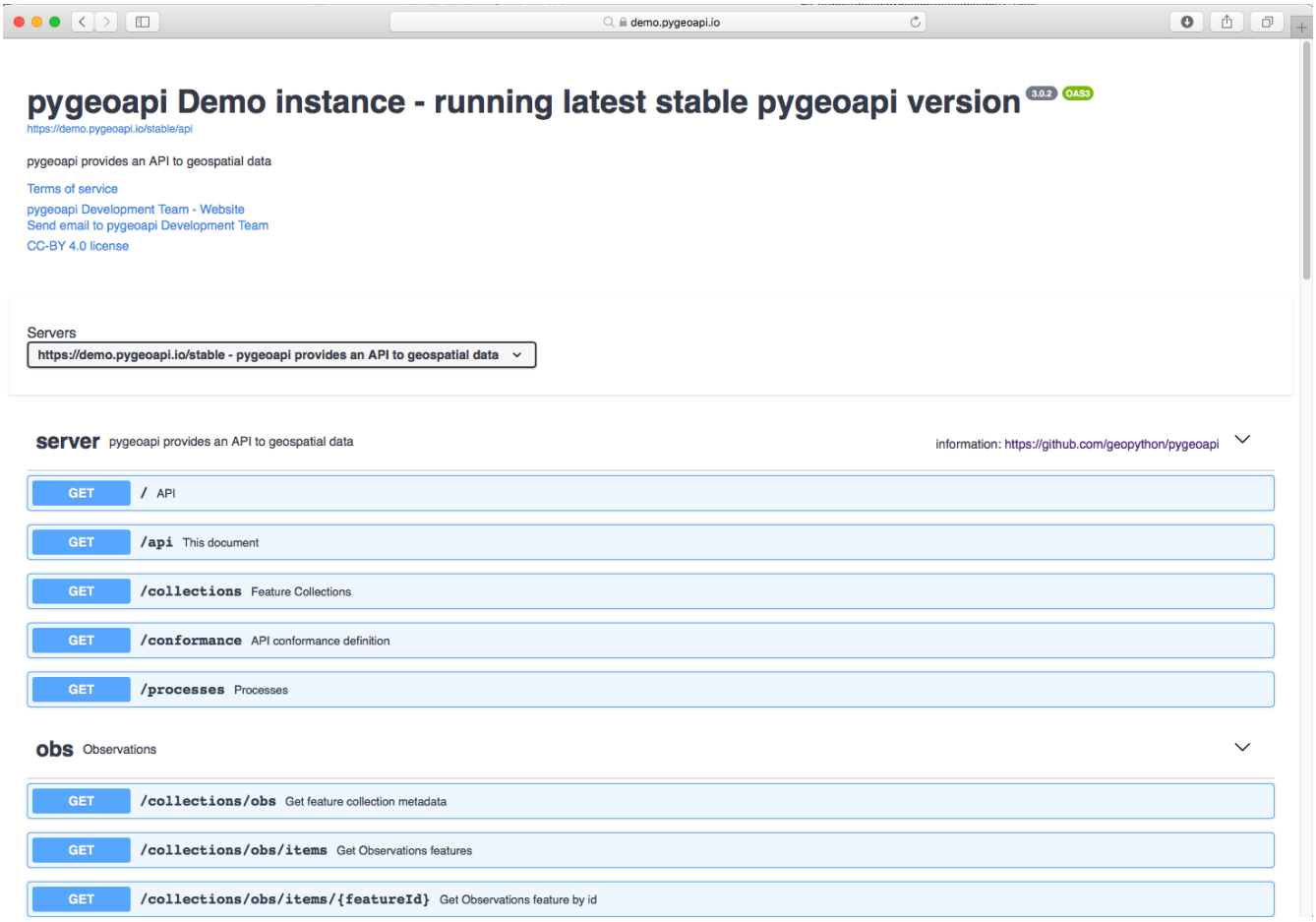

Figure 17. The OpenAPI definition of the pygeoapi instance deployed by the Meteorological Service of Canada

A.39.3. Proposed Alternatives

TBA

A.39.4. Experiences with OGC API Specifications

TBA

A.39.5. Other Impressions & Recommendations

TBA

A.40. Met Office

The Met Office is the national meteorological service for the United Kingdom. It produces both daily weather forecasts and long term climate predictions as well as performing fundamental science. It also runs several forecasting services for oceanography. Its customers cover a wide range of domains, such as aviation, defence, public sector, marine, private industry, media.

It has been an active Member of OGC since 2009, and, along with several other national meteorological services, founded the OGC Met-Ocean Domain Working Group and initiated a Memorandum of Understanding between OGC and the World Meteorological Organisation (WMO). WMO is the United Nations international treaty organisation that coordinates 193 national

hydrometeorological services. It also defines international standards for meteorology, hydrology and oceanography.

The Met Office is also active in the World Wide Web Consortium (W3C) standards development organisation.

A.40.1. Motivation to Participate

Meteorology has had a long tradition of inventing and using technologies for its specific and very demanding requirements. As weather and climate information become ever more important to many aspects of society, it has become increasingly important to make information available using widespread technologies and approaches. It is envisaged that using OpenAPI version 3 for defining public and private APIs to Met Office data and information will have many benefits, for both customers and Met Office infrastructure, especially when supporting services from computing clouds. The Met Office would like the APIs to be consistent with, and conformant to, any OGC OpenAPI standards.

A.40.2. Implemented Solution

Weather on the Web [https://github.com/opengeospatial/weather-on-the-web] (WotW) is an initiative to agree APIs for common data retrieval patterns, such as points, time-series, polygons, and trajectories, in 2, 3 and 4 Dimensions. The intent is to make it a global standard for meteorological and environmental services.

Point Data has been working for some time, as have Time-series at a point, and Polygons. Trajectories and Data Tiles are being developed.

A.40.3. Proposed Alternatives

Fall-back is to develop our meteorological APIs separately from the OGC proposals and standardise through WMO, though this will be much slower.

A.40.4. Experiences with OGC API Specifications

A Hackathon was held in December 2018 in Washington DC, USA, building on the OGC WFS3.0 specification. Servers and clients based on existing WFS software were readily developed. Agreement was reached on the initial data retrieval patterns to support: point, timeseries, etc..

A.40.5. Other Impressions & Recommendations

In the WFS3.0 spec, /Items/ needs to be replaced by 'point', 'timeseries', trajectory', etc. This is consistent with the approach advocated by Joan Maso for maps and tiles.

A.41. National Aeronautics and Space Administration (NASA)

TBA

A.41.1. Motivation to Participate

TBA

A.41.2. Implemented Solution

TBA

A.41.3. Proposed Alternatives

TBA

A.41.4. Experiences with OGC API Specifications

TBA

A.41.5. Other Impressions & Recommendations

TBA

A.42. National Land Survey of Finland

TBA

A.42.1. Motivation to Participate

TBA

A.42.2. Implemented Solution

TBA

A.42.3. Proposed Alternatives

TBA

A.42.4. Experiences with OGC API Specifications

TBA

A.42.5. Other Impressions & Recommendations

TBA

A.43. Natural Resources Canada

TBA

A.43.1. Motivation to Participate

TBA

A.43.2. Implemented Solution

TBA

A.43.3. Proposed Alternatives

TBA

A.43.4. Experiences with OGC API Specifications

TBA

A.43.5. Other Impressions & Recommendations

TBA

A.44. U.S. National Geospatial-Intelligence Agency, GEOINT Services, Mobile Apps

Developers

Brian Osborn [https://github.com/bosborn], CACI-BITS [http://www.caci.com/bit-systems/]

Author of NGA's published open source GeoPackage [https://ngageoint.github.io/GeoPackage/] libraries used in NGA mobile applications

Robert St. John [https://github.com/restjohn], CACI-BITS [http://www.caci.com/bit-systems/]

Developer on NGA's open source MAGE [https://github.com/ngageoint/MAGE] mobile, server, and web applications

A.44.1. Motivation to Participate

- Assess the feasibility of implementing OGC's new OpenAPI-based Features API as native operations in the MAGE server to expose MAGE data through a standard, interoperable API.
- Assess the feasibility of implementing a consumer of OGC's new OpenAPI-based Features API that can build GeoPackages using standard feature data from multiple different services for offline use in MAGE and any other offline-capable mobile app.

A.44.2. Implemented Solution

- MAGE server OGC API - Features [https://github.com/ngageoint/mage-server/tree/wfs3]
- OGC API Features JSON [https://github.com/ngageoint/ogc-api-features-json-java]
  - Extends Simple Features GeoJSON [https://github.com/ngageoint/simple-features-geojson-java/tree/develop]

- GeoPackage Feature generator
  - GeoPackage Core [https://github.com/ngageoint/geopackage-core-java/tree/develop/src/main/java/mil/nga/geopackage/features]
  - GeoPackage Java [https://github.com/ngageoint/geopackage-java/tree/develop/src/main/java/mil/nga/geopackage/features]
  - GeoPackage Android [https://github.com/ngageoint/geopackage-android/tree/develop/geopackage-sdk/src/main/java/mil/nga/geopackage/features]

A.44.3. Proposed Alternatives

- None

A.44.4. Experiences with OGC API Specifications

- The OGC API - Features repository [https://github.com/opengeospatial/WFS_FES] reuse of the Simple Features specification [https://www.opengeospatial.org/standards/sfa] was helpful.

A.44.5. Other Impressions & Recommendations

All of the following are based on reading http://docs.opengeospatial.org/DRAFTS/17-069r2.html.

- Keep the OGC API - Features [https://github.com/opengeospatial/WFS_FES] repository up to date, including
  - the SwaggerHub [https://app.swaggerhub.com/apis/cholmesgeo/WFS3/M1] referenced from the README [https://github.com/opengeospatial/WFS_FES/blob/master/README.md#using-the-standard]
  - the local yaml [https://github.com/opengeospatial/WFS_FES/blob/master/openapi.yaml] documents
- Improve the documentation on CRS extension usage
- Validate the referenced implementations [https://github.com/opengeospatial/WFS_FES/blob/master/implementations.md] against the current specification
- Update Simple Feature references to refer to Simple Feature Access - Part 1: Common Architecture [https://www.opengeospatial.org/standards/sfa], version 1.2.1, document 06-103r4 [http://portal.opengeospatial.org/files/?artifact_id=25355]
- Consider requiring *XML syntax for HTML* [https://www.w3.org/TR/html5/introduction.html#html-vs-xhtml] for HTML conformance, which implies all HTML documents are well-formed.
  - makes the document more machine-friendly without sacrificing human-readability
  - makes the document easier to consume for dynamic/generic clients using widely available XML libraries instead of more lax, HTML-specific libraries with HTML's specific parsing requirements
  - facilitates HTTP/1.1 agent-driven negotiation for non-user-facing clients whose initial request to a service returns an HTML response
  - enables the use of XPath and XSLT on HTML documents
- Section 5.5.3 [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#_references_to_openapi_components_in_normative_statements]: core response requirements defined

using OpenAPI JSON Schema fragments imply a response media type of `application/json`. Is this actually the requirement? Either way, this requires more specific explanation.

- Section 7.2.2 [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#_response], landing page response:
  - Is the core requirement for the landing page to return JSON by default?
  - If following RFC 8288, the link relation types `conformance` and `data` should be URIs, according to RFC 8288, section 2.1.2 [https://tools.ietf.org/html/rfc8288#section-2.1.2], because they are "extension" link types that do not appear in the IANA Registry [https://www.iana.org/assignments/link-relations/link-relations.xhtml].
- section 7.4 [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#_declaration_of_conformance_classes]: Ostensibly, the response for the `/conformance` path must be a JSON document, but the language in the spec is not clear. Is that the case? If so, the requirements should state the required `Content-Type` of the response is `application/json` and the JSON document must be valid with respect to the OpenAPI JSON Schema [https://raw.githubusercontent.com/opengeospatial/WFS_FES/master/core/openapi/schemas/conf-classes.yaml].
- Section 7.9 [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#encodings]: another reference to content negotiation as defined by HTTP/1.1. HTTP/1.1 content negotiation is quite abstract without many concrete requirements. The *NOTE* at the end of the section gives the `accept` and `f` query parameters as examples, but not requirements. See below.
- Require specific attributes on HTML links so a dynamic client can easily parse and inspect them, and to enable automated testing of the HTML conformance class rather than having to "Manually inspect the document against the schema." [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#_html_content] Some ideas for HTML `link` and `a` tags are below.
  - Require the `rel` attribute to include the relationship types the spec defines.
  - Require the `type` attribute to specify the media type of the target link.
  - Perhaps require the `class` attribute to include a meaningful marker, such as ogc:api.
  - If other link attributes are necessary, the spec could define data tag requirements.
  - See HTML5 Extensibility [https://www.w3.org/TR/html5/introduction.html#design-notes-extensibility]
- Roy Fielding's ReST, 6.3.2.7 Content Negotiation [https://www.ics.uci.edu/~fielding/pubs/dissertation/evaluation.htm#sec_6_3_2_7]

Content Negotiation

During the hackathon, we had some issues developing the *OGC API - Features* client against the available services relating to content negotiation. We observed that many of the OGCAF service implementations used at the hackathon relied on the `f=json` query parameter to return GeoJSON to the client, while the value in the `Accept` request header had no effect. This is presumably due to the note block in section 7.9 [https://www.kalea.at/en/news-en/out-now-german-bier-box-xxl/] and some example snippets [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#example_12] in the OGCAF draft spec document using that parameter as a strategy for content negotiation. However, that parameter is not a formal requirement or recommendation anywhere in the specification.

There are several points in the spec document that reference HTTP content negotiation to determine the format of the response as described in the HTTP/1.1 spec [https://tools.ietf.org/html/rfc2616#section-12]. Requirement req/core/http [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#

_http_1_1], and section 7.9 [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#encodings] states that `req/core/http` implies server implementations must support content negotiation as the HTTP/1.1 spec defines. Unfortunately, while the HTTP/1.1 spec describes the options of server-driven and agent-driven negotiation, requirements for implementing both types of negotiation are open-ended, leaving many details to individual implementations.

The OGCAF Core conformance class could simplify client development by defining concrete requirements for content negotiation. For example, all server implementations must use a `format` query parameter whose value is a media type string or media type short alias, such as `format=json`. This would be the implementation of server-driven negotiation.

For agent-driven negotiation, the OGCAF Core could include a requirement that all resources with `alternate` links to other representations must include those `alternate` links in the `Link` response header and must include the link `type` attribute, per RFC 8288 [https://tools.ietf.org/html/rfc8288#section-3]. This is a formal recommendation [http://docs.opengeospatial.org/DRAFTS/17-069r2.html#_link_headers] in the OGCAF spec at the time of this writing, but includes wording that invalidates the recommendation under certain circumstances. For the specific purpose of `alternate` links of the context resource, the `Link` header should be a requirement so generic clients can have concrete expectations to negotiate the content types they support. This would also allow clients to obtain the `alternate` links with a `HEAD` request as opposed to a more expensive `GET` request.

Missing `DescribeFeatureType`

While developing the OGCAF client at the Hackathon, we questioned the lack of a `DescribeFeatureType` operation in OGCAF analogous to that of WFS 2. Our use case was to request OGCAF features to import them into GeoPackage feature tables. The initial concept assumed the client would request information on the type of features in a feature collection to setup the database schema in a GeoPackage before beginning to import the features themselves to the tables. Without an explicit `DescribeFeatureType` operation to describe the feature structure, the solution was to build the schema on-the-fly as the client encountered features and their properties, which required quite complex transactions in the context of a GeoPackage relational database.

Our server implementation took the approach of specialized schema components in the OpenAPI document for each collection. That produced quite an unwieldy OpenAPI document and could make the data model more difficult for generic clients to construct.

We observed that this is an open issue [https://github.com/opengeospatial/WFS_FES/issues/56]. There are as some comments [https://github.com/opengeospatial/WFS_FES/issues/56#issuecomment-371191281] on the issue that reflect the problems in our server implementation's OpenAPI document. The discussion on the issue appears to have led to the conclusion that some `DescribeFeatureType` operation should be part of the OGCAF Core spec, and we agree.

A.45. NOAA/NWS

TBA

A.45.1. Motivation to Participate

TBA

A.45.2. Implemented Solution

TBA

A.45.3. Proposed Alternatives

TBA

A.45.4. Experiences with OGC API Specifications

TBA

A.45.5. Other Impressions & Recommendations

TBA

A.46. OSGeo

The Open Source Geospatial Foundation (OSGeo) is a not-for-profit organization whose mission is to foster global adoption of open geospatial technology by being an inclusive software foundation devoted to an open philosophy and participatory community driven development.

A.46.1. Motivation to Participate

OSGeo projects [https://www.osgeo.org/projects] have a long history of implementing OGC standards. Examples include (but are not limited to) PostGIS, QGIS, MapServer, GeoServer and many others.

The recent efforts around modernizing the OGC API standards provide opportunities for any project to implement OGC standards with a lower barrier to entry. In addition, the clean break approach provides opportunity to streamline codebases and implementations with less dependencies. Finally, OSGeo projects already provide reference implementations for numerous OGC standards. Participating at early stages of specification development allows for testing of approaches as well as leading the initial support of the standards into the FOSS4G community ecosystem.

A.46.2. Implemented Solution

The below provides a summary of participating projects:

- pycsw
  - meetings on CAT 4.0
  - CAT 4.0 SWG will be created at OGC TC next week (Leuven)
  - pycsw 3 will be the LTR for CSW 2/3
  - pycsw 4 will align with CAT 4.0
  - discussions / testing on whether pycsw 4 is built with pygeoapi underneath with addition of full search conformance class

- pygeoapi
  - continued implementation of WPS REST binding (jobs, results)
  - implementation of process manager to support asynchronous processing and job storage
  - write documentation
- ZOO-Project:
  - test implementation available at https://demo.mapmint.com/WPS3/
  - Swagger-ui demonstration available at https://demo.mapmint.com/swagger-ui/dist/
  - Demo UI using both pygeoapi demo server (https://demo.pygeoapi.io/master/) and, ZOO-Project test implementation server for processing, avallable at https://demo.mapmint.com/examples3/spatialtools.html (based on old code from https://zoo-project.org)
  - Sample execute requests for using Orfeo ToolBox BandMath application using wps-rest-api available at http://www.zoo-project.org/trac/wiki/OGC_Hackathon_2019
- EOxServer:
  - Very basic OGC API - Coverages implementation available at https://ows.eox.at/openapi/oapi/
  - Good discussion and progress on OGC API - Coverages in general

A.46.3. Proposed Alternatives

TBA

A.46.4. Experiences with OGC API Specifications

The abovementioned projects (as well as others) are already implementing the OGC API Specifications and are actively participating in discussions to address gaps and improvements. Making the specification development process openly available on GitHub (as well as Gitter for chat) provides more opportunities for non-OGC members to provide input/feedback.

A.46.5. Other Impressions & Recommendations

It is recommended to hold similar Hackathon events more regularly given the synergies and progress made during such a focused event. It is also recommended for Hackathons to be longer than 2 days in duration which may result in increased participation so as to justify travel.

A.47. Princeton University

TBA

A.47.1. Motivation to Participate

TBA

A.47.2. Implemented Solution

TBA

A.47.3. Proposed Alternatives

TBA

A.47.4. Experiences with OGC API Specifications

TBA

A.47.5. Other Impressions & Recommendations

TBA

A.48. Princeton University Library

TBA

A.48.1. Motivation to Participate

TBA

A.48.2. Implemented Solution

TBA

A.48.3. Proposed Alternatives

TBA

A.48.4. Experiences with OGC API Specifications

TBA

A.48.5. Other Impressions & Recommendations

TBA

A.49. Quick Caption

TBA

A.49.1. Motivation to Participate

TBA

A.49.2. Implemented Solution

TBA

A.49.3. Proposed Alternatives

TBA

A.49.4. Experiences with OGC API Specifications

TBA

A.49.5. Other Impressions & Recommendations

TBA

A.50. Secure Dimensions

TBA

A.50.1. Motivation to Participate

TBA

A.50.2. Implemented Solution

TBA

A.50.3. Proposed Alternatives

TBA

A.50.4. Experiences with OGC API Specifications

TBA

A.50.5. Other Impressions & Recommendations

TBA

A.51. SigmaBravo

Sigma Bravo is a specialist provider of ICT services focused specifically on military operations. We enable and support an integrated, informed and agile 5th generation force.

A.51.1. Motivation to Participate

Sigma Bravo has a strong support of open standards as a path to interoperability. We recognise the value of simple, implementer-friendly standards.

A.51.2. Implemented Solution

Sigma Bravo extended the OpenSphere web application to support OGC API - Features and OGC API - Map Tiles. Interoperability with GeoServer, pygeoapi and SpaceBel OGC API - Features servers was demonstrated. Interoperability with ESRI OGC API - Map Tiles was also demonstrated.

A.51.3. Experiences with OGC API Specifications

Sigma Bravo has significant experience with previous OGC Specifications, particulary on GeoPackage. The most mature part of our OGC API implementation is OGC API - Features.

A.51.4. Other Impressions & Recommendations

Sigma Bravo commends the OGC on the OGC API program of work, and thanks OGC staff and GeoVation for their work in organising and hosting the hackathon. Sigma Bravo recommends that OGC seek to mature the OGC API standards through ongoing engagement and outreach activities, development of comprehensive Executable Test Suites and ongoing "in the open" standards development.

A.52. Sinergise

Sinergise is a GIS company building large turn-key geospatial systems in the fields of cloud GIS, agriculture and real-estate administration. One of the Sinergise's disruptive technologies is Sentinel Hub (https://sentinel-hub.com/), which enables real-time visualisation of multi-spectral data and supports building new earth-observation products, such as vegetation indices, in a matter of seconds.

A.52.1. Motivation to Participate

Motivation to participate was to assess possibility of using the new OGC API for Sinergise products and services and to contribute feedback to standards body.

A.52.2. Implemented Solution

We have implemented a frontend client which connects to two different backends and displays data, obtained via OGC Coverages API, on the map. Client is available at http://webdev.sentinel-hub.com/ogc-hackathon/index.html (view source for additional info). At the time of this writing one of the backends is not available, so we have updated the example so that it still loads after timeout.

A.52.3. Proposed Alternatives

None.

A.52.4. Experiences with OGC API Specifications

Sinergise is using OGC WMS, WCS and WFS in production systems. There are some limitations in the existing standards so we welcome development of better alternatives.

A.52.5. Other Impressions & Recommendations

Recommendations were submitted during hackathon sessions via tickets.

A.53. Solenix

TBA

A.53.1. Motivation to Participate

TBA

A.53.2. Implemented Solution

TBA

A.53.3. Proposed Alternatives

TBA

A.53.4. Experiences with OGC API Specifications

TBA

A.53.5. Other Impressions & Recommendations

TBA

A.54. Spacebel

A.54.1. Motivation to Participate

Spacebel was present in London to participate to the OGC API for Processes activities contributing an OGC API Processes implementation (Proxy).

In addition, Spacebel participated remotely on behalf of the H2020 DataBio project [https://www.databio.eu/en/] contributing a Catalog Server implementation hosting application and collection metadata from the DataBio Hub (https://www.databiohub.eu/registry/) aiming to improve alignment of the DataBio catalog and Hub implementation with the OGC API Common specification in addition to the Testbed-15 EOPAD discovery approach.

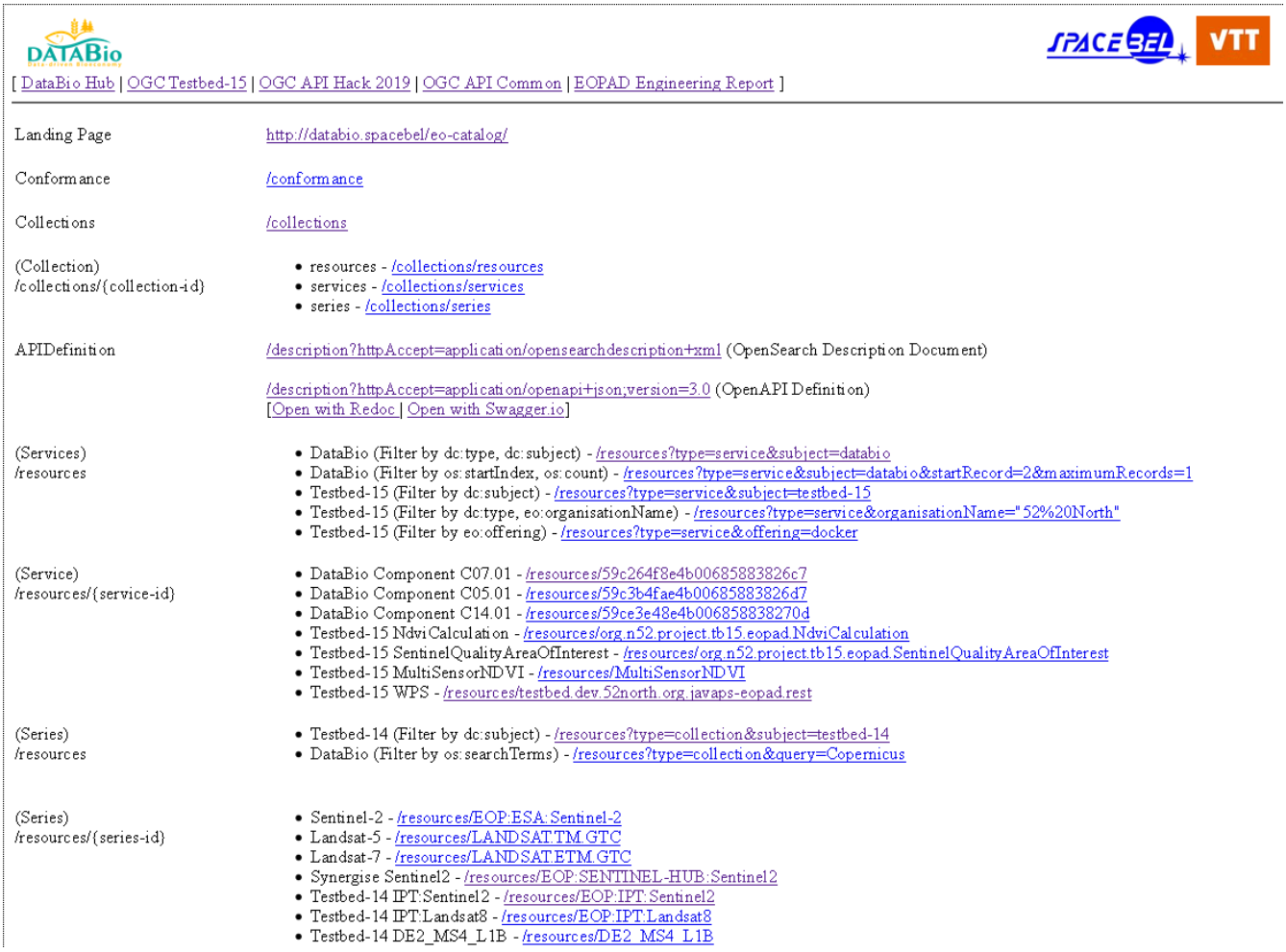

Figure 18. DataBio Catalog Server test page

A.54.2. Implemented Solution

(1) DataBio Catalog Server (https://databio.spacebel.be/eo-catalog/readme.html) hosting EO applications and services (OGC 19-020), EO collections (OGC 17-084) and EO product (OGC 17-003) metadata implementing OpenSearch (OGC 10-032r8 and OGC 13-026r8) and Open API Common interfaces. Resources `/`, `/conformance`, `/collections` were implemented and interoperability was demonstrated through TIE testing with the OpenSphere client [http://frozen-lime.surge.sh/] implementing OGC API Features provided by another participant. A `limit` parameter needed to be added server-side in addition to the `maximumRecords` parameter (which was used to comply with OASIS searchRetrieve (SRU) specifications) which was originally mapped on `{count}`.

(2) Web Processing Service (http://34.77.240.214/ades-proxy/swagger-ui/index.html) with a OGC API for Processes as defined in OGC Testbed 14 (https://raw.githubusercontent.com/spacebel/testbed14/master/json-spec/wps-t_tb14_spacebel-v1.6.yaml), including the Transactional and the Quoting & Billing extensions. Resources `/`, `/conformance`, `/processes`, `/jobs`were implemented and interoperability was shown through TIE testing with the Solenix client.

A.54.3. Proposed Alternatives

The Catalog Server combines an OpenSearch interface with GeoJSON responses (OGC 13-026r8, OGC 17-047) for simple clients and a more advanced OpenAPI-based interface.

A.54.4. Experiences with OGC API Specifications

Spacebel has experience with Swagger and OpenAPI since 2016 and already used this technology in previous OGC Testbeds.

OGC API Common

Wrapping an OpenSearch compliant catalog with an OGC API Common interface was achieved as part of the hackaton. Extending the interface to OGC API Features (mainly temporal and geograpical searches) is future work.

The main issue encountered was to define what /collections (which has a fixed response) format might return in the case of an OpenSearch catalog hosting EO application and service metadata, EO collection metadata and EO product metadata simultaneously. The proposed approach can be seen at https://databio.spacebel.be/eo-catalog/collections. The hyperlinks included in this response allow to refer directly to an OpenSearch OSDD (rel="search") and to the applicable JSON Schemas (rel="describedby").

The figure below shows that service and application data could be sucessfully discovered via the OpenSphere client accessing the DataBio Catalog Server.

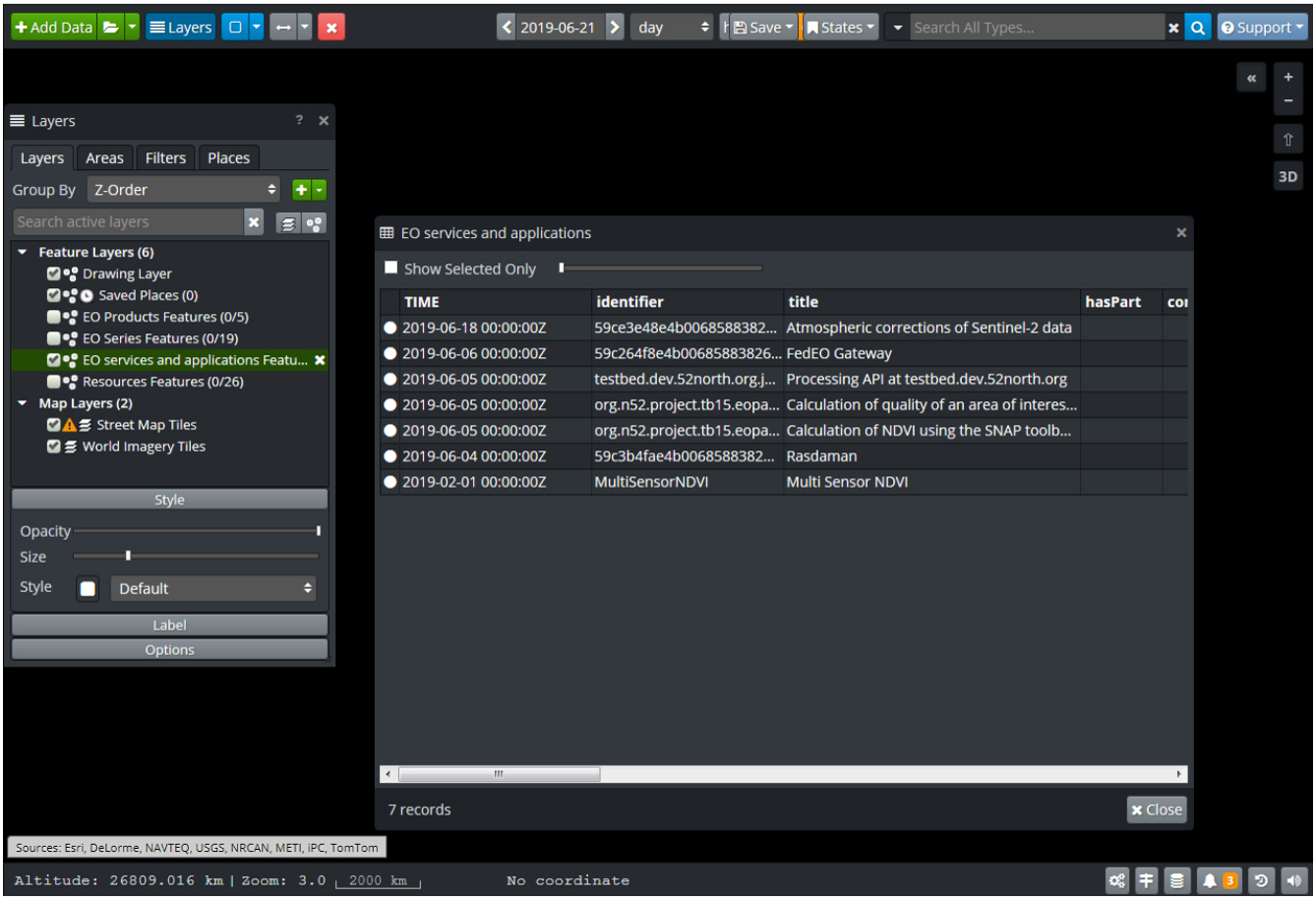

Figure 19. EO Service and Application metadata (OGC 19-020) from DataBio and OGC Testbed-15 shown in OpenSphere

The OpenSpere client also allows browsing EO Product metadata, visualise corresponding footprints on the map and display metadata properties for a particular EO Product.

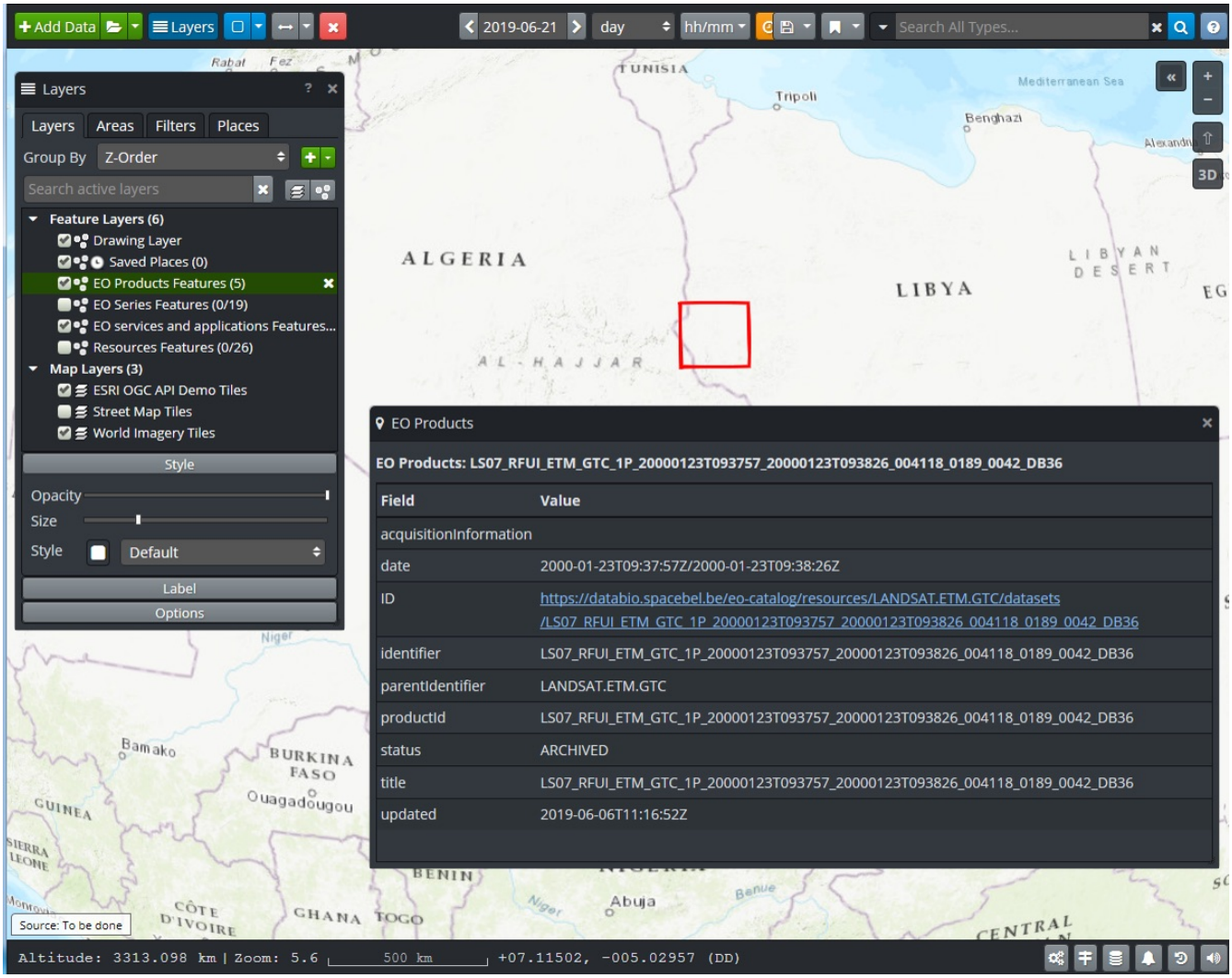

Figure 20. EO Product metadata (OGC 17-003) shown in OpenSphere

OGC API for Processes

A major discussion during the OGC Hackaton 2019 (London) was about describing the process interfaces (i.e. the Process Description including inputs and outputs definitions) directly in JSON Schema and/or OpenAPI. Indeed, as OpenAPI already supports descriptions of schemas/interfaces, this would remove the need of using a specific Process Description schema, and this would also ease the work of Web client developers.

For each existing process, a resource with a HTTP path is defined in the API document. Therefore, processes are discovered through the API document (no need of discovery and describe process operations) and the Client directly knows how to invoke the execution. The API document is illustrated below:

Example of processes exposed as OpenAPI operations

```
openapi: 3.0.0
paths:
 # For each process the path and interface is provided as below
 '/processes/mySampleProcess/jobs':
   post:
      summary: Start mySampleProcess execution.
      requestBody:
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/mySampleProcessExecuteRequest'
      responses:
        '201':
          headers:
            Location:
              schema:
                type: string
              description: URL to check the status of the execution/job.
```

A complete report about the mapping between the Process Description specification and the JSON Schema format is available at https://github.com/spacebel/testbed14/wiki/OGC-Hackaton-2019.

Others topics have also been covered during the Hackaton:

- The transactional extension specification has been submitted to the offical github repository at https://github.com/opengeospatial/wps-rest-binding/commit/7bdee9df5652ad3a7ad13075c535b84f9b264d0b.
- An extension supporting callbacks would allow a more modern pattern for monitoring the jobs status. Instead of observing (repeated polling), the client can be notified on the following event: onSuccess, onFailure, onUpdate. Spacebel has proposed a draft specification for such notification feature (relying on OpenAPI callbacks): https://github.com/opengeospatial/wps-rest-binding/commit/8cc2bdaf6483af7d8c5a85c7ad0a45b8e68cc4b6
- A very classical issue related to the possibility to report list of files as outputs was discussed. The conclusion of the discussion was that the new Processing API should support the presence of output file arrays.
- Some fixes listed at https://github.com/opengeospatial/wps-rest-binding/issues have been proposed during the Hackaton.

A.54.5. Other Impressions & Recommendations

Further alignment of the OpenSearch Catalog Server with OGC API Features interfaces, requires reconciling the time and bbox related search parameters from OGC 10-032 and OGC API Features. While OGC 10-032r8 has separate search parameters representing the start and end of a search interval `{time:start}` and `{time:end}` respectively, OGC API Features imposes a single search parameter to represent the interval.

OpenSearch and OpenAPI Common convergence would benefit from a revision of OGC 10-032r8 to ensure that the geo:box, time:start and time:end can be combined in a single URL template with the actual HTTP query parameter names imposed by OpenAPI Common for temporal and geographical search.

The approach to represent hyperlinks in JSON is unfortunately different from the encoding proposed by OGC 14-055r2 which means that an OpenSearch implemention based simultaneously on OGC 14-055r2 and OGC 17-047 in combination with OGC API Common will have different encodings for links in search responses and in other resource representations (e.g. `/conformance`, `/` etc).

The OGC API specifications are imposing to advertise "paths" in the Landing Page response and also contain wording suggesting that actual path names such as "api", "conformance", "collections" are mandatory and not just examples. This should be made clearer and it seems redundant to impose the declaration of paths in the landing page if indeed the path names are "fixed".

Making (JSON) data models available as separate JSON Schemas (https://swagger.io/docs/specification/data-models/keywords/) and not mixing them with actual OpenAPI descriptions (but refer to them) would allow validating JSON representations separately with JSON schema validation tools and before a service is put up.

A.55. Strategic Alliance Consulting Inc

TBA

A.55.1. Motivation to Participate

TBA

A.55.2. Implemented Solution

TBA

A.55.3. Proposed Alternatives

TBA

A.55.4. Experiences with OGC API Specifications

TBA

A.55.5. Other Impressions & Recommendations

TBA

A.56. University of Birmingham

TBA

A.56.1. Motivation to Participate

TBA

A.56.2. Implemented Solution

TBA

A.56.3. Proposed Alternatives

TBA

A.56.4. Experiences with OGC API Specifications

TBA

A.56.5. Other Impressions & Recommendations

TBA

A.57. University of Münster

Participant: Matthias Mohr

A.57.1. Motivation to Participate

- Align the openEO API with OGC API - Commons.
- Start discussions with the WPS community about alignment and their take on process chaining.
- Figure out future steps of WFS3 to port them back to the STAC specification.
- Discuss with CSW/CAT group about the planned steps and alignment with STAC.

A.57.2. Implemented Solution

- Tried to implement a WPS on top of the openEO Google Earth Engine driver (https://github.com/Open-EO/openeo-earthengine-driver). Implementation was not possible due to WPS/GEE restrictions.

A.57.3. Proposed Alternatives

- Workflows (process chaining) for WPS would be mandatory, but is not foreseen yet.
- WPS: Use JSON Schema for data types? See openEO approach for processes (https://open-eo.github.io/openeo-api/apireference/#tag/Process-Discovery).
- CSW/CAT should align with STAC! Very similar approach, diverging doesn't make sense.

A.57.4. Experiences with OGC API Specifications

Problems with **WPS** for openEO:

- WPS is not flexible enough for modern workflow execution, especially chaining of processes is missing
- openEO only allows a single return value (like mathematical functions), WPS allows multiple. This is problematic for process chaining (openEO process graphs).
- A parameter can be specified multiple times, which was possible in XML, but needs a workaround in JSON.
- Data types between openEO and WPS are quite different. WPS allows sending the data to the process, openEO prefers to load it from the cloud, which is more feasible with big data sets.
- Synchronous execution still has a state on the server and doesn't directly return the result in WPS, see https://github.com/opengeospatial/wps-rest-binding/issues/40

WFS:

- How to propose extensions?
- What query langauge to use for the API? CQL?

A.57.5. Other Impressions & Recommendations

- I can't stress this enough: Don't just make standalone specifications, but make them work together. This is not only having a common set of functionality with OGC API - Commons, but using WFS/WCS/WPS/CAT in a SINGLE API. We tried this with openEO for the previous versions of the standards and miserably failed. Therefore, we had to come up with non OGC standards, especially for processing. So make sure you have communication between the groups how the standards can be used seamlessly together!
- Plan a CAT and/or WFS sprint together with STAC?

A.58. University of Notre Dame

TBA

A.58.1. Motivation to Participate

TBA

A.58.2. Implemented Solution

TBA

A.58.3. Proposed Alternatives

TBA

A.58.4. Experiences with OGC API Specifications

TBA

A.58.5. Other Impressions & Recommendations

TBA

A.59. WebGeoDataVore

TBA

A.59.1. Motivation to Participate

TBA

A.59.2. Implemented Solution

TBA

A.59.3. Proposed Alternatives

TBA

A.59.4. Experiences with OGC API Specifications

TBA

A.59.5. Other Impressions & Recommendations

TBA

A.60. West University of Timisoara

The West University of Timisoara is an universal university from Timisoara, Romania. Our group [http://sage.ieat.ro/] is involved in a multitude of research projects spanning from Earth Observation, Machine Learning to Cloud Computing

Participants:

- Teodora Selea [http://www.sage.ieat.ro/p/teodora/]
- Marian Neagul [http://www.sage.ieat.ro/p/marian/]
- Gabriel Iuhasz [http://www.sage.ieat.ro/p/gabriel/]

A.60.1. Motivation to Participate

Our participation to the EOEP Hackathon was motivated by our aim of further extending the WPS 2.0 server developed as part of the ESA funded EO4SEE Project.

Particularly we are interested in insuring interoperability with third-party WPS implementations and adherence to the recommendations originating from the Testbed activities.

A.60.2. Implemented Solution

As part of the Hackathon we extended EWPS (our server implementation) to support the REST based bindings suggested by the draft standard proposal. The implementation was successfully tested with two client implementations, particularly those developed by Solenix and Helyx.

A.60.3. Proposed Alternatives

We propose modifying the current proposal to be more REST friendly by adapting WPS 2.0 conventions to RESTful alternatives

A.60.4. Experiences with OGC API Specifications

UVT is using OGC WMS, WPS and WCS in research systems.

A.60.5. Other Impressions & Recommendations

During the hackathon we submitted a series of recommendations regarding the standard, particularly an `callback` or `notification` API that would allow for more micro-service oriented applications. The notification API would allow the development of Workflow based (DAG) applications.

Also we suggested extending the `Common API` to provide monitoring information in an implementation agnostic way. This would allow various tools to interoperate in a more friendly manner with OGC compliant services.

Appendix B: Invitation to Participate

B.1. Invitation Announcement

Hosted and Sponsored by

The Open Geospatial Consortium (OGC) is organizing a Hackathon to develop OGC Application Programming Interface (API) specifications and invites you to participate.

The motivation for these OGC APIs is discussed on the OGC Blog at http://www.opengeospatial.org/blog/2996

This hackathon will test draft OpenAPI-based standards for coverages, map tiles, processes using a common template based on the OGC API for features, aka WFS3 [1].

The event will be instrumental to the evolution of the OWS standards to a modern API based approach, setting the course for open geospatial standards for the next decade. The hackathon will be organized around:

- Coverages
- Map Tiles
- Processing

Use of the OGC API for features, aka WFS3, is anticipated during many of the hackathon activities.

The outputs of the hackathon will inform the development of the OGC API - Common standard [2], the OGC API - Features standard [3], OGC API – Processes s standard [4], the OGC API – Coverages standard [5] and the OGC API – Map Tiles standard [6].

An OGC Hackathon is a collaborative and inclusive event driven by innovative and rapid programming with minimum process and organization constraints to support the development of new applications and open standards.

The scope of the event is proposed to include service development and testing, using one or more implementations of OpenAPI/Swagger [7]. Participants are welcome to bring partial or complete implementations of servers or clients to support the Hackathon.

A repository for collaborative work across the OGC API teams has been set up [8].

The Hackathon will begin on June 20th, 2019 at 09:00am, and end on June 21st, 2019 at 05:00pm. It will be hosted by Ordnance Survey at the Geovation Hub (https://geovation.uk/) in London. The physical address of the Geovation Hub is:

Sutton Yard, 4th Floor

65 Goswell road

London

EC1V 7EN

There will be opportunity for joint discussion with all participants on the goals and objectives of the event, as well as final briefing of findings and opinions of the participants. However, the majority of the time will be spent in collaboration between participants in active coding.

The Hackathon will be run by Standards Working Group (SWG) Chairs, with support from OGC staff.

Attendance priority will be given to those with an implementation or desire to implement the specifications.

Register by 1st May 2019 at https://ogc-api-hack2019.eventbrite.com

If you require funding to support your travel to the hackathon, please also complete the form (by May 1st, 2019) at https://docs.google.com/forms/d/1c0Zxy1d-9PvuRnfN2R-iIeP3Rcgbc9PMw1UfdN6Kw-A

Logistics information can be found at https://portal.opengeospatial.org/files/?artifact_id=83748

Remote Participation information can be found at https://portal.opengeospatial.org/files/?artifact_id=83864

The agenda for the event can be found at https://portal.opengeospatial.org/files/?artifact_id=83865

We're looking forward to seeing you at the Hackathon.

Appendix B - References:

1. WFS3 draft specification, https://cdn.rawgit.com/opengeospatial/WFS_FES/3.0.0-draft.1/docs/17-069.html
2. OGC API Common specification Github repository, https://github.com/opengeospatial/oapi_common
3. WFS3 Github repository, https://github.com/opengeospatial/WFS_FES
4. WPS Rest Binding Github repository, https://github.com/opengeospatial/wps-rest-binding
5. OGC API – Coverages Github repository, https://github.com/opengeospatial/ogc_api_coverages
6. OGC API – Map Tiles Github repository, https://github.com/opengeospatial/OGC-API-Map-Tiles
7. OpenAPI Specification 3.0.1, https://github.com/OAI/OpenAPI-Specification/blob/master/versions/3.0.1.md
8. OGC API Hackathon 2019 Cross Team Github repository, https://github.com/opengeospatial/OGC-API-Hackathon-2019

B.2. Questionnaires

This section presents the questionnaires that were presented to hackathon participants to facilitate organization of the event.

B.3. Travel Support Request

Software Development Experience

- ▢ Coding is not my day to day job, but I often hack on things to solve key problems.
- ▢ I am fluent in a variety of program languages and have shipped production systems with thousands of users.
- ▢ I have several years of professional software development experience and write code almost every day.
- ▢ I am comfortable with code, and can copy and paste pieces or script things together.
- ▢ Other

Experience with WFS, WCS, WMTS or WPS Specifications

- ▢ No experience with any of the web services listed (totally ok! We want you too!)
- ▢ Have used web services based on one or more of the standards listed above
- ▢ Have created a client implementation of one or more of the web service standards listed above
- ▢ Have created a server implementation of one or more of the web service standards listed above
- ▢ Have implemented web services and API's that are not based on OGC standards
- ▢ Other

What is your LinkedIn profile link

What is your GitHub profile link

Are you a Chair of one or more of the following OGC Standards Working Groups: WPS SWG, WCS SWG, WMS SWG, WFS SWG ?

- ▢ Yes
- ▢ No

Are you an editor of one or more of the following specifications: OGC API - Coverages, OGC API - Features, OGC API - Processes, OGC API - Map Tiles?

- ▢ Yes
- ▢ No

Have you implemented one or more of the following draft specifications: OGC API - Coverages, OGC API - Features, OGC API - Processes, OGC API - Map Tiles?

- ☐ Yes
- ☐ No

Do you agree to the terms in the OGC Privacy Policy at https://www.opengeospatial.org/ogc/policies/privacy ?

- ☐ Yes
- ☐ No

B.3.1. Infrastructure

Which challenge are you proposing to work on?

- ☐ OGC API - Processes
- ☐ OGC API - Common
- ☐ OGC API - Map Tiles
- ☐ OGC API - Coverages
- ☐ Other

How much data (in Gigabytes) are you bringing to the Hackathon?

Does the data you are bringing to the Hackathon contain any personal or personally identifiable information that would fall under GDPR?

- ☐ Yes
- ☐ No

Are you bringing any commercially sensitive data to the Hackathon?

- ☐ Yes
- ☐ No

Which base image will your containers be built on? Include operating system or distribution if known.

What is the minimum required RAM for running and testing your software?

- ☐ 1 GB
- ☐ 2 GB
- ☐ 4 GB
- ☐ More than 4GB (Please justify this requirement in the Notes section)

What is the minimum number of CPUs required to run your software?

- ☐ 1
- ☐ 2

- ▢ More than 2 (Please justify this requirement in the Notes section)

What is the minimum storage (in Gigabytes) you will require for running and testing your software?

Please rate your team's Microsoft Azure knowledge

- ▢ None
- ▢ Other Cloud Knowledge eg AWS
- ▢ Azure Developer

NOTES: anything else you think we should know about your requirements for the environment your application and data require for the Hackathon?

B.3.2. Additional Information

What is your Github Handle?

Dietary restrictions

- ▢ None
- ▢ Vegetarian
- ▢ Vegan
- ▢ Kosher
- ▢ Gluten-free
- ▢ Other

Which team will you work mostly with during the Hackathon?

- ▢ OGC API - Processes
- ▢ OGC API - Common
- ▢ OGC API - Map Tiles
- ▢ OGC API - Coverages
- ▢ Other

Do you agree to the terms in the OGC Privacy Policy at https://www.opengeospatial.org/ogc/policies/privacy ?

- ▢ Yes
- ▢ No

Appendix C: Revision History

Table 4. Revision History

Date	Editor	Release	Primary clauses modified	Descriptions
June 2, 2019	G. Hobona	.1	5	Adapted Scott Simmons's blog
June 3, 2019	G. Hobona	.2	all	initial version
TBA	TBA	TBA	TBA	TBA
TBA	TBA	TBA	TBA	TBA

Appendix D: Bibliography

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