

# OGC Web Feature Service 3.0

## *Part 1 - Core*

# Table of Contents

1. Scope .....	7
2. Conformance .....	8
3. References .....	10
4. Terms and Definitions .....	11
4.1. dataset .....	11
4.2. distribution .....	11
4.3. feature .....	11
4.4. feature collection; collection .....	11
5. Conventions .....	12
5.1. Open issues .....	12
5.2. Identifiers .....	12
5.3. UML model .....	12
5.4. Link relations .....	12
5.5. Use of HTTPS .....	12
5.6. API definition .....	13
5.6.1. General remarks .....	13
5.6.2. Role of OpenAPI .....	13
5.6.3. References to OpenAPI components in normative statements .....	13
5.6.4. Paths in OpenAPI definitions .....	14
5.6.5. Reusable OpenAPI components .....	14
6. Overview .....	15
6.1. Evolution from previous versions of WFS .....	15
6.2. Encodings .....	16
6.3. Examples .....	17
7. Requirement Class "Core" .....	18
7.1. Overview .....	18
7.2. API landing page .....	21
7.2.1. Operation .....	21
7.2.2. Response .....	21
7.3. API definition .....	22
7.3.1. Operation .....	22
7.3.2. Response .....	22
7.4. Declaration of conformance classes .....	23
7.4.1. Operation .....	23
7.4.2. Response .....	23
7.5. HTTP 1.1 .....	24
7.6. Web caching .....	24
7.7. Support for cross-origin requests .....	25

7.8. Encodings .....	25
7.9. Coordinate reference systems .....	26
7.10. Link headers .....	26
7.11. Feature collections metadata .....	27
7.11.1. Operation .....	27
7.11.2. Response .....	27
7.12. Feature collection metadata .....	32
7.12.1. Operation .....	32
7.12.2. Response .....	32
7.13. Feature collections .....	32
7.13.1. Operation .....	32
7.13.2. Parameter limit .....	32
7.13.3. Parameter bbox .....	33
7.13.4. Parameter time .....	35
7.13.5. Parameters for filtering on feature properties .....	36
7.13.6. Response .....	38
7.14. Feature .....	42
7.14.1. Operation .....	42
7.14.2. Response .....	42
8. Requirements classes for encodings .....	44
8.1. Overview .....	44
8.2. Requirement Class "HTML" .....	44
8.3. Requirement Class "GeoJSON" .....	45
8.4. Requirement Class "Geography Markup Language (GML), Simple Features Profile, Level 0" .....	48
8.5. Requirement Class "Geography Markup Language (GML), Simple Features Profile, Level 2" .....	49
9. Requirements class "OpenAPI 3.0" .....	51
9.1. Basic requirements .....	51
9.2. Complete definition .....	52
9.3. Exceptions .....	52
9.4. Security .....	53
9.5. Features .....	53
10. Media Types .....	54
Annex A: Conformance Class Abstract Test Suite (Normative) .....	55
Annex B: OpenAPI definition example (Informative) .....	56
B.1. Overview .....	56
B.2. Generic OpenAPI definition .....	56
B.3. OpenAPI definition with details on the collection and its features .....	66
Annex C: Revision History .....	79
Annex D: Bibliography .....	81

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### OGC Web Feature Service 3.0 - Part 1: Core

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## i. Abstract

A Web Feature Service (WFS) offers the capability to create, modify and query spatial data on the Web. WFS is a multi-part standard. This part specifies the core capabilities that every WFS supports and is restricted to read-access to data. Additional capabilities that address specific needs will be specified in additional parts. Examples include support for creating and modifying data, more complex data models, richer queries, additional coordinate reference systems.

By default, every WFS provides access to a single dataset. Rather than sharing the data as a complete dataset, WFS offers direct, fine-grained access to the data at the feature (object) level.

Consistent with the architecture of the Web, this version of WFS uses a resource architecture and specifies a RESTful service interface consistent with the HTTP/HTTPS standards.

This standard specifies discovery and query operations that are implemented using the HTTP GET method. Support for additional methods (in particular POST, PUT, DELETE, PATCH) will be specified in additional parts.

Discovery operations allow the server to be interrogated to determine its capabilities and retrieve information (metadata) about this distribution of the dataset. This includes the API definition of the server as well as metadata about the feature collections provided by the server.

Query operations allow features or values of feature properties to be retrieved from the underlying data store based upon selection criteria, defined by the client, on feature properties.

This standard defines the resources listed in Table 1. For an overview of the resources, see section [7.1 Overview](#).

*Table 1. Overview of resources, applicable HTTP methods and links to the document sections*

Resource	Path	HTTP method	Document reference
Landing page	/	GET	<a href="#">7.2 API landing page</a>
API definition	/api	GET	<a href="#">7.3 API definition</a>
Conformance classes	/conformance	GET	<a href="#">7.4 Declaration of conformance classes</a>
Feature collections metadata	/collections	GET	<a href="#">7.11 Feature collections metadata</a>
Feature collection metadata	/collections/{name}	GET	<a href="#">7.12 Feature collection metadata</a>
Feature collection	/collections/{name}/items	GET	<a href="#">7.13 Feature collections</a>
Feature	/collections/{name}/items/{fid}	GET	<a href="#">7.14 Feature</a>

## ii. Keywords

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, web feature service, wfs, feature, property, geographic information, spatial

data, spatial things, dataset, distribution, API, openapi, geojson, gml, html

### **iii. Preface**

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- CubeWerx Inc.
- interactive instruments GmbH
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...	...

# Chapter 1. Scope

This International Standard specifies the behaviour of a server that provides access to features in a dataset in a manner independent of the underlying data store. It specifies discovery and query operations.

Discovery operations allow the server to be interrogated to determine its capabilities and retrieve information (metadata) about this distribution of the dataset. This includes the API definition of the server as well as metadata about the feature collections provided by the server.

Query operations allow features to be retrieved from the underlying data store based upon simple selection criteria, defined by the client.

# Chapter 2. Conformance

This standard defines six requirements / conformance classes.

The standardization targets of all conformance classes are "web services".

The main requirements class is:

- [Core](#).

It specifies requirements that all WFS have to meet.

The "Core" does not mandate any encoding or format for representing features or feature collections. Four requirements classes depend on the "Core" and specify representations for these resources in commonly used encodings for spatial data on the web:

- [HTML](#),
- [GeoJSON](#),
- [Geography Markup Language \(GML\), Simple Features Profile, Level 0](#), and
- [Geography Markup Language \(GML\), Simple Features Profile, Level 2](#).

None of these encodings are mandatory and an implementation of the "Core" requirements class may also decide to use none of them, but to use another encoding instead.

That said, the [Core](#) requirements class includes recommendations to support [HTML](#) and [GeoJSON](#) as encodings, where practical. [Clause 6 \(Overview\)](#) includes a discussion about recommended encodings.

The "Core" does not mandate any encoding or format for the formal definition of the API either. One option is the OpenAPI 3.0 specification and a requirements class has been defined for this, which depends on the "Core":

- [OpenAPI specification 3.0](#).

Like with the feature encodings, an implementation of the "Core" requirements class may also decide to use other representations of the API definition in addition or instead of an OpenAPI 3.0 definition. Examples for alternative API definitions: OpenAPI 2.0 (Swagger), future versions of the OpenAPI specification or an OWS Common 2.0 capabilities document.

The "Core" is intended to be the minimal useful service interface for fine-grained access to a spatial dataset.

Additional capabilities, for example, support for transactions, complex data structures, rich queries, other coordinate reference systems, subscription/notification, returning aggregated results, etc., may be specified in future parts of WFS or as vendor-specific extensions.

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies

and Procedures and the OGC Compliance Testing web site.

# Chapter 3. References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

- Open API Initiative: OpenAPI Specification 3.0.1, <https://github.com/OAI/OpenAPI-Specification/blob/master/versions/3.0.1.md>
- Fielding, R., Gettys, J., Mogul, J., Frystyk, H., Masinter, L., Leach, P., Berners-Lee, T.: IETF RFC 2616, HTTP/1.1, <http://tools.ietf.org/rfc/rfc2616.txt>
- Klyne, G., Newman, C.: IETF RFC 3339, Web Linking, <http://tools.ietf.org/rfc/rfc3339.txt>
- Nottingham, M.: IETF RFC 5988, Web Linking, <http://tools.ietf.org/rfc/rfc5988.txt>
- van den Brink, L., Portele, C., Vretanos, P.: OGC 10-100r3, Geography Markup Language (GML) Simple Features Profile, [http://portal.opengeospatial.org/files/?artifact\\_id=42729](http://portal.opengeospatial.org/files/?artifact_id=42729)
- Butler, H., Daly, M., Doyle, A., Gillies, S., Hagen, S., Schaub, T.: IETF RFC 7946, The GeoJSON Format, <https://tools.ietf.org/rfc/rfc7946.txt>
- W3C: HTML5, W3C Recommendation, <http://www.w3.org/TR/html5/>
- Schema.org: <http://schema.org/docs/schemas.html>

# Chapter 4. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

For the purposes of this document, the following additional terms and definitions apply.

**CAUTION** | Add link to the informative WFS Guide, once it is available.

## 4.1. dataset

collection of data, published or curated by a single agent, and available for access or download in one or more formats [\[DCAT\]](#)

**NOTE** | The use of 'collection' in the definition from [\[DCAT\]](#) is broader than the use of the term collection in this specification. See the definition of 'feature collection'.

## 4.2. distribution

represents an accessible form of a **dataset** [\[DCAT\]](#)

EXAMPLE: a downloadable file, an RSS feed or a web service that provides the data.

## 4.3. feature

abstraction of real world phenomena [ISO 19101-1:2014]

**NOTE** | If you are unfamiliar with the term 'feature', the explanations in the [W3C/OGC Spatial Data on the Web Best Practice document](#) may help, in particular the section on [Spatial Things, Features and Geometry](#).

## 4.4. feature collection; collection

a set of **features** from a **dataset**

**NOTE** | In this specification, 'collection' is used as a synonym for 'feature collection'. This is done to make, for example, URI path expressions shorter and easier to understand for those that are not geo-experts.

# Chapter 5. Conventions

## 5.1. Open issues

This version is a draft. It is not complete and there are open issues that are under discussion. These cases are shown as "CAUTION" annotations with a link to the issue on GitHub and a brief summary of the issue.

The current expectation is to have a stable version of the Core specification in 2019. Criteria to move the specification to the next stage in the process are:

- Multiple implementations of each conformance class,
- a conformance test suite for each conformance class,
- multiple implementations of a generic WFS client,
- multiple implementations of clients using the OpenAPI definition of a WFS,
- multiple draft extensions to verify the extensibility, and
- resolution of comments received on GitHub or in formal reviews in OGC and ISO/TC 211.

## 5.2. Identifiers

The normative provisions in this specification are denoted by the URI <http://www.opengis.net/spec/wfs-1/3.0>.

All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base.

## 5.3. UML model

UML diagrams are included in this standard to illustrate the conceptual model that underpins Web Feature Service implementations. The UML model is not normative. The UML profile used is specified in ISO 19103:2015.

Resources are modelled as UML interfaces.

## 5.4. Link relations

To express relationships between resources, [RFC 5988 \(Web Linking\)](#) and [registered link relation types](#) are used.

## 5.5. Use of HTTPS

For simplicity, this document in general only refers to the HTTP protocol. This is not meant to exclude the use of HTTPS and simply is a shorthand notation for "HTTP or HTTPS". In fact, most WFS are expected to use HTTPS, not HTTP.

## 5.6. API definition

### 5.6.1. General remarks

Good documentation is essential for every API so that developers can learn how to use it. In the best case, documentation will be available in HTML and in a format that can be processed by software to connect to the API.

This standard specifies requirements and recommendations for APIs that share feature data and that want to follow a standard way of doing so. In general, APIs will go beyond the requirements and recommendations stated in this standard - or other parts of the Web Feature Service standard series - and will support additional operations, parameters, etc. that are specific to the API or the software tool used to implement the API.

### 5.6.2. Role of OpenAPI

This document uses OpenAPI 3.0 fragments as examples and to formally state requirements. However, using OpenAPI 3.0 is not required.

The "Core" requirements class, therefore, only requires that an API definition is provided at path `/api`.

A separate requirements class is specified for API definitions that follow the [OpenAPI specification 3.0](#), but this does not preclude that in the future or in parallel other versions of OpenAPI or other descriptions are provided by a server.

#### NOTE

This approach is used to avoid lock-in to a specific approach to defining an API as it is expected that the landscape will continue to evolve.

In this document, fragments of OpenAPI definitions are shown in YAML since YAML is easier to read than JSON and is typically used in OpenAPI editors.

### 5.6.3. References to OpenAPI components in normative statements

Some normative statements (requirements, recommendations and permissions) use a phrase that a component in the API definition of the server must be "based upon" a schema or parameter component in the OGC schema repository.

In this case, the following changes to the pre-defined OpenAPI component are permitted:

- If the server supports an XML encoding, `xml` properties may be added to the relevant OpenAPI schema components.
- The range of values of a parameter or property may be extended (additional values) or constrained (if only a subset of all possible values are applicable to the service). An example for a constrained range of values is to explicitly specify the supported values of a string parameter or property using an enum.
- Additional properties may be added to the schema definition of a Response Object.
- Informative text may be changed or added, like comments or description properties.



For API definitions that do not conform to the [OpenAPI Specification 3.0](#) the normative statement should be interpreted in the context of the API definition language used.

#### 5.6.4. Paths in OpenAPI definitions

All paths in an OpenAPI definition are relative to a base URL of the server.

##### CAUTION

##### ISSUE 98

Server Ambiguity in OpenAPI

*Example 1. URL of the OpenAPI definition*

If the OpenAPI Server Object would look like this:

```
servers:
- url: https://dev.example.org/
  description: Development server
- url: https://data.example.org/
  description: Production server
```

The path `"/mypath"` in the OpenAPI definition of a WFS would be the URL <https://data.example.org/mypath> for the production server.

#### 5.6.5. Reusable OpenAPI components

Reusable components for OpenAPI definitions of a WFS are referenced from this document.

##### CAUTION

During the development phase, these components use a base URL of `"https://raw.githubusercontent.com/opengeospatial/WFS_FES/master/"`, but eventually they are expected to be available under the base URL `"http://schemas.opengis.net/wfs/3.0/openapi/"`.

# Chapter 6. Overview

## 6.1. Evolution from previous versions of WFS

The previous versions of the WFS standard used a Remote-Procedure-Call-over-HTTP architectural style using XML for any payloads as it was state-of-the-art in the late 1990s and early 2000s, when WFS was originally designed. This version specifies a modernized service, that follows the current Web architecture and in particular the [W3C/OGC best practices for sharing Spatial Data on the Web](#) as well as the [W3C best practices for sharing Data on the Web](#).

Beside the general alignment with the architecture of the Web (e.g., consistency with HTTP/HTTPS, hypermedia controls), another goal is modularization. This has a few facets:

- Clear separation between core requirements that almost everyone has who wants to share or use spatial data on a fine-grained level (this document) and more advanced capabilities that communities are using today (extensions specified in additional parts of WFS 3.0).
- Technologies that change more frequently are decoupled and specified in separate modules ("requirements classes" in OGC terminology). This enables, for example, the use/re-use of new encodings for spatial data or API descriptions.
- Modularization is not just about WFS modules, but about providing building blocks for fine-grained access to spatial data that can be used in data APIs in general. In other words, a server supporting WFS 3.0 should not be seen as a standalone WFS service. A corollary of this is that it should be possible to implement a data API that at the same time conforms to conformance classes from WFS 3.0 and from other OGC Web Service standards following a similar approach.

This approach intends to support two types of client developers:

- those that have never heard about WFS - it should be possible to create a client using the API definition without the need to read the WFS standard (they may need to learn a little bit about geometry, etc.);
- those that want to write a "generic" client that can access WFSs, i.e. are not specific for a particular API/server.

As a result of this modernization, WFS 3.0 implementations are not backwards compatible with WFS 2.0 implementations per se. However, it has been a design goal to define WFS 3.0 in a way so that the WFS 3.0 interface can be mapped to a WFS 2.0 implementation. WFS 3.0 is intended to be simpler and more modern, but still an evolution from the previous versions and their implementations.

The modernization is discussed in more detail [here](#).

### CAUTION

Change this link and point to the WFS 3.0 Guide once a draft is available. The Guide will include a mapping between OGC Capabilities and OpenAPI as well as a mapping between WFS 2.0 operations and WFS 3.0.

## 6.2. Encodings

This standard does not mandate any encoding or format for representing features or feature collections. In addition to HTML as the standard encoding for Web content, rules for commonly used encodings for spatial data on the web are provided (GeoJSON, GML).

None of these encodings is mandatory and an implementation of the "Core" requirements class may also decide to use none of them, but to use another encoding instead.

[Support for HTML is recommended](#) as HTML is the core language of the World Wide Web. A server that supports HTML will support browsing the data with a web browser and it will enable search engines to crawl and index the dataset.

GeoJSON is a commonly used format that is simple to understand and well supported by tools and software libraries. Since most Web developers are comfortable with using a JSON-based format, this version of the Web Feature Service standard [recommends to support GeoJSON for encoding feature data](#), if the feature data can be represented in GeoJSON for the intended use.

Some examples for cases that are out-of-scope of GeoJSON are:

- solids are used a geometries (e.g. in a 3D city model),
- geometries include non-linear curve interpolations that cannot be simplified (e.g., use of arcs in authoritative geometries),
- geometries have to be represented in a coordinate reference system that is not based on WGS 84 longitude/latitude (e.g. an authoritative national reference system),
- features have more than one geometric property, etc.

In addition to HTML and GeoJSON, a significant amount of feature data is available in XML-based formats, notably GML. GML supports more complex requirements than GeoJSON and does not have any of the limitations mentioned in the previous paragraph, but as a result GML also more complex to handle for both servers and clients. Conformance classes for GML are, therefore, included in this standard, but it is expected that these will typically be supported by servers where users are known to expect feature data in XML/GML.

The recommendations for HTML and GeoJSON reflect the importance of HTML and the current popularity of JSON-based data formats. As the practices in the Web community evolve, the recommendations will likely be updated, too, in future versions of this standard to provide guidance.

This part of WFS 3.0 does not provide any guidance on other encodings. The supported encodings, or more precisely the media types of the supported encodings, can be determined from the API definition. The desired encoding is selected using HTTP content negotiation.

For example, if the server supports [GeoJSON Text Sequences](#), an encoding that is based on JSON text sequences and GeoJSON to support streaming by making the the data incrementally parseable, the media type `application/geo+json-seq` would be used.

In addition, HTTP supports compression and the standard HTTP mechanisms can be used to reduce the size of the messages between the server and the client.

## 6.3. Examples

This document uses a simple example throughout the document: The dataset contains buildings and the server provides access to them through a single feature collection ("buildings") and two encodings, GeoJSON and HTML.

The buildings have a few (optional) properties: the polygon geometry of the building footprint, a name, the function of the building (residential, commercial or public use), the floor count and the timestamp of the last update of the building feature in the dataset.

# Chapter 7. Requirement Class "Core"

## 7.1. Overview

Requirements Class	
<a href="http://www.opengis.net/spec/wfs-1/3.0/req/core">http://www.opengis.net/spec/wfs-1/3.0/req/core</a>	
Target type	Web service
Dependency	<a href="#">RFC 2616 (HTTP/1.1)</a>
Dependency	<a href="#">RFC 3339 (Date and Time on the Internet: Timestamps)</a>
Dependency	<a href="#">RFC 5988 (Web Linking)</a>

Figure 1 illustrates the resources supported by the Core requirements class using UML. Each resource type available through the server is an «interface».

A server that implements the WFS API provides access to the features in a dataset. In other words, the API is a distribution of that dataset. A file download, for example, would be another distribution.

That is, each WFS has a single **LandingPage** (path `/`) that provides links to

- the **APIDefinition** (path `/api`),
- the **Conformance** statements (path `/conformance`),
- the **DatasetDistribution** metadata (path `/collections`).

The **APIDefinition** describes the capabilities of the server and which can be used by clients to connect to the server or by development tools to support the implementation of servers and clients. Accessing the **APIDefinition** using HTTP GET returns a description of the API.

Accessing the **Conformance** using HTTP GET returns a list of URIs of requirements classes implemented by the server.

The distribution consists of a set of feature collections. This specification does not include any requirements how the features in the dataset have to be aggregated into collections. A typical approach is to aggregate by feature type, but any other approach that fits the dataset or the applications using this distribution may be used, too.

Accessing the **DatasetDistribution** using HTTP GET returns a **DatasetDistributionResponse**, which includes a link to each **Collection** in the distribution along with metadata about each collection:

- a local identifier for the collection that is unique within the WFS;
- a list of coordinate reference systems in which geometries may be returned by the server, where the first one is the default coordinate reference system (in the Core, the default is always WGS 84 with axis order longitude/latitude);
- an optional title and description for the collection;
- an optional extent that can be used to provide an indication of the spatial and temporal extent

of the collection - typically derived from the data.

Each **Collection** (path `/collections/{collection-name}/items`) consists of the features in the collection where each feature in the distribution is part of exactly one collection.

**CAUTION**

**ISSUE 30**

Allow also features that do not belong to any collection?

**CAUTION**

**ISSUE 66**

Support features that do belong to multiple collections?

Accessing a **Collection** using HTTP GET returns a **CollectionResponse**, which basically consists of features in the collection. The features included in the response are determined by the server based on parameters of the request.

A **bbox** or **time** parameter may be used to select only a subset of the features in the collection (the features that are located in the bounding box or time period).

The **limit** parameter may be used to request only a subset of the selected features and to indicate that the client wants to page through the selected features of the collection.

The **CollectionResponse** may include metadata about the number of selected and returned features (**numberMatched** and **numberReturned**) as well as links to simplify paging (**next** and **prev**).

Each **Feature** (path `/collections/{collection-name}/items/{feature-id}`) is also a separate resource and may be requested individually using HTTP GET.

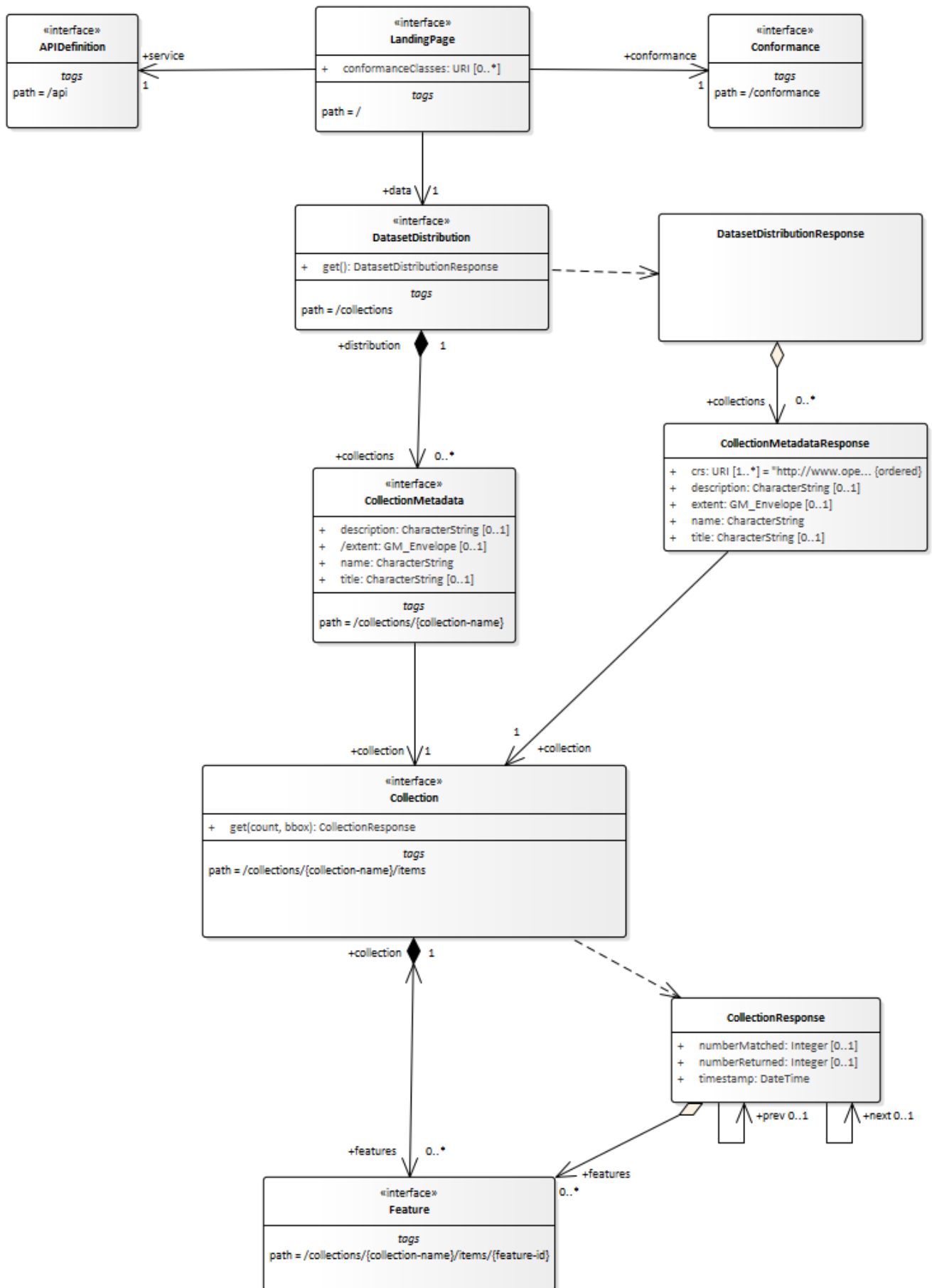


Figure 1. Resources in the Core requirements class

**CAUTION****ISSUE 90**

More flexible path structure under **/collections**?

## 7.2. API landing page

### 7.2.1. Operation

<b>Requirement 1</b>	<p>/req/core/root-op</p> <p>The server SHALL support the HTTP GET operation at the path <b>/</b>.</p>
----------------------	---

### 7.2.2. Response

<b>Requirement 2</b>	<p>/req/core/root-success</p> <p>A successful execution of the operation SHALL be reported as a response with a HTTP status code <b>200</b>.</p> <p>The content of that response SHALL be based upon the OpenAPI 3.0 schema <a href="#">root.yaml</a> and include at least links to the following resources:</p> <ul style="list-style-type: none"><li>• <b>/api</b> (relation type 'service')</li><li>• <b>/conformance</b> (relation type 'conformance')</li><li>• <b>/collections</b> (relation type 'data')</li></ul>
----------------------	---

**CAUTION****ISSUE 101**

Landing page: Can we reuse existing relation types instead of 'conformance' and 'data'?

#### *Schema for the landing page*

```
type: object
required:
  - links
properties:
  links:
    type: array
    items:
      $ref:
https://raw.githubusercontent.com/opengeospatial/WFS_FES/master/core/openapi/schemas/links.yaml
```



```
{
  "links": [
    { "href": "http://data.example.org/",
      "rel": "self", "type": "application/json", "title": "this document" },
    { "href": "http://data.example.org/api",
      "rel": "service", "type": "application/openapi+json;version=3.0", "title":
"the API definition" },
    { "href": "http://data.example.org/conformance",
      "rel": "conformance", "type": "application/json", "title": "WFS 3.0
conformance classes implemented by this server" },
    { "href": "http://data.example.org/collections",
      "rel": "data", "type": "application/json", "title": "Metadata about the
feature collections" }
  ]
}
```

## 7.3. API definition

### 7.3.1. Operation

Every WFS provides an API definition that describes the capabilities of the server and which can be used by developers to understand the API, by software clients to connect to the server or by development tools to support the implementation of servers and clients.

<b>Requirement 3</b>	<code>/req/core/api-definition-op</code>  The server SHALL support the HTTP GET operation at the path <code>/api</code> .
----------------------	---

### 7.3.2. Response

<b>Requirement 4</b>	<code>/req/core/api-definition-success</code>  A successful execution of the operation SHALL be reported as a response with a HTTP status code <code>200</code> .  The server SHALL return an API definition document.
----------------------	--

Recommendation 1	/rec/core/api-definition-oas  If the API definition document uses the OpenAPI Specification 3.0, the document SHOULD conform to the <a href="#">OpenAPI Specification 3.0 requirements class</a> .
------------------	--

If multiple API definition formats are supported by a server, use content negotiation to select the desired representation.

The API definition document describes the API. I.e., there is no need to include the `/api` operation in the API definition itself.

The idea is that any WFS can be used by developers that are familiar with the API definition language(s) supported by the server. For example, if an OpenAPI definition is used, it should be possible to create a working client using the OpenAPI definition. The developer may need to learn a little bit about geometry, etc., but it should not be required to read this standard to access the data via the API.

## 7.4. Declaration of conformance classes

### 7.4.1. Operation

To support "generic" clients for accessing Web Feature Services in general - and not "just" a specific API / server, the server has to declare the requirements classes it implements and conforms to, too.

Requirement 5	/rec/core/conformance-op  The server SHALL support the HTTP GET operation at the path <code>/conformance</code> .
---------------	---

### 7.4.2. Response

Requirement 6	/rec/core/conformance-success  A successful execution of the operation SHALL be reported as a response with a HTTP status code <code>200</code> .  The content of that response SHALL be based upon the OpenAPI 3.0 schema <a href="#">req-classes.yaml</a> and list all WFS 3.0 requirements classes that the server conforms to.
---------------	--

```
type: object
required:
  - conformsTo
properties:
  conformsTo:
    type: array
    items:
      type: string
```

*Example 3. Requirements class response document*

This example response in JSON is for a server that supports OpenAPI 3.0 for the API definition and HTML and GeoJSON as encodings for features.

```
{
  "conformsTo": [
    "http://www.opengis.net/spec/wfs-1/3.0/req/core",
    "http://www.opengis.net/spec/wfs-1/3.0/req/oas30",
    "http://www.opengis.net/spec/wfs-1/3.0/req/html",
    "http://www.opengis.net/spec/wfs-1/3.0/req/geojson"
  ]
}
```

## 7.5. HTTP 1.1

Requirement 7	/req/core/http
	The server SHALL conform to <a href="#">HTTP 1.1</a> .

This includes the correct use of status codes, headers, etc.

## 7.6. Web caching

Entity tags are a mechanism for web cache validation and for supporting conditional requests to reduce network traffic. Entity tags are specified by [HTTP/1.1 \(RFC 2616\)](#).

Recommendation 2	/rec/core/etag
	The service SHOULD support entity tags and the associated headers as specified by HTTP/1.1.

**CAUTION**

More detail / examples on caching. Add an example OpenAPI operation (headers, response codes) - here or in clause 9.

## 7.7. Support for cross-origin requests

To access data from a HTML page where the data is on another host than the webpage is by default prohibited for security reasons ("same-origin policy"). A typical example is a web-application accessing feature data from multiple distributed datasets.

Recommendation 3	<p>/rec/core/cross-origin</p> <p>If the server is intended to be accessed from the browser, cross-origin requests <b>SHOULD</b> be supported. Note that support can also be added in a proxy layer on top of the server.</p>
------------------	--

Two common mechanisms to support cross-origin requests are:

- [Cross-origin resource sharing \(CORS\)](#)
- [JSONP \(JSON with padding\)](#)

## 7.8. Encodings

While WFS 3.0 does not include any mandatory encoding, it recommends the following encodings. See [Clause 6 \(Overview\)](#) for a discussion.

Recommendation 4	<p>/rec/core/html</p> <p>To support browsing a WFS with a web browser and to enable search engines to crawl and index a dataset, implementations <b>SHOULD</b> consider to support an HTML encoding.</p>
------------------	--

Recommendation 5	<p>/rec/core/geojson</p> <p>If the feature data can be represented for the intended use in GeoJSON, implementations <b>SHOULD</b> consider to support GeoJSON as an encoding for features and feature collections.</p>
------------------	--

**Requirement** [/req/core/http](#) implies that the encoding of a server response is determined using content negotiation as specified by the HTTP specification.

The section [Media Types](#) includes guidance on media types for [encodings](#) that are specified in this document.

Note that any server that supports multiple encodings will have to support a mechanism to mint

encoding-specific URIs for resources in order to express links, for example, to alternate representations of the same resource. This document does not mandate any particular approach how this is supported by the server.

As clients simply need to dereference the URI of the link, the implementation details and the mechanism how the encoding is included in the URI of the link are not important. Developers interested in the approach of a particular implementation, for example, to manipulate ("hack") URIs in the browser address bar, can study the API definition.

**NOTE**

Two common approaches are:

- an additional path for each encoding of each resource (this can be expressed, for example, using format specific suffixes like ".html");
- an additional query parameter (for example, "accept" or "f") that overrides the Accept header of the HTTP request.

## 7.9. Coordinate reference systems

As discussed in Chapter 9 of the [W3C/OGC Spatial Data on the Web Best Practices](#), how to express and share the location of features in a consistent way is one of the most fundamental aspects of publishing geographic data and it is important to be clear about the coordinate reference system that coordinates are in.

For the reasons discussed in the Best Practices, Web Feature Service 3.0 uses WGS84 longitude and latitude as the default coordinate reference system.

<b>Requirement 8</b>	<p>/req/core/crs84</p> <p>Unless the client explicitly requests a different coordinate reference system, all spatial geometries SHALL be in the coordinate reference system <a href="http://www.opengis.net/def/crs/OGC/1.3/CRS84">http://www.opengis.net/def/crs/OGC/1.3/CRS84</a> (WGS84 longitude/latitude).</p>
----------------------	---

The implementations compliant with the Core are not required to support publishing feature geometries in coordinate reference systems other than <http://www.opengis.net/def/crs/OGC/1.3/CRS84>. The Core also does not specify a capability to request feature geometries in a different coordinate reference system than the native one of the published features. Such a capability will be specified in another part(s) of the WFS 3.0 series.

## 7.10. Link headers

Recommendation 6	<p>/rec/core/link-header</p> <p>Links included in payload of responses SHOULD also be included as <b>Link</b> headers in the HTTP response according to <a href="#">RFC 5988, Clause 5</a>.</p> <p>This recommendation does not apply, if there are a large number of links included in a response or a link is not known when the HTTP headers of the response are created.</p>
------------------	--

## 7.11. Feature collections metadata

### 7.11.1. Operation

Requirement 9	<p>/req/core/fc-md-op</p> <p>The server SHALL support the HTTP GET operation at the path <b>/collections</b>.</p>
---------------	---

### 7.11.2. Response

Requirement 10	<p>/req/core/fc-md-success</p> <p>A successful execution of the operation SHALL be reported as a response with a HTTP status code <b>200</b>.</p> <p>The content of that response SHALL be based upon the OpenAPI 3.0 schema <a href="#">content.yaml</a>.</p>
----------------	--

```
type: object
required:
  - links
  - collections
properties:
  links:
    type: array
    items:
      $ref:
https://raw.githubusercontent.com/opengeospatial/WFS\_FES/master/core/openapi/schemas/link.yaml
  collections:
    type: array
    items:
      $ref:
https://raw.githubusercontent.com/opengeospatial/WFS\_FES/master/core/openapi/schemas/collectionInfo.yaml
```

**Requirement 11**

/req/core/fc-md-links

A **200**-response SHALL include the following links in the **links** property of the response:

- a link to this response document (relation: **self**),
- a link to the response document in every other media type supported by the server (relation: **alternate**).

All links SHALL include the **rel** and **type** link parameters.

**Recommendation 7**

/rec/core/fc-md-descriptions

If external schemas or descriptions for the dataset exist that provide information about the structure or semantics of the data, a **200**-response SHOULD include links to each of those resources in the **links** property of the response (relation: **describedBy**).

The **type** link parameter SHOULD be provided for each link.

This applies to resources that describe to the whole dataset. For resources that describe the contents of a feature collection, the links SHOULD be set in the **links** property of the appropriate object in the **collections** resource.

Examples for descriptions are: XML Schema, Schematron, JSON Schema, RDF Schema, OWL, SHACL, a feature catalogue, etc.

**CAUTION****ISSUE 56**

Lack of DescribeFeatureType request

**CAUTION****ISSUE 102**

Add a recommendation about a link to the dataset metadata (for example, in DCAT). Which link relation type?

**Requirement 12**

/req/core/fc-md-items

For each feature collection in this distribution of the dataset, an item SHALL be provided in the property **collections**.

**Requirement 13**

/req/core/fc-md-items-links

For each feature collection in this distribution of the dataset, the **links** property of the collection SHALL include an item for each supported encoding with a link to the collection resource (relation: **item**).

All links SHALL include the **rel** and **type** properties.

**CAUTION****ISSUE 103**

Can/should we make use of the new **Link Object** in OpenAPI 3.0?

**Requirement 14**

/req/core/fc-md-extent

For each feature collection, the **extent** property, if provided, SHALL be a bounding box that includes all spatial and temporal geometries in this collection.

If a feature has multiple properties with spatial or temporal information, it is the decision of the server whether only a single spatial or temporal geometry property is used to determine the extent or all relevant geometries.



```
type: object
required:
  - name
  - links
properties:
  name:
    description: identifier of the collection used, for example, in URIs
    type: string
  title:
    description: human readable title of the collection
    type: string
  description:
    description: a description of the features in the collection
    type: string
  links:
    type: array
    items:
      $ref:
https://raw.githubusercontent.com/opengeospatial/WFS\_FES/master/core/openapi/schemas/link.yaml
  extent:
    $ref:
https://raw.githubusercontent.com/opengeospatial/WFS\_FES/master/core/openapi/schemas/extent.yaml
  crs:
    description: the list of coordinate reference systems supported by the service;
the first item is the default coordinate reference system
    type: array
    items:
      type: string
    default:
      - http://www.opengis.net/def/crs/OGC/1.3/CRS84
```

**NOTE** | The **crs** property is not used by this conformance class, but reserved for future use.

#### Example 4. Feature collection metadata response document

This feature collection metadata example response in JSON is for a dataset with a single collection "buildings". It includes links to the collection resource in all formats that are supported by the service ([link relation type](#): "item").

Representations of the metadata resource in other formats are referenced using [link relation type](#) "alternate".

Additional links to a GML application schema for the building data and to a web page that has additional information about buildings are provided, too, using [link relation type](#) "describedBy".

Coordinate reference system information is not provided as the service provides geometries only in the default system (WGS84 longitude/latitude).

```
{
  "links": [
    { "href": "http://data.example.org/collections.json",
      "rel": "self", "type": "application/json", "title": "this document" },
    { "href": "http://data.example.org/collections.html",
      "rel": "alternate", "type": "text/html", "title": "this document as HTML" },
    { "href": "http://schemas.example.org/1.0/foobar.xsd",
      "rel": "describedBy", "type": "application/xml", "title": "XML schema for
Acme Corporation data" }
  ],
  "collections": [
    {
      "name": "buildings",
      "title": "Buildings",
      "description": "Buildings in the city of Bonn.",
      "extent": {
        "spatial": [ 7.01, 50.63, 7.22, 50.78 ],
        "temporal": [ "2010-02-15T12:34:56Z", "2018-03-18T12:11:00Z" ]
      },
      "links": [
        { "href": "http://data.example.org/collections/buildings/items",
          "rel": "item", "type": "application/geo+json",
          "title": "Buildings" },
        { "href": "http://example.org/concepts/building.html",
          "rel": "describedBy", "type": "text/html",
          "title": "Feature catalogue for buildings" }
      ]
    }
  ]
}
```

## 7.12. Feature collection metadata

### 7.12.1. Operation

<b>Requirement 15</b>	<p>/req/core/sfc-md-op</p> <p>The server SHALL support the HTTP GET operation at the path <code>/collections/{name}</code>.</p> <p>The parameter <code>name</code> is each property of the same name in the feature collections metadata (JSONPath: <code>\$.collections[*].name</code>).</p>
-----------------------	---

### 7.12.2. Response

<b>Requirement 16</b>	<p>/req/core/sfc-md-success</p> <p>A successful execution of the operation SHALL be reported as a response with a HTTP status code <code>200</code>.</p> <p>The content of that response SHALL be the same as the content for this feature collection in the <code>/collections</code> response.</p>
-----------------------	--

## 7.13. Feature collections

### 7.13.1. Operation

<b>Requirement 17</b>	<p>/req/core/fc-op</p> <p>For every feature collection identified in the metadata about the feature collection (path <code>/</code>), the server SHALL support the HTTP GET operation at the path <code>/collections/{name}/items</code>.</p> <p>The parameter <code>name</code> is each property of the same name in the feature collections metadata (JSONPath: <code>\$.collections[*].name</code>).</p>
-----------------------	---

### 7.13.2. Parameter limit

<b>Requirement 18</b>	<p>/req/core/fc-limit-definition</p> <p>Each feature collection operation SHALL support a parameter <b>limit</b> with the following characteristics (using an OpenAPI Specification 3.0 fragment):</p> <pre> name: limit in: query required: false schema:   type: integer   minimum: 1   maximum: 10000   default: 10 style: form explode: false </pre>
<b>Permission 1</b>	<p>/per/core/fc-limit-default-maximum</p> <p>The values for <b>maximum</b> and <b>default</b> in requirement <b>/req/core/fc-limit-definition</b> are only examples and MAY be changed.</p>
<b>Requirement 19</b>	<p>/req/core/fc-limit-response-1</p> <p>The response SHALL not contain more features than specified by the optional <b>limit</b> parameter. If the API definition specifies a maximum value for <b>limit</b> parameter, the response SHALL not contain more features than this maximum value.</p> <p>Only items are counted that are on the first level of the collection. Any nested objects contained within the explicitly requested items SHALL not be counted.</p>
<b>Permission 2</b>	<p>/per/core/fc-limit-response-2</p> <p>The server MAY return less features than requested (but not more).</p>

A template for the definition of the parameter in YAML according to OpenAPI 3.0 is available at [limit.yaml](#).

### 7.13.3. Parameter bbox

<b>Requirement 20</b>	<p>/req/core/fc-bbox-definition</p> <p>Each feature collection operation SHALL support a parameter <b>bbox</b> with the following characteristics (using an OpenAPI Specification 3.0 fragment):</p> <pre> name: bbox in: query required: false schema:   type: array   minItems: 4   maxItems: 6   items:     type: number style: form explode: false </pre>
<b>Requirement 21</b>	<p>/req/core/fc-bbox-response</p> <p>Only features that have a spatial geometry that intersects the bounding box SHALL be part of the result set, if the <b>bbox</b> parameter is provided.</p> <p>The bounding box is provided as four or six numbers, depending on whether the coordinate reference system includes a vertical axis (elevation or depth):</p> <ul style="list-style-type: none"> <li>• Lower left corner, coordinate axis 1</li> <li>• Lower left corner, coordinate axis 2</li> <li>• Lower left corner, coordinate axis 3 (optional)</li> <li>• Upper right corner, coordinate axis 1</li> <li>• Upper right corner, coordinate axis 2</li> <li>• Upper right corner, coordinate axis 3 (optional)</li> </ul> <p>The coordinate reference system of the values SHALL be interpreted as WGS84 longitude/latitude (<a href="http://www.opengis.net/def/crs/OGC/1.3/CRS84">http://www.opengis.net/def/crs/OGC/1.3/CRS84</a>) unless a different coordinate reference system is specified in a parameter <b>bbox-crs</b>.</p>

"Intersects" means that the rectangular area specified in the parameter **bbox** includes a coordinate that is part of the (spatial) geometry of the feature. This includes the boundaries of the geometries (e.g. for curves the start and end position and for surfaces the outer and inner rings).

This specification does not specify the parameter **bbox-crs**. This parameter will be specified in an

additional part of the WFS 3.0 series.

For WGS84 longitude/latitude the bounding box is in most cases the sequence of minimum longitude, minimum latitude, maximum longitude and maximum latitude. However, in cases where the box spans the antimeridian the first value (west-most box edge) is larger than the third value (east-most box edge).

*Example 5. The bounding box of the New Zealand Exclusive Economic Zone*

The bounding box of the New Zealand Exclusive Economic Zone in WGS84 (from 160.6°E to 170°W and from 55.95°S to 25.89°S) would be represented in JSON as [ 160.6, -55.95, -170, -25.89 ] and in a query as `bbox=160.6,-55.95,-170,-25.89`.

A template for the definition of the parameter in YAML according to OpenAPI 3.0 is available at [bbox.yaml](#).

#### 7.13.4. Parameter time

<b>Requirement 22</b>	<p>/req/core/fc-time-definition</p> <p>Each feature collection operation SHALL support a parameter <code>time</code> with the following characteristics (using an OpenAPI Specification 3.0 fragment):</p> <pre>name: time in: query required: false schema:   type: string style: form explode: false</pre>
<b>Requirement 23</b>	<p>/req/core/fc-time-response</p> <p>Only features that have a temporal geometry that intersects the timestamp or time period SHALL be part of the result set, if the <code>time</code> parameter is provided.</p> <p>The temporal information is either a date-time or a period string that adheres to RFC 3339.</p> <p>If a feature has multiple temporal properties, it is the decision of the server whether only a single temporal property is used to determine the extent or all relevant temporal properties.</p>

"Intersects" means that the time (instant or period) specified in the parameter `time` includes a

timestamp that is part of the temporal geometry of the feature (again, a time instant or period). For time periods this includes the start and end time.

*Example 6. A date-time*

February 12, 2018, 23:20:52 GMT:

`time=2018-02-12T23%3A20%3A50Z`

For features with a temporal property that is a timestamp (like `lastUpdate` in the building features), a date-time value would match all features where the temporal property is identical.

For features with a temporal property that is a date or a time period, a date-time value would match all features where the timestamp is on that day or within the time period.

*Example 7. A period using start and end time*

February 12, 2018, 00:00:00 GMT to March 18, 2018, 12:31:12 GMT:

`time=2018-02-12T00%3A00%3A00Z%2F2018-03-18T12%3A31%3A12Z`

*Example 8. A period using start time and a duration*

A duration of 1 month, 6 days, 12 hours, 31 minutes and 12 seconds from February 12, 2018, 00:00:00 GMT:

`time=2018-02-12T00%3A00%3A00Z%2FP1M6DT12H31M12S`

For features with a temporal property that is a timestamp (like `lastUpdate` in the building features), a time period would match all features where the temporal property is within the period.

For features with a temporal property that is a date or a time period, a time period would match all features where the values overlap.

A template for the definition of the parameter in YAML according to OpenAPI 3.0 is available at [time.yaml](#).

### 7.13.5. Parameters for filtering on feature properties

Recommendation 8	<p>/rec/core/fc-filters</p> <p>If features in the feature collection include a feature property that has a simple value (for example, a string or integer) that is expected to be useful for applications using the service to filter the features of the collection based on this property, you <b>SHOULD</b> support a parameter with the name of the feature property and with the following characteristics (using an OpenAPI Specification 3.0 fragment):</p> <pre> in: query required: false style: form explode: false </pre> <p>The <b>schema</b> property <b>SHOULD</b> be the same as the definition of the feature property in the response schema.</p>
------------------	--

*Example 9. An additional parameter to filter buildings based on their function*

```

name: function
in: query
description: >-
  Only return buildings of a particular function.\

  Default = return all buildings.
required: false
schema:
  type: string
  enum:
    - residential
    - commercial
    - public use
style: form
explode: false
example: 'function=public+use'

```



```
name: name
in: query
description: >-
  Only return buildings with a particular name. Use '*' as a wildcard.\

  Default = return all buildings.
required: false
schema:
  type: string
style: form
explode: false
example: 'name=A*'
```

For string-valued properties, servers could support wildcard searches. The example included in the OpenAPI fragment would search for all buildings with a name that starts with "A".

#### CAUTION

#### ISSUE 20

Query parameter name collisions.

### 7.13.6. Response

<b>Requirement 24</b>	<code>/req/core/fc-response</code>  A successful execution of the operation SHALL be reported as a response with a HTTP status code <b>200</b> .  The response SHALL only include features selected by the request.
-----------------------	---

The number of features returned depends on the server and the parameter **limit**:

- The client can request a limit it is interested in.
- The server likely has a default value for the limit, and a maximum limit.
- If the server has any more results available than it returns (the number it returns is less than or equal to the requested/default/maximum limit) then the server will include a link to the next set of results.

So (using the default/maximum values of 10/10000 from the OpenAPI fragment in requirement `/req/core/fc-limit-definition`):

- If you ask for 10, you will get 0 to 10 (as requested) and a **next** link, if there are more.
- If you don't specify a limit, you will get 0 to 10 (default) and a **next** link, if there are more.
- If you ask for 50000, you might get up to 10000 (server-limited) and a **next** link, if there are

more.

- If you follow the next link from the previous response, you might get up to 10000 additional features and a **next** link, if there are more.

Requirement 25	<p>/req/core/fc-links</p> <p>A <b>200</b>-response SHALL include the following links:</p> <ul style="list-style-type: none"><li>• a link to this response document (relation: <b>self</b>),</li><li>• a link to the response document in every other media type supported by the service (relation: <b>alternate</b>).</li></ul>
Recommendation 9	<p>/rec/core/fc-next-1</p> <p>A <b>200</b>-response SHOULD include a link to the next "page" (relation: <b>next</b>), if more features have been selected than returned in the response.</p>
Recommendation 10	<p>/rec/core/fc-next-2</p> <p>Dereferencing a <b>next</b> link SHOULD return additional features from the set of selected features that have not yet been returned.</p>
Recommendation 11	<p>/rec/core/fc-next-3</p> <p>The number of features in a response to a <b>next</b> link SHOULD follow the same rules as for the response to the original query and again include a <b>next</b> link, if there are more features in the selection that have not yet been returned.</p>

This document does not mandate any specific implementation approach for the **next** links.

An implementation could use opaque links that are managed by the server. It is up to the server to determine how long these links can be de-referenced. Clients should be prepared to receive a 404 response.

Another implementation approach is to use an implementation-specific parameter like the **startIndex** parameter that was used in previous versions of WFS (and which may be added again in an extension to this specification).

Permission 3	<p>/per/core/fc-prev</p> <p>A response to a <b>next</b> link MAY include a <b>prev</b> link to the resource that included the <b>next</b> link.</p>
--------------	---

Providing **prev** links supports navigating back and forth between pages, but depending on the implementation approach it may be complex to implement.

<b>Requirement 26</b>	<code>/req/core/fc-rel-type</code>  All links SHALL include the <b>rel</b> and <b>type</b> link parameters.
<b>Requirement 27</b>	<code>/req/core/fc-timeStamp</code>  If a property <b>timeStamp</b> is included in the response, the value SHALL be set to the time stamp when the response was generated.
<b>Requirement 28</b>	<code>/req/core/fc-numberMatched</code>  If a property <b>numberMatched</b> is included in the response, the value SHALL be identical to the number of features in the feature collections that match the selection parameters like <b>bbox</b> , <b>time</b> or additional filter parameters.  A server MAY omit this information in a response, if the information about the number of matching features is not known or difficult to compute.
<b>Requirement 29</b>	<code>/req/core/fc-numberReturned</code>  If a property <b>numberReturned</b> is included in the response, the value SHALL be identical to the number of features in the response.  A server MAY omit this information in a response, if the information about the number of features in the response is not known or difficult to compute.

**CAUTION**

Related to [ISSUE 8](#)

Define these as headers or include them in the payload? **timeStamp**, for example, may not be needed given the 'Date' HTTP header. For **numberMatched** and **numberReturned** headers do not seem to be a good idea as, for example, **numberReturned** can only be included at the end, if streaming is used.

**NOTE**

The representation of the links and the other properties in the payload depends on the encoding of the feature collection.

*Example 11. Links*

If the request is to return building features and "10" is the default **limit**, the links in the

response could be (in this example represented as link headers and using an additional parameter `startIndex` to implement `next` links - and the optional `prev` links):

```
Link: <http://data.example.org/collections/buildings/items.json>; rel="self";
type="application/geo+json"
Link: <http://data.example.org/collections/buildings/items.html>; rel="alternate";
type="text/html"
Link: <http://data.example.org/collections/buildings/items.json?startIndex=10>;
rel="next"; type="application/geo+json"
```

Following the `next` link could return:

```
Link: <http://data.example.org/collections/buildings/items.json?startIndex=10>;
rel="self"; type="application/geo+json"
Link: <http://data.example.org/collections/buildings/items.html?startIndex=10>;
rel="alternate"; type="text/html"
Link: <http://data.example.org/collections/buildings/items.json?startIndex=0>;
rel="prev"; type="application/geo+json"
Link: <http://data.example.org/collections/buildings/items.json?startIndex=20>;
rel="next"; type="application/geo+json"
```

If an explicit `limit` of "50" is used, the links in the response could be:

```
Link: <http://data.example.org/collections/buildings/items.json?limit=50>;
rel="self"; type="application/geo+json"
Link: <http://data.example.org/collections/buildings/items.html?limit=50>;
rel="alternate"; type="text/html"
Link:
<http://data.example.org/collections/buildings/items.json?limit=50&startIndex=50>;
rel="next"; type="application/geo+json"
```

Following the `next` link could return:

```
Link:
<http://data.example.org/collections/buildings/items.json?limit=50&startIndex=50>;
rel="self"; type="application/geo+json"
Link:
<http://data.example.org/collections/buildings/items.html?limit=50&startIndex=50>;
rel="alternate"; type="text/html"
Link:
<http://data.example.org/collections/buildings/items.json?limit=50&startIndex=0>;
rel="prev"; type="application/geo+json"
Link:
<http://data.example.org/collections/buildings/items.json?limit=50&startIndex=100>;
rel="next"; type="application/geo+json"
```

## 7.14. Feature

### 7.14.1. Operation

Requirement 30	<p>/req/core/f-op</p> <p>For every feature in a feature collection (path <code>/collections/{name}/items</code>), the service SHALL support the HTTP GET operation at the path <code>/collections/{name}/items/{id}</code>.</p> <p>The parameter <code>name</code> is each property of the same name in the feature collections metadata (JSONPath: <code>\$.collections[*].name</code>). <code>id</code> is a local identifier of the feature.</p>
Permission 4	<p>/per/core/f-id</p> <p>The Core requirements class only requires that the feature URI is unique. Implementations MAY apply stricter rules and, for example, use unique <code>id</code> values per dataset or collection.</p>

#### CAUTION

#### ISSUE 47

There are two types of feature identifiers and we need to make sure we distinguish between them.

### 7.14.2. Response

Requirement 31	<p>/req/core/f-success</p> <p>A successful execution of the operation SHALL be reported as a response with a HTTP status code <code>200</code>.</p>
Requirement 32	<p>/req/core/f-links</p> <p>A <code>200</code>-response SHALL include the following links in the response:</p> <ul style="list-style-type: none"><li>• a link to the response document (relation: <code>self</code>),</li><li>• a link to the response document in every other media type supported by the service (relation: <code>alternate</code>), and</li><li>• a link to the feature collection that contains this feature (relation: <code>collection</code>).</li></ul> <p>All links SHALL include the <code>rel</code> and <code>type</code> link parameters.</p>

**NOTE**

The representation of the links in the payload will depend on the encoding of the feature.

*Example 12. Links*

The links in a feature could be (in this example represented as link headers):

```
Link: <http://data.example.org/collections/buildings/items/123.json>; rel="self";  
type="application/geo+json"  
Link: <http://data.example.org/collections/buildings/items/123.html>;  
rel="alternate"; type="text/html"  
Link: <http://data.example.org/collections/buildings/items.json>;  
rel="collection"; type="application/geo+json"
```

# Chapter 8. Requirements classes for encodings

## 8.1. Overview

This clause specifies four pre-defined requirements classes for encodings to be used in a WFS. These encodings are commonly used encodings for spatial data on the web:

- [HTML](#)
- [GeoJSON](#)
- [Geography Markup Language \(GML\), Simple Features Profile, Level 0](#)
- [Geography Markup Language \(GML\), Simple Features Profile, Level 2](#)

None of these encodings is mandatory and an implementation of the [Core](#) requirements class may also decide to use none of them, but to use another encoding instead.

The [Core](#) requirements class includes recommendations to support [HTML](#) and [GeoJSON](#) as encodings, where practical. [Clause 6 \(Overview\)](#) includes a discussion about recommended encodings.

## 8.2. Requirement Class "HTML"

Geographic information that is only accessible in formats like GeoJSON or GML has two issues:

- it is not discoverable using the most common mechanism for discovering information, that is the search engines of the Web;
- it can not be viewed directly in a browser - additional tools are required to view the data.

Therefore, sharing data on the Web should include publication in HTML. To be consistent with the Web, it should be done in a way that enables users and search engines to access all data.

This is discussed in detail in [Best Practice 2: Make your spatial data indexable by search engines \[SDWBP\]](#). This standard therefore [recommends to support HTML as an encoding](#).

Requirements Class	
<a href="http://www.opengis.net/spec/wfs-1/3.0/req/html">http://www.opengis.net/spec/wfs-1/3.0/req/html</a>	
Target type	Web service
Dependency	<a href="#">WFS 3.0 Core</a>
Dependency	<a href="#">HTML5</a>
Dependency	<a href="#">Schema.org</a>

<b>Requirement 33</b>	/req/html/definition  Every 200-response of an operation of the server SHALL support the media type <code>text/html</code> .
<b>Requirement 34</b>	/req/html/content  Every 200-response of the server with the media type "text/html" SHALL be a <a href="#">HTML 5 document</a> that includes the following information in the HTML body: <ul style="list-style-type: none"> <li>• all information identified in the schemas of the <a href="#">Response Object</a> in the HTML <code>&lt;body/&gt;</code>, and</li> <li>• all links in HTML <code>&lt;a/&gt;</code> elements in the HTML <code>&lt;body/&gt;</code>.</li> </ul>
<b>Recommendation 12</b>	/rec/html/schema-org  A 200-response with the media type <code>text/html</code> , SHOULD include <a href="#">Schema.org</a> annotations.

## 8.3. Requirement Class "GeoJSON"

GeoJSON is a commonly used format that is simple to understand and well supported by tools and software libraries. Since most Web developers are comfortable with using a JSON-based format, supporting GeoJSON is recommended, if the feature data can be represented in GeoJSON for the intended use.

Requirements Class	
<a href="http://www.opengis.net/spec/wfs-1/3.0/req/geojson">http://www.opengis.net/spec/wfs-1/3.0/req/geojson</a>	
Target type	Web service
Dependency	<a href="#">WFS 3.0 Core</a>
Dependency	<a href="#">GeoJSON</a>
<b>Requirement 35</b>	/req/geojson/definition  200-responses of the server SHALL support the following media types: <ul style="list-style-type: none"> <li>• <code>application/geo+json</code> for feature collections and features, and</li> <li>• <code>application/json</code> for all other resources.</li> </ul>



<b>Requirement 36</b>	<p>/req/geojson/content</p> <p>Every 200-response with the media type <code>application/geo+json</code> SHALL be</p> <ul style="list-style-type: none"> <li>• a <a href="#">GeoJSON FeatureCollection Object</a> for feature collections, and</li> <li>• a <a href="#">GeoJSON Feature Object</a> for features.</li> </ul> <p>The links specified in the requirements <code>/req/core/fc-links</code> and <code>/req/core/f-links</code> SHALL be added in a extension property (foreign member) with the name <code>links</code>.</p> <p>The schema of all responses with the media type <code>application/json</code> SHALL conform with the JSON Schema specified for the resource in the requirements class <a href="#">WFS 3.0 Core</a>.</p>
-----------------------	---

Templates for the definition of the schemas for the GeoJSON responses in OpenAPI definitions are available at [featureCollectionGeoJSON.yaml](#) and [featureGeoJSON.yaml](#). These are generic schemas that do not include any application schema information about specific feature types or their properties.

*Example 13. A GeoJSON FeatureCollection Object response*

In the example below, only the first and tenth feature is shown. Coordinates are not shown.

```

{
  "type" : "FeatureCollection",
  "links" : [ {
    "href" : "http://data.example.com/collections/buildings/items/?f=json",
    "rel" : "self",
    "type" : "application/geo+json",
    "title" : "this document"
  }, {
    "href" : "http://data.example.com/collections/buildings/items/?f=html",
    "rel" : "alternate",
    "type" : "text/html",
    "title" : "this document as HTML"
  }, {
    "href" :
"http://data.example.com/collections/buildings/items/?f=json&startIndex=10&limit=10",
    "rel" : "next",
    "type" : "application/geo+json",
    "title" : "next page"
  } ],
  "timestamp" : "2018-04-03T14:52:23Z",
  "numberMatched" : 123,
  "numberReturned" : 10,
  "features" : [ {
    "type" : "Feature",
    "id" : "123",
    "geometry" : {
      "type" : "Polygon",
      "coordinates" : [ ... ]
    },
    "properties" : {
      "function" : "residential",
      "floors" : "2",
      "lastUpdate" : "2015-08-01T12:34:56Z"
    }
  }, { ...
  }, {
    "type" : "Feature",
    "id" : "132",
    "geometry" : {
      "type" : "Polygon",
      "coordinates" : [ ... ]
    },
    "properties" : {
      "function" : "public use",
      "floors" : "10",
      "lastUpdate" : "2013-12-03T10:15:37Z"
    }
  } ]
}

```

In the example below, coordinates are not shown.

```
{
  "type" : "Feature",
  "links" : [ {
    "href" : "http://data.example.com/collections/buildings/items/123/?f=json",
    "rel" : "self",
    "type" : "application/geo+json",
    "title" : "this document"
  }, {
    "href" : "http://data.example.com/collections/buildings/items/123/?f=html",
    "rel" : "alternate",
    "type" : "text/html",
    "title" : "this document as HTML"
  }, {
    "href" : "http://data.example.com/collections/buildings/items",
    "rel" : "collection",
    "type" : "application/geo+json",
    "title" : "the collection document"
  } ],
  "id" : "123",
  "geometry" : {
    "type" : "Polygon",
    "coordinates" : [ ... ]
  },
  "properties" : {
    "function" : "residential",
    "floors" : "2",
    "lastUpdate" : "2015-08-01T12:34:56Z"
  }
}
```

## 8.4. Requirement Class "Geography Markup Language (GML), Simple Features Profile, Level 0"

In addition to HTML and GeoJSON, a significant amount of feature data is available in XML-based formats, notably GML. Therefore, this standard specifies requirement classes for GML. The Simple Features Profile, Level 0, is the simplest profile of GML and is typically supported by tools. It is restricted to data with 2D geometries supported by most tools. In addition, the profile is limited to features that can be stored in a tabular data structure.

Requirements Class	
<a href="http://www.opengis.net/spec/wfs-1/3.0/req/gmlsf0">http://www.opengis.net/spec/wfs-1/3.0/req/gmlsf0</a>	
Target type	Web service

Dependency	<a href="#">WFS 3.0 Core</a>
Dependency	<a href="#">Geography Markup Language (GML), Simple Features Profile, Level 0</a>

<b>Requirement 37</b>	<p>/req/gmlsf0/definition</p> <p>200-responses of the server SHALL support the following media types:</p> <ul style="list-style-type: none"> <li>• <a href="#">application/gml+xml;version=3.2;profile=http://www.opengis.net/def/profile/ogc/2.0/gml-sf0</a> for feature collections and features,</li> <li>• <a href="#">application/xml</a> for all other resources.</li> </ul>
-----------------------	--

<b>Requirement 38</b>	<p>/req/gmlsf0/content</p> <p>Every 200-response with the media type <a href="#">application/gml+xml;version=3.2;profile=http://www.opengis.net/def/profile/ogc/2.0/gml-sf0</a> SHALL be</p> <ul style="list-style-type: none"> <li>• a <a href="#">WFS 3.0 Core FeatureCollection Object</a> for feature collections, and</li> <li>• a <a href="#">GML 3.2 Feature</a> for features.</li> </ul> <p>Every feature SHALL conform to the <a href="#">GML Simple Features Profile, Level 0</a>.</p> <p>The schema of all responses with the media type <a href="#">application/xml</a> SHALL conform with XML Schema ....</p> <p>The links specified in the requirements <a href="#">/req/core/fc-links</a> and <a href="#">/req/core/f-links</a> SHALL be added in ...</p>
-----------------------	--

<b>CAUTION</b>	<p><a href="#">ISSUE 58</a></p> <p>Add and describe XML schema for XML/GML responses. Clarify the mapping of the resources from Core to the XML schema. Add examples.</p>
----------------	---

## 8.5. Requirement Class "Geography Markup Language (GML), Simple Features Profile, Level 2"

The difference between this requirement class and the [Level 0](#) requirements class is that non-spatial feature properties are not restricted to atomic values (strings, numbers, etc.).

<b>Requirements Class</b>	
<a href="http://www.opengis.net/spec/wfs-1/3.0/req/gmlsf2">http://www.opengis.net/spec/wfs-1/3.0/req/gmlsf2</a>	
Target type	Web service

Dependency	<a href="#">WFS 3.0 Core</a>
Dependency	<a href="#">Geography Markup Language (GML), Simple Features Profile, Level 2</a>

<b>Requirement 39</b>	<p>/req/gmlsf2/definition</p> <p>200-responses of the server SHALL support the following media types:</p> <ul style="list-style-type: none"> <li>• <a href="#">application/gml+xml;version=3.2;profile=http://www.opengis.net/def/profile/ogc/2.0/gml-sf2</a> for feature collections and features,</li> <li>• <a href="#">application/xml</a> for all other resources.</li> </ul>
-----------------------	--

<b>Requirement 40</b>	<p>/req/gmlsf0/content</p> <p>Every 200-response with the media type <a href="#">application/gml+xml;version=3.2;profile=http://www.opengis.net/def/profile/ogc/2.0/gml-sf2</a> SHALL be</p> <ul style="list-style-type: none"> <li>• a <a href="#">WFS 3.0 Core FeatureCollection Object</a> for feature collections, and</li> <li>• a <a href="#">GML 3.2 Feature</a> for features.</li> </ul> <p>Every feature SHALL conform to the <a href="#">GML Simple Features Profile, Level 2</a>.</p> <p>The schema of all responses with the media type <a href="#">application/xml</a> SHALL conform with XML Schema ....</p> <p>The links specified in the requirements <a href="#">/req/core/fc-links</a> and <a href="#">/req/core/f-links</a> SHALL be added in ...</p>
-----------------------	--

## CAUTION

### ISSUE 58

See the same note in the "Geography Markup Language (GML), Simple Features Profile, Level 0" requirements class above.

# Chapter 9. Requirements class "OpenAPI 3.0"

## 9.1. Basic requirements

The API of servers conforming to this requirements class are defined by an [OpenAPI Document](#).

Requirements Class	
<a href="http://www.opengis.net/spec/wfs-1/3.0/req/oas30">http://www.opengis.net/spec/wfs-1/3.0/req/oas30</a>	
Target type	Web service
Dependency	<a href="#">WFS 3.0 Core</a>
Dependency	<a href="#">OpenAPI Specification 3.0.1</a>

<b>Requirement 41</b>	<code>/req/oas30/oas-definition-1</code>  The service SHALL provide an OpenAPI definition in JSON and HTML at the path <code>/api</code> using the media type <code>application/openapi+json;version=3.0</code> .
-----------------------	---

<b>Requirement 42</b>	<code>/req/oas30/oas-definition-2</code>  The JSON representation SHALL conform to the <a href="#">OpenAPI Specification, version 3.0</a> .
-----------------------	---

<b>CAUTION</b>	Related to <a href="#">ISSUE 90</a> If we have a rigid path pattern there seems to be no need to add requirements for fixed operationId values. However, if the path pattern would be flexible, maybe we should require specific operationIds for selected resources?
----------------	--

Two example OpenAPI documents are included in [Annex B](#).

<b>Requirement 43</b>	<code>/req/oas30/oas-impl</code>  The server SHALL implement all capabilities specified in the OpenAPI definition.
-----------------------	--

<b>CAUTION</b>	<a href="#">ISSUE 46</a> Currently, no tool is known to validate that a server implements the API specified in its OpenAPI definition.
----------------	---

## 9.2. Complete definition

<b>Requirement 44</b>	<p>/req/oas30/completeness</p> <p>The OpenAPI definition SHALL specify for each operation all <a href="#">HTTP Status Codes</a> and <a href="#">Response Objects</a> that the server uses in responses.</p> <p>This includes the successful execution of an operation as well as all error situations that originate from the server.</p>
-----------------------	---

Note that servers that, for example, are access-controlled (see [Security](#)), that support web cache validation, CORS or that use HTTP redirection will make use of additional HTTP status codes beyond regular codes like **200** for successful GET requests and **400**, **404** or **500** for error situations.

Clients have to be prepared to receive responses not documented in the OpenAPI definition. For example, additional errors may occur in the transport layer outside of the server.

## 9.3. Exceptions

<b>Requirement 45</b>	<p>/req/oas30/exceptions-codes</p> <p>For error situations that originate from the server, the API definition SHALL cover all applicable HTTP Status Codes.</p>
-----------------------	---

### CAUTION

#### [ISSUE 45](#)

Listing of all applicable HTTP Status Codes

### CAUTION

#### [ISSUE 105](#)

WFS 2.0 defined exception codes and mapped them to HTTP status codes. Should WFS 3.0 do this, too, or should we simply require that http status codes are used correctly?

```
description: An error occurred.
content:
  application/json:
    schema:
      $ref:
        https://raw.githubusercontent.com/opengeospatial/WFS_FES/master/core/openapi/schemas/exception.yaml
  text/html:
    schema:
      type: string
```

## 9.4. Security

<b>Requirement 46</b>	<code>/req/oas30/security</code>  For cases, where the operations of the server are access-controlled, the security scheme(s) SHALL be documented in the OpenAPI definition.
-----------------------	--

The OpenAPI specification currently supports the following [security schemes](#):

- HTTP authentication,
- an API key (either as a header or as a query parameter),
- OAuth2's common flows (implicit, password, application and access code) as defined in RFC6749, and
- OpenID Connect Discovery.

<b>CAUTION</b>	<b>ISSUE 41</b> How does a client determine which security protocols/standards/etc. a server supports?
----------------	---

## 9.5. Features

<b>Recommendation 13</b>	<code>/rec/oas30/f-key-properties</code>  The schema for the Response Objects of the HTTP GET operation for features SHOULD include key feature properties of the features in that feature collection.  This is in particular helpful, if filter parameters are defined for the collection (see recommendation <a href="#">/rec/core/fc-filters</a> ).
--------------------------	--



# Chapter 10. Media Types

JSON media types that would typically be used in a WFS that supports JSON are

- `application/geo+json` for feature collections and features, and
- `application/json` for all other resources.

XML media types that would typically occur in a WFS that supports XML are

- `application/gml+xml;version=3.2` for any GML 3.2 feature collections and features,
- `application/gml+xml;version=3.2;profile=http://www.opengis.net/def/profile/ogc/2.0/gml-sf0` for GML 3.2 feature collections and features conforming to the GML Simple Feature Level 0 profile,
- `application/gml+xml;version=3.2;profile=http://www.opengis.net/def/profile/ogc/2.0/gml-sf2` for GML 3.2 feature collections and features conforming to the GML Simple Feature Level 2 profile, and
- `application/xml` for all other resources.

The typical HTML media type for all "web pages" in a WFS would be `text/html`.

The media type for an OpenAPI definition in JSON is `application/openapi+json;version=3.0`.

## NOTE

The media type for the OpenAPI definition has not yet been registered with IANA. See <https://github.com/OAI/OpenAPI-Specification/issues/110>.

# Annex A: Conformance Class Abstract Test Suite (Normative)

NOTE

TODO

CAUTION

[ISSUE 46](#)

OpenAPI Validation

# Annex B: OpenAPI definition example (Informative)

## B.1. Overview

This annex includes two complete examples of an OpenAPI definition for a WFS.

The first example ([Generic OpenAPI definition](#)) is a generic example that uses path parameters to describe all feature collections and all features. This OpenAPI definition does not provide any details on the collections or the feature content. This information is only available from the feature collection metadata.

The second example ([OpenAPI definition with details on the collection and its features](#)) does not use a path parameter for the collections and explicitly provides information about the feature collection 'buildings' (paths `/collections/buildings` etc.), the schema of the building features (schema `buildingGeoJSON`) and a filter parameter for building features (parameter `function`).

## B.2. Generic OpenAPI definition

```
openapi: 3.0.1
info:
  title: A sample API conforming to the OGC Web Feature Service standard
  version: 0.0.1
  description: >-
    This is a sample OpenAPI definition that conforms to the OGC Web Feature
    Service specification (conformance classes: "Core", "GeoJSON", "HTML" and
    "OpenAPI 3.0").
  contact:
    name: Acme Corporation
    email: info@example.org
    url: 'http://example.org/'
  license:
    name: CC-BY 4.0 license
    url: 'https://creativecommons.org/licenses/by/4.0/'
servers:
  - url: 'https://dev.example.org/'
    description: Development server
  - url: 'https://data.example.org/'
    description: Production server
paths:
  '/':
    get:
      summary: landing page of this API
      description: >-
        The landing page provides links to the API definition, the Conformance
        statements and the metadata about the feature data in this dataset.
      operationId: getLandingPage
```

```

tags:
  - Capabilities
responses:
  '200':
    description: links to the API capabilities
    content:
      application/json:
        schema:
          $ref: '#/components/schemas/root'
      text/html:
        schema:
          type: string
'/conformance':
  get:
    summary: information about standards that this API conforms to
    description: >-
      list all requirements classes specified in a standard (e.g., WFS 3.0
      Part 1: Core) that the server conforms to
    operationId: getRequirementsClasses
    tags:
      - Capabilities
    responses:
      '200':
        description: the URIs of all requirements classes supported by the server
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/req-classes'
      default:
        description: An error occurred.
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/exception'
'/collections':
  get:
    summary: describe the feature collections in the dataset
    operationId: describeCollections
    tags:
      - Capabilities
    responses:
      '200':
        description: Metadata about the feature collections shared by this API.
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/content'
          text/html:
            schema:
              type: string
      default:

```

```

    description: An error occurred.
    content:
      application/json:
        schema:
          $ref: '#/components/schemas/exception'
      text/html:
        schema:
          type: string
'/collections/{collectionId}':
  get:
    summary: 'describe the {collectionId} feature collection'
    operationId: describeCollection
    tags:
      - Capabilities
    parameters:
      - $ref: '#/components/parameters/collectionId'
    responses:
      '200':
        description: 'Metadata about the {collectionId} collection shared by this
API.'
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/collectionInfo'
          text/html:
            schema:
              type: string
    default:
      description: An error occurred.
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/exception'
        text/html:
          schema:
            type: string
'/collections/{collectionId}/items':
  get:
    summary: 'retrieve features of feature collection {collectionId}'
    description: >-
      Every feature in a dataset belongs to a collection. A dataset may
      consist of multiple feature collections. A feature collection is often a
      collection of features of a similar type, based on a common schema.\

      Use content negotiation to request HTML or GeoJSON.
    operationId: getFeatures
    tags:
      - Features
    parameters:
      - $ref: '#/components/parameters/collectionId'
      - $ref: '#/components/parameters/limit'

```

```

- $ref: '#/components/parameters/bbox'
- $ref: '#/components/parameters/time'
responses:
  '200':
    description: >-
      Information about the feature collection plus the first features
      matching the selection parameters.
    content:
      application/geo+json:
        schema:
          $ref: '#/components/schemas/featureCollectionGeoJSON'
      text/html:
        schema:
          type: string
    default:
      description: An error occurred.
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/exception'
        text/html:
          schema:
            type: string
'/collections/{collectionId}/items/{featureId}':
  get:
    summary: retrieve a feature; use content negotiation to request HTML or GeoJSON
    operationId: getFeature
    tags:
      - Features
    parameters:
      - $ref: '#/components/parameters/collectionId'
      - $ref: '#/components/parameters/featureId'
    responses:
      '200':
        description: A feature.
        content:
          application/geo+json:
            schema:
              $ref: '#/components/schemas/featureGeoJSON'
          text/html:
            schema:
              type: string
        default:
          description: An error occurred.
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/exception'
            text/html:
              schema:
                type: string

```

components:

parameters:

limit:

name: limit

in: query

description: |

The optional limit parameter limits the number of items that are presented in the response document.

Only items are counted that are on the first level of the collection in the response document. Nested objects contained within the explicitly requested items shall not be counted.

\* Minimum = 1

\* Maximum = 10000

\* Default = 10

required: false

schema:

type: integer

minimum: 1

maximum: 10000

default: 10

style: form

explode: false

bbox:

name: bbox

in: query

description: >

Only features that have a geometry that intersects the bounding box are selected.

The bounding box is provided as four or six numbers, depending on whether the coordinate reference system includes a vertical axis (elevation or depth):

\* Lower left corner, coordinate axis 1

\* Lower left corner, coordinate axis 2

\* Lower left corner, coordinate axis 3 (optional)

\* Upper right corner, coordinate axis 1

\* Upper right corner, coordinate axis 2

\* Upper right corner, coordinate axis 3 (optional)

The coordinate reference system of the values is WGS84 longitude/latitude (<http://www.opengis.net/def/crs/OGC/1.3/CRS84>) unless a different coordinate reference system is specified in the parameter `bbox-crs`.

For WGS84 longitude/latitude the values are in most cases the sequence of minimum longitude, minimum latitude, maximum longitude and maximum latitude. However, in cases where the box spans the antimeridian the first value (west-most box edge) is larger than the third value (east-most box edge).

If a feature has multiple spatial geometry properties, it is the decision of the

server whether only a single spatial geometry property is used to determine the extent or all relevant geometries.

required: false

schema:

type: array

minItems: 4

maxItems: 6

items:

type: number

style: form

explode: false

time:

name: time

in: query

description: >-

Either a date-time or a period string that adheres to RFC 3339. Examples:

\* A date-time: "2018-02-12T23:20:50Z"

\* A period: "2018-02-12T00:00:00Z/2018-03-18T12:31:12Z" or "2018-02-12T00:00:00Z/P1M6DT12H31M12S"

Only features that have a temporal property that intersects the value of `time` are selected.

If a feature has multiple temporal properties, it is the decision of the server whether only a single temporal property is used to determine the extent or all relevant temporal properties.

required: false

schema:

type: string

style: form

explode: false

collectionId:

name: collectionId

in: path

required: true

description: Identifier (name) of a specific collection

schema:

type: string

featureId:

name: featureId

in: path

description: Local identifier of a specific feature

required: true

schema:

type: string

schemas:

exception:

type: object

required:

- code



```

properties:
  code:
    type: string
  description:
    type: string
root:
  type: object
  required:
    - links
  properties:
    links:
      type: array
      items:
        $ref: '#/components/schemas/link'
      example:
        - href: 'http://data.example.org/'
          rel: self
          type: application/json
          title: this document
        - href: 'http://data.example.org/api'
          rel: service
          type: application/openapi+json;version=3.0
          title: the API definition
        - href: 'http://data.example.org/conformance'
          rel: conformance
          type: application/json
          title: WFS 3.0 conformance classes implemented by this server
        - href: 'http://data.example.org/collections'
          rel: data
          type: application/json
          title: Metadata about the feature collections
req-classes:
  type: object
  required:
    - conformsTo
  properties:
    conformsTo:
      type: array
      items:
        type: string
      example:
        - 'http://www.opengis.net/spec/wfs-1/3.0/req/core'
        - 'http://www.opengis.net/spec/wfs-1/3.0/req/oas30'
        - 'http://www.opengis.net/spec/wfs-1/3.0/req/html'
        - 'http://www.opengis.net/spec/wfs-1/3.0/req/geojson'
link:
  type: object
  required:
    - href
  properties:
    href:

```

```

    type: string
  rel:
    type: string
    example: prev
  type:
    type: string
    example: application/geo+json
  hreflang:
    type: string
    example: en
content:
  type: object
  required:
    - links
    - collections
  properties:
    links:
      type: array
      items:
        $ref: '#/components/schemas/link'
      example:
        - href: 'http://data.example.org/collections.json'
          rel: self
          type: application/json
          title: this document
        - href: 'http://data.example.org/collections.html'
          rel: alternate
          type: text/html
          title: this document as HTML
        - href: 'http://schemas.example.org/1.0/foobar.xsd'
          rel: describedBy
          type: application/xml
          title: XML schema for Acme Corporation data
    collections:
      type: array
      items:
        $ref: '#/components/schemas/collectionInfo'
collectionInfo:
  type: object
  required:
    - name
    - links
  properties:
    name:
      description: 'identifier of the collection used, for example, in URIs'
      type: string
      example: buildings
    title:
      description: 'human readable title of the collection'
      type: string
      example: Buildings

```

```

description:
  description: 'a description of the features in the collection'
  type: string
  example: Buildings in the city of Bonn.
links:
  type: array
  items:
    $ref: '#/components/schemas/link'
  example:
    - href: 'http://data.example.org/collections/buildings/items'
      rel: item
      type: application/geo+json
      title: Buildings
    - href: 'http://example.org/concepts/building.html'
      rel: describedBy
      type: text/html
      title: Feature catalogue for buildings
extent:
  $ref: '#/components/schemas/extent'
crs:
  description: >-
    The coordinate reference systems in which geometries
    may be retrieved. Coordinate reference systems are identified
    by a URI. The first coordinate reference system is the
    coordinate reference system that is used by default. This
    is always "http://www.opengis.net/def/crs/OGC/1.3/CRS84", i.e.
    WGS84 longitude/latitude.
  type: array
  items:
    type: string
  default:
    - 'http://www.opengis.net/def/crs/OGC/1.3/CRS84'
extent:
  type: object
  properties:
    crs:
      description: >-
        Coordinate reference system of the coordinates in the spatial extent
        (property `spatial`).
        In the Core, only WGS84 longitude/latitude is supported. Extensions may
        support additional
        coordinate reference systems.
      type: string
      enum:
        - 'http://www.opengis.net/def/crs/OGC/1.3/CRS84'
      default: 'http://www.opengis.net/def/crs/OGC/1.3/CRS84'
    spatial:
      description: >-
        West, north, east, south edges of the spatial extent. The minimum and
        maximum values apply to the coordinate reference system WGS84
        longitude/latitude

```

that is supported in the Core. If, for example, a projected coordinate reference

system is used, the minimum and maximum values need to be adjusted.

type: array

minItems: 4

maxItems: 6

items:

type: number

example:

- -180

- -90

- 180

- 90

trs:

description: >-

Temporal reference system of the coordinates in the temporal extent (property `temporal`).

In the Core, only the Gregorian calendar is supported. Extensions may support additional

temporal reference systems.

type: string

enum:

- 'http://www.opengis.net/def/uom/ISO-8601/0/Gregorian'

default: 'http://www.opengis.net/def/uom/ISO-8601/0/Gregorian'

temporal:

description: Begin and end times of the temporal extent.

type: array

minItems: 2

maxItems: 2

items:

type: string

format: dateTime

example:

- '2011-11-11T12:22:11Z'

- '2012-11-24T12:32:43Z'

featureCollectionGeoJSON:

type: object

required:

- features

properties:

features:

type: array

items:

\$ref: '#/components/schemas/featureGeoJSON'

featureGeoJSON:

type: object

required:

- type

- geometry

- properties

properties:

```

    type:
      type: string
      enum:
        - Feature
    geometry:
      $ref: '#/components/schemas/geometryGeoJSON'
    properties:
      type: object
      nullable: true
    id:
      oneOf:
        - type: string
        - type: integer
  geometryGeoJSON:
    type: object
    required:
      - type
    properties:
      type:
        type: string
        enum:
          - Point
          - MultiPoint
          - LineString
          - MultiLineString
          - Polygon
          - MultiPolygon
          - GeometryCollection
  tags:
    - name: Capabilities
      description: >-
        Essential characteristics of this API including information about the
        data.
    - name: Features
      description: >-
        Access to data (features).
```

### B.3. OpenAPI definition with details on the collection and its features

```

openapi: 3.0.1
info:
  title: A sample API conforming to the OGC Web Feature Service standard
  version: 0.0.1
  description: >-
    This is a sample OpenAPI definition that conforms to the OGC Web Feature
    Service specification (conformance classes: "Core", "GeoJSON", "HTML" and
    "OpenAPI 3.0").\
```

The API provides access to a single feature collection: buildings. The buildings have a few (optional) properties: the polygon geometry of the building footprint, a name, the function of the building (residential, commercial or public use), the floor count and the timestamp of the last update of the building feature in the dataset.

contact:

name: Acme Corporation  
email: info@example.org  
url: 'http://example.org/'

license:

name: CC-BY 4.0 license  
url: 'https://creativecommons.org/licenses/by/4.0/'

servers:

- url: 'https://dev.example.org/'  
description: Development server
- url: 'https://data.example.org/'  
description: Production server

paths:

'/':

get:

summary: landing page of this API

description: >-

The landing page provides links to the API definition, the Conformance statements and the metadata about the feature data in this dataset.

operationId: getLandingPage

tags:

- Capabilities

responses:

'200':

description: links to the API capabilities

content:

application/json:

schema:

\$ref: '#/components/schemas/root'

text/html:

schema:

type: string

'/conformance':

get:

summary: information about standards that this API conforms to

description: >-

list all requirements classes specified in a standard (e.g., WFS 3.0 Part 1: Core) that the server conforms to

operationId: getRequirementsClasses

tags:

- Capabilities

responses:

'200':

description: the URIs of all requirements classes supported by the server

content:

```

        application/json:
          schema:
            $ref: '#/components/schemas/req-classes'
      default:
        description: An error occurred.
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/exception'
'/collections':
  get:
    summary: describe the feature collections in the dataset
    operationId: describeCollections
    tags:
      - Capabilities
    responses:
      '200':
        description: Metadata about the feature collections shared by this API.
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/content'
          text/html:
            schema:
              type: string
      default:
        description: An error occurred.
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/exception'
          text/html:
            schema:
              type: string
'/collections/buildings':
  get:
    summary: 'describe the buildings feature collection'
    operationId: describeCollection
    tags:
      - Capabilities
    responses:
      '200':
        description: 'Metadata about the buildings collection shared by this API.'
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/collectionInfo'
          text/html:
            schema:
              type: string
      default:

```

```

    description: An error occurred.
    content:
      application/json:
        schema:
          $ref: '#/components/schemas/exception'
      text/html:
        schema:
          type: string
'/collections/buildings/items':
  get:
    summary: 'retrieve features of buildings feature collection'
    description: >-
      Every feature in a dataset belongs to a collection. A dataset may
      consist of multiple feature collections. A feature collection is often a
      collection of features of a similar type, based on a common schema.\

      Use content negotiation to request HTML or GeoJSON.
    operationId: getFeatures
    tags:
      - Features
    parameters:
      - $ref: '#/components/parameters/limit'
      - $ref: '#/components/parameters/bbox'
      - $ref: '#/components/parameters/time'
      - $ref: '#/components/parameters/function'
    responses:
      '200':
        description: >-
          Information about the feature collection plus the first features
          matching the selection parameters.
        content:
          application/geo+json:
            schema:
              $ref: '#/components/schemas/featureCollectionGeoJSON'
          text/html:
            schema:
              type: string
      default:
        description: An error occurred.
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/exception'
          text/html:
            schema:
              type: string
'/collections/buildings/items.json':
  get:
    summary: 'retrieve features of buildings feature collection in GeoJSON'
    description: >-
      Every feature in a dataset belongs to a collection. A dataset may

```



consist of multiple feature collections. A feature collection is often a collection of features of a similar type, based on a common schema.\

This operation returns GeoJSON.

operationId: getFeaturesJSON

tags:

- Features

parameters:

- \$ref: '#/components/parameters/limit'
- \$ref: '#/components/parameters/bbox'
- \$ref: '#/components/parameters/time'
- \$ref: '#/components/parameters/function'

responses:

'200':

description: >-

Information about the feature collection plus the first features matching the selection parameters.

content:

application/geo+json:

schema:

\$ref: '#/components/schemas/featureCollectionGeoJSON'

default:

description: An error occurred.

content:

application/json:

schema:

\$ref: '#/components/schemas/exception'

'/collections/buildings/items/{featureId}':

get:

summary: retrieve a feature; use content negotiation to request HTML or GeoJSON

operationId: getFeature

tags:

- Features

parameters:

- \$ref: '#/components/parameters/featureId'

responses:

'200':

description: A feature.

content:

application/geo+json:

schema:

\$ref: '#/components/schemas/buildingGeoJSON'

text/html:

schema:

type: string

default:

description: An error occurred.

content:

application/json:

schema:

\$ref: '#/components/schemas/exception'

```

    text/html:
      schema:
        type: string
'/collections/buildings/items/{featureId}.json':
  get:
    summary: retrieve a feature in GeoJSON
    operationId: getFeatureJSON
    tags:
      - Features
    parameters:
      - $ref: '#/components/parameters/featureId'
    responses:
      '200':
        description: A feature.
        content:
          application/geo+json:
            schema:
              $ref: '#/components/schemas/buildingGeoJSON'
      default:
        description: An error occurred.
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/exception'
components:
  parameters:
    limit:
      name: limit
      in: query
      description: |
        The optional limit parameter limits the number of items that are
        presented in the response document.

        Only items are counted that are on the first level of the collection in
        the response document. Nested objects contained within the explicitly
        requested items shall not be counted.

        * Minimum = 1
        * Maximum = 10000
        * Default = 10
      required: false
      schema:
        type: integer
        minimum: 1
        maximum: 10000
        default: 10
      style: form
      explode: false
    bbox:
      name: bbox
      in: query

```

description: >

Only features that have a geometry that intersects the bounding box are selected.

The bounding box is provided as four or six numbers, depending on whether the coordinate reference system includes a vertical axis (elevation or depth):

- \* Lower left corner, coordinate axis 1
- \* Lower left corner, coordinate axis 2
- \* Lower left corner, coordinate axis 3 (optional)
- \* Upper right corner, coordinate axis 1
- \* Upper right corner, coordinate axis 2
- \* Upper right corner, coordinate axis 3 (optional)

The coordinate reference system of the values is WGS84 longitude/latitude (<http://www.opengis.net/def/crs/OGC/1.3/CRS84>) unless a different coordinate reference system is specified in the parameter `bbox-crs`.

For WGS84 longitude/latitude the values are in most cases the sequence of minimum longitude, minimum latitude, maximum longitude and maximum latitude. However, in cases where the box spans the antimeridian the first value (west-most box edge) is larger than the third value (east-most box edge).

If a feature has multiple spatial geometry properties, it is the decision of the

server whether only a single spatial geometry property is used to determine the extent or all relevant geometries.

required: false

schema:

type: array

minItems: 4

maxItems: 6

items:

type: number

style: form

explode: false

time:

name: time

in: query

description: >-

Either a date-time or a period string that adheres to RFC 3339. Examples:

\* A date-time: "2018-02-12T23:20:50Z"

\* A period: "2018-02-12T00:00:00Z/2018-03-18T12:31:12Z" or "2018-02-12T00:00:00Z/P1M6DT12H31M12S"

Only features that have a temporal property that intersects the value of `time` are selected.

If a feature has multiple temporal properties, it is the decision of the server whether only a single temporal property is used to determine the extent or all relevant temporal properties.

```

    required: false
    schema:
      type: string
    style: form
    explode: false
  function:
    name: function
    in: query
    description: >-
      Only return buildings of a particular function.\

      Default = return all buildings.
    required: false
    schema:
      type: string
      enum:
        - residential
        - commercial
        - public use
    style: form
    explode: false
    example: 'function=public+use'
  featureId:
    name: featureId
    in: path
    description: Local identifier of a specific feature
    required: true
    schema:
      type: string
  schemas:
    exception:
      type: object
      required:
        - code
      properties:
        code:
          type: string
        description:
          type: string
  root:
    type: object
    required:
      - links
    properties:
      links:
        type: array
        items:
          $ref: '#/components/schemas/link'
        example:
          - href: 'http://data.example.org/'
            rel: self

```

```

    type: application/json
    title: this document
  - href: 'http://data.example.org/api'
    rel: service
    type: application/openapi+json;version=3.0
    title: the API definition
  - href: 'http://data.example.org/conformance'
    rel: conformance
    type: application/json
    title: WFS 3.0 conformance classes implemented by this server
  - href: 'http://data.example.org/collections'
    rel: data
    type: application/json
    title: Metadata about the feature collections
req-classes:
  type: object
  required:
    - conformsTo
  properties:
    conformsTo:
      type: array
      items:
        type: string
    example:
      - 'http://www.opengis.net/spec/wfs-1/3.0/req/core'
      - 'http://www.opengis.net/spec/wfs-1/3.0/req/oas30'
      - 'http://www.opengis.net/spec/wfs-1/3.0/req/html'
      - 'http://www.opengis.net/spec/wfs-1/3.0/req/geojson'
link:
  type: object
  required:
    - href
  properties:
    href:
      type: string
    rel:
      type: string
      example: prev
    type:
      type: string
      example: application/geo+json
    hreflang:
      type: string
      example: en
content:
  type: object
  required:
    - links
    - collections
  properties:
    links:

```

```

    type: array
    items:
      $ref: '#/components/schemas/link'
  example:
    - href: 'http://data.example.org/collections.json'
      rel: self
      type: application/json
      title: this document
    - href: 'http://data.example.org/collections.html'
      rel: alternate
      type: text/html
      title: this document as HTML
    - href: 'http://schemas.example.org/1.0/foobar.xsd'
      rel: describedBy
      type: application/xml
      title: XML schema for Acme Corporation data
  collections:
    type: array
    items:
      $ref: '#/components/schemas/collectionInfo'
  collectionInfo:
    type: object
    required:
      - name
      - links
    properties:
      name:
        description: 'identifier of the collection used, for example, in URIs'
        type: string
        example: buildings
      title:
        description: 'human readable title of the collection'
        type: string
        example: Buildings
      description:
        description: 'a description of the features in the collection'
        type: string
        example: Buildings in the city of Bonn.
      links:
        type: array
        items:
          $ref: '#/components/schemas/link'
    example:
      - href: 'http://data.example.org/collections/buildings/items'
        rel: item
        type: application/geo+json
        title: Buildings
      - href: 'http://example.org/concepts/building.html'
        rel: describedBy
        type: text/html
        title: Feature catalogue for buildings

```

```

    extent:
      $ref: '#/components/schemas/extent'
    crs:
      description: >-
        The coordinate reference systems in which geometries
        may be retrieved. Coordinate reference systems are identified
        by a URI. The first coordinate reference system is the
        coordinate reference system that is used by default. This
        is always "http://www.opengis.net/def/crs/OGC/1.3/CRS84", i.e.
        WGS84 longitude/latitude.
      type: array
      items:
        type: string
      default:
        - 'http://www.opengis.net/def/crs/OGC/1.3/CRS84'
  extent:
    type: object
    properties:
      crs:
        description: >-
          Coordinate reference system of the coordinates in the spatial extent
          (property `spatial`).
          In the Core, only WGS84 longitude/latitude is supported. Extensions may
          support additional
          coordinate reference systems.
        type: string
        enum:
          - 'http://www.opengis.net/def/crs/OGC/1.3/CRS84'
        default: 'http://www.opengis.net/def/crs/OGC/1.3/CRS84'
      spatial:
        description: >-
          West, north, east, south edges of the spatial extent. The minimum and
          maximum values apply to the coordinate reference system WGS84
          longitude/latitude
          that is supported in the Core. If, for example, a projected coordinate
          reference
          system is used, the minimum and maximum values need to be adjusted.
        type: array
        minItems: 4
        maxItems: 6
        items:
          type: number
        example:
          - -180
          - -90
          - 180
          - 90
      trs:
        description: >-
          Temporal reference system of the coordinates in the temporal extent
          (property `temporal`).

```

In the Core, only the Gregorian calendar is supported. Extensions may support additional

temporal reference systems.

type: string

enum:

- 'http://www.opengis.net/def/uom/ISO-8601/0/Gregorian'

default: 'http://www.opengis.net/def/uom/ISO-8601/0/Gregorian'

temporal:

description: Begin and end times of the temporal extent.

type: array

minItems: 2

maxItems: 2

items:

type: string

format: dateTime

example:

- '2011-11-11T12:22:11Z'

- '2012-11-24T12:32:43Z'

featureCollectionGeoJSON:

type: object

required:

- features

properties:

features:

type: array

items:

\$ref: '#/components/schemas/featureGeoJSON'

featureGeoJSON:

type: object

required:

- type

- geometry

- properties

properties:

type:

type: string

enum:

- Feature

geometry:

\$ref: '#/components/schemas/geometryGeoJSON'

properties:

type: object

nullable: true

id:

oneOf:

- type: string

- type: integer

geometryGeoJSON:

type: object

required:

- type



```

    properties:
      type:
        type: string
        enum:
          - Point
          - MultiPoint
          - LineString
          - MultiLineString
          - Polygon
          - MultiPolygon
          - GeometryCollection
  buildingGeoJSON:
    type: object
    required:
      - type
      - geometry
      - properties
    properties:
      type:
        type: string
        enum:
          - Feature
      geometry:
        $ref: '#/components/schemas/geometryGeoJSON'
      properties:
        type: object
        nullable: true
        properties:
          name:
            type: string
          function:
            type: string
            enum:
              - residential
              - commercial
              - public use
          floors:
            type: integer
            minimum: 1
          lastUpdate:
            type: string
            format: dateTime
  tags:
    - name: Capabilities
      description: >-
        Essential characteristics of this API including information about the
        data.
    - name: Features
      description: >-
        Access to data (features).
```

# Annex C: Revision History

Date	Release	Editor	Primary clauses modified	Description
2017-10-09	SNAPSHOT	C. Portele	all	initial version
2017-10-11	SNAPSHOT	C. Portele	all	changes discussed in SWG/PT call on 2017-10-09
2017-12-13	SNAPSHOT	C. Portele	all	address issues <a href="#">#2</a> , <a href="#">#5</a> , <a href="#">#6</a> , <a href="#">#7</a> , <a href="#">#8</a> , <a href="#">#14</a> , <a href="#">#15</a> , <a href="#">#19</a>
2018-01-22	SNAPSHOT	C. Portele	7	add description of the UML diagram
2018-02-01	SNAPSHOT	C. Portele	2,3,5,7	add links to recent issues on GitHub; address issues <a href="#">#31</a> , <a href="#">#32</a>
2018-02-11	SNAPSHOT	C. Portele	2,6,7,8	address issue <a href="#">#25</a>
2018-02-27	SNAPSHOT	C. Portele	all	address issues <a href="#">#3</a> , <a href="#">#9</a> , <a href="#">#12</a> , <a href="#">#22</a> , <a href="#">#23</a> , <a href="#">#24</a> , <a href="#">#44</a> ; add links to issues <a href="#">#41</a> , <a href="#">#45</a> , <a href="#">#46</a> , <a href="#">#47</a>
2018-03-04	SNAPSHOT	T. Schaub	7,B	JSON schema fixes <a href="#">#54</a> , <a href="#">#55</a>
2018-03-12	SNAPSHOT for ISO NWIP	C. Portele	all	Updates after the WFS 3.0 Hackathon <a href="#">#59</a> , <a href="#">#61</a> , <a href="#">#62</a> , <a href="#">#63</a> , <a href="#">#64</a> , <a href="#">#69</a> , <a href="#">#72</a> , <a href="#">#77</a> , <a href="#">#78</a> ; resolve <a href="#">#4</a> ; editorial edits
2018-03-15	SNAPSHOT	J. Amara	7	Uniqueness of feature id <a href="#">#83</a>
2018-03-21	SNAPSHOT	I. Rinne	7	Clarified the requirement /req/core/crs84 <a href="#">#92</a>

Date	Release	Editor	Primary clauses modified	Description
2018-03-28	SNAPSHOT	C. Portele	3,4,7	Temporal support <a href="#">#57</a> , bbox no longer restricted to CRS84 <a href="#">#60</a> , clarify 'collection' <a href="#">#86</a> , clarify feature id constraints <a href="#">#84</a>
2018-04-02	SNAPSHOT	C. Portele	7,B	Clarify 'item' links <a href="#">#81</a> , clean up OpenAPI example in Annex B
2018-04-03	SNAPSHOT	C. Portele	4,5,6,7,8,9	Clean-up asciidoc <a href="#">#100</a>

# Annex D: Bibliography

- W3C/OGC: Spatial Data on the Web Best Practices, W3C Working Group Note 28 September 2017, <https://www.w3.org/TR/sdw-bp/>
- W3C: Data on the Web Best Practices, W3C Recommendation 31 January 2017, <https://www.w3.org/TR/dwbp/>
- W3C: Data Catalog Vocabulary, W3C Recommendation 16 January 2014, <https://www.w3.org/TR/vocab-dcat/>
- IANA: Link Relation Types, <https://www.iana.org/assignments/link-relations/link-relations.xml>