bSDD

Semantic bSDD by Ontotext

Improving the GraphQL, JSON and RDF Representations of buildingSmart Data Dictionary

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11th Linked Data in Architecture and Construction Workshop, 15-16 June 2023, Matera, Italy"

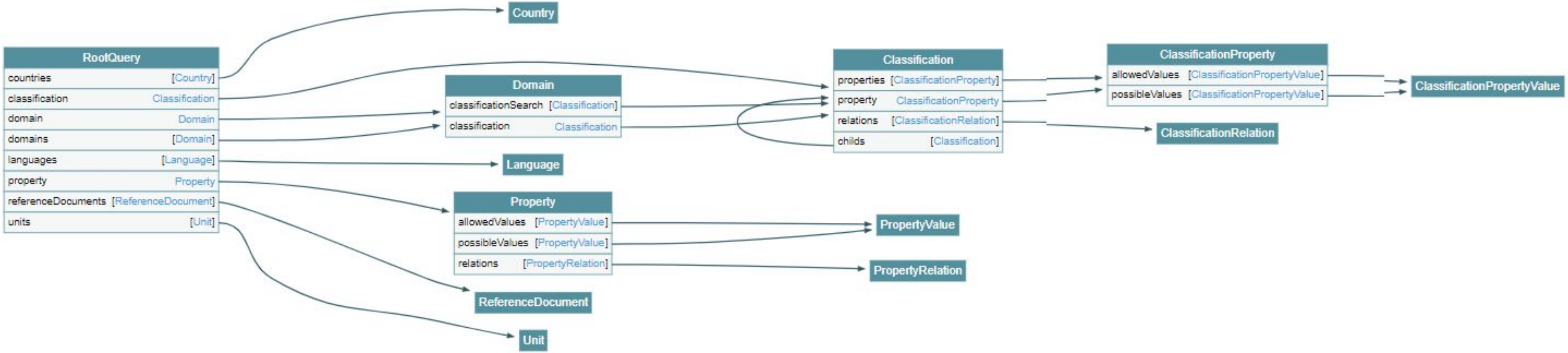
ontotext

Outline

- Highlight the defects in the original GraphQL implementation of bSDD
- Overview the refactored solution proposed by Ontotext
- Overview data quality issues
- Overview the proposed improvements

BSDD GRAPHQL SCHEMA: VOYAGER

Voyager: Original Schema



RootQuery	
countries	[Country]
classification	Classification
domain	Domain
domains	[Domain]
languages	[Language]
property	Property
referenceDocuments	[ReferenceDocument]
units	[Unit]

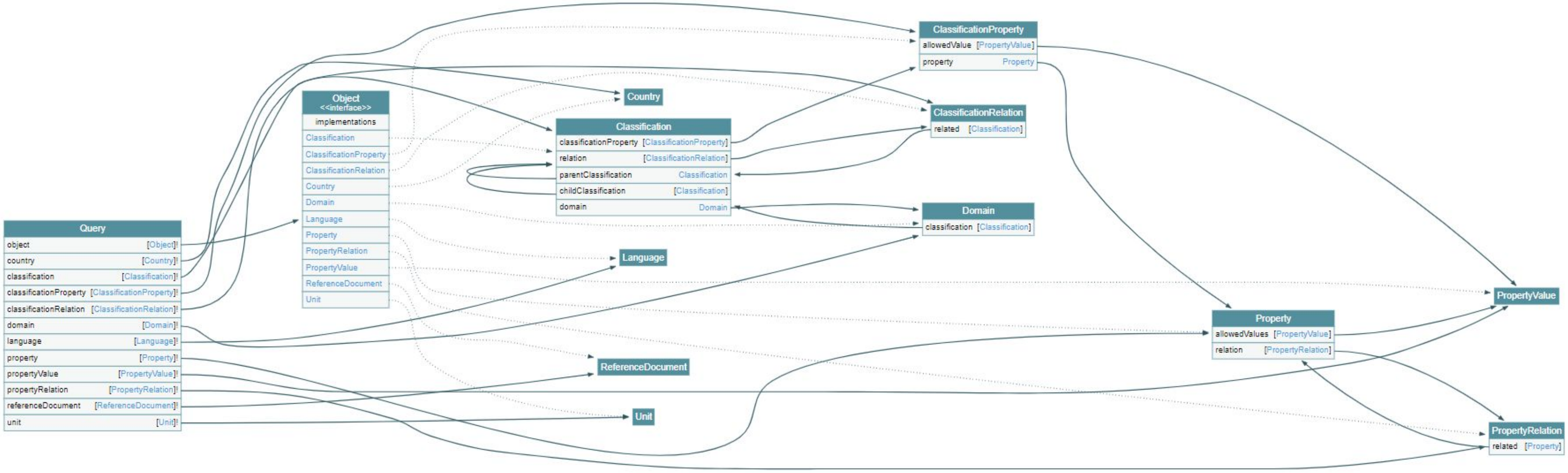
Domain	
classificationSearch	[Classification]
classification	Classification

Classification	
properties	[ClassificationProperty]
property	ClassificationProperty
relations	[ClassificationRelation]
childs	[Classification]

ClassificationProperty	
allowedValues	[ClassificationPropertyValue]
possibleValues	[ClassificationPropertyValue]

Property	
allowedValues	[PropertyValue]
possibleValues	[PropertyValue]
relations	[PropertyRelation]

Voyager: Refactored Schema



Query	
object	[Object]!
country	[Country]!
classification	[Classification]!
classificationProperty	[ClassificationProperty]!
classificationRelation	[ClassificationRelation]!
domain	[Domain]!
language	[Language]!
property	[Property]!
propertyValue	[PropertyValue]!
propertyRelation	[PropertyRelation]!
referenceDocument	[ReferenceDocument]!
unit	[Unit]!

Object <<interface>>
implementations
Classification
ClassificationProperty
ClassificationRelation
Country
Domain
Language
Property
PropertyRelation
PropertyValue
ReferenceDocument
Unit

Classification	
classificationProperty	[ClassificationProperty]
relation	[ClassificationRelation]
parentClassification	Classification
childClassification	[Classification]
domain	Domain

ClassificationProperty	
allowedValue	[PropertyValue]
property	Property

ClassificationRelation	
related	[Classification]

Domain	
classification	[Classification]

Property	
allowedValues	[PropertyValue]
relation	[PropertyRelation]

PropertyRelation	
related	[Property]

Original GraphQL: Findings (1/3)

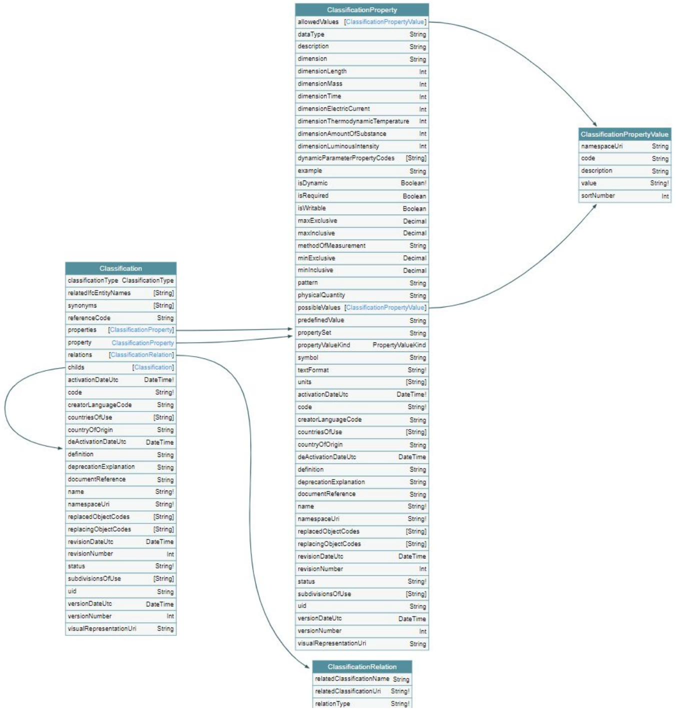
- Reference entities `ReferenceDocument`, `Country`, `Unit`, `Language` are disconnected from the rest of the schema
- Relation entities have only an incoming link but no outgoing link
- Many entities cannot be queried directly from the `Root`
- No backward arrows to get from a lower-level entity back to its “parent” entity
- A number of parallel arrows. GraphQL schema can use parameters to distinguish between the different uses

Original GraphQL: Findings (2/3)

At the high level of detail:

- `Property` and `ClassificationProperty` are very similar, but there’s no inheritance/relation between them
- `PropertyValue` and `ClassificationPropertyValue` are exactly the same, so can be reduced to one entity

Original GraphQL: Findings (3/3)



Classification	
classificationType	ClassificationType
relatedIfcEntityNames	[String]
synonyms	[String]
referenceCode	String
properties	[ClassificationProperty]
property	ClassificationProperty
relations	[ClassificationRelation]
childs	[Classification]
activationDateUtc	DateTime!
code	String!
creatorLanguageCode	String
countriesOfUse	[String]
countryOfOrigin	String
deActivationDateUtc	DateTime
definition	String
deprecationExplanation	String
documentReference	String
name	String!
namespaceUri	String!
replacedObjectCodes	[String]
replacingObjectCodes	[String]
revisionDateUtc	DateTime
revisionNumber	Int
status	String!
subdivisionsOfUse	[String]
uid	String
versionDateUtc	DateTime
versionNumber	Int
visualRepresentationUri	String

ClassificationProperty	
allowedValues	[ClassificationPropertyValue]
dataType	String
description	String
dimension	String
dimensionLength	Int
dimensionMass	Int
dimensionTime	Int
dimensionElectricCurrent	Int
dimensionThermodynamicTemperature	Int
dimensionAmountOfSubstance	Int
dimensionLuminousIntensity	Int
dynamicParameterPropertyCodes	[String]
example	String
isDynamic	Boolean!
isRequired	Boolean
isWritable	Boolean
maxExclusive	Decimal
maxInclusive	Decimal
methodOfMeasurement	String
minExclusive	Decimal
minInclusive	Decimal
pattern	String
physicalQuantity	String
possibleValues	[ClassificationPropertyValue]
predefinedValue	String
propertySet	String
propertyValueKind	PropertyValueKind
symbol	String
textFormat	String!
units	[String]
activationDateUtc	DateTime!
code	String!
creatorLanguageCode	String
countriesOfUse	[String]
countryOfOrigin	String
deActivationDateUtc	DateTime
definition	String
deprecationExplanation	String
documentReference	String
name	String!
namespaceUri	String!
replacedObjectCodes	[String]
replacingObjectCodes	[String]
revisionDateUtc	DateTime
revisionNumber	Int
status	String!
subdivisionsOfUse	[String]
uid	String
versionDateUtc	DateTime
versionNumber	Int
visualRepresentationUri	String

ClassificationPropertyValue	
namespaceUri	String
code	String
description	String
value	String!
sortNumber	Int

ClassificationRelation	
relatedClassificationName	String
relatedClassificationUri	String!
relationType	String!

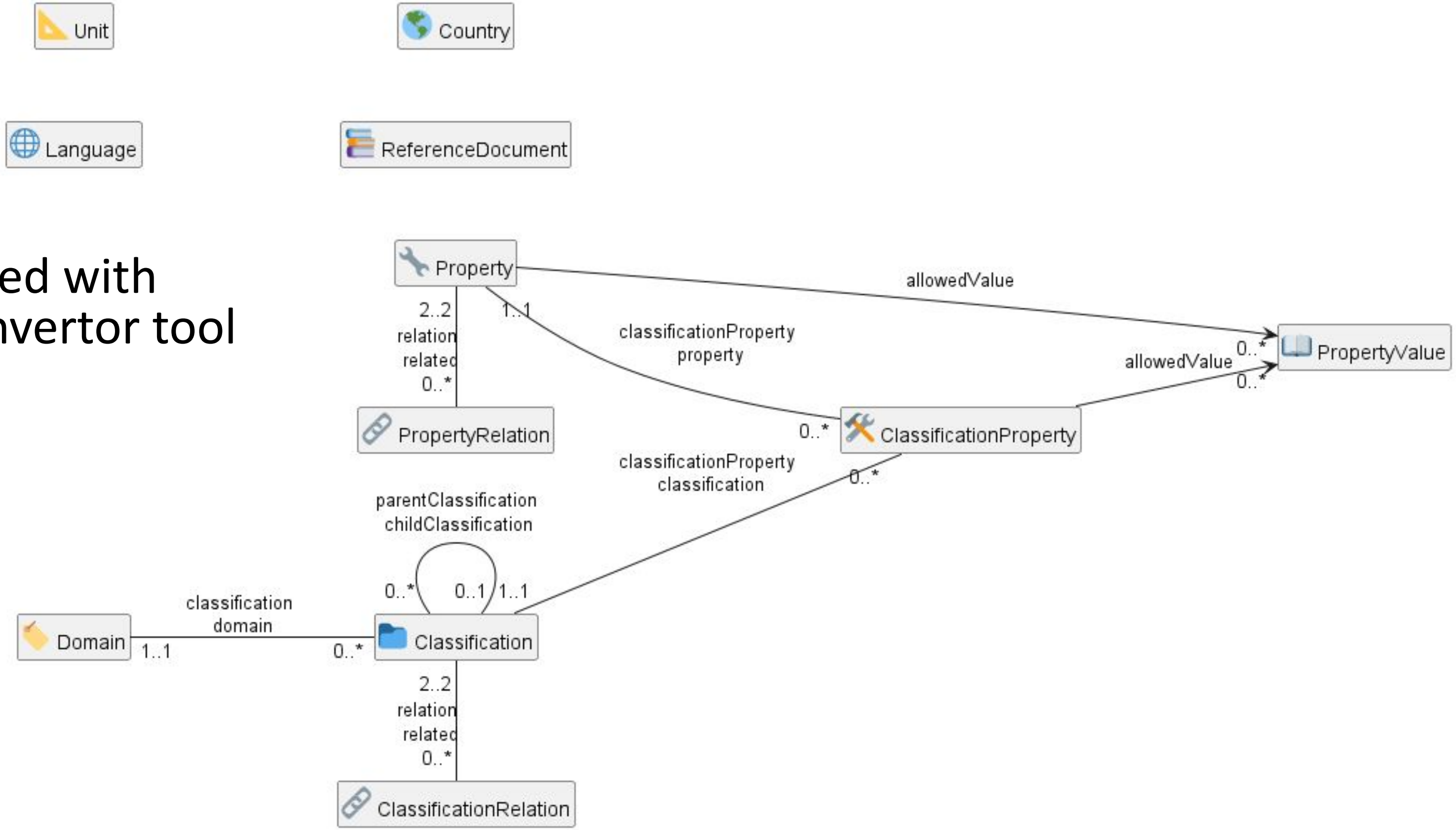
Mixture of singular/plural in property names(*)

`property/properties, relations, synonyms, countriesOfUse, relatedIfcPropertyNames`, etc.

(*) - already discussing at forums.buildingsmart.org

bSDD Refactored Schema: PlantUML

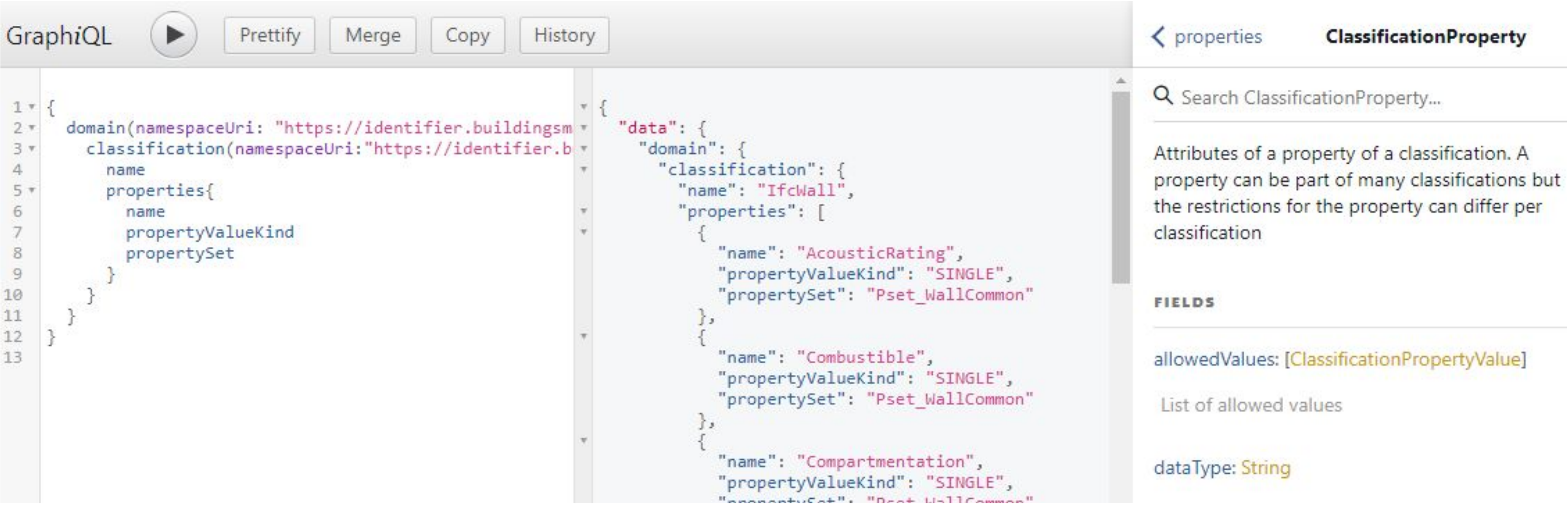
PlantUML is used with [soml2puml] convertor tool



Refactored GraphQL: Improvements

- All entities are queryable directly from the `Root`
- No parallel links, use GraphQL query parameters instead
- Pagination for bulk query results
- GraphQL syntax highlight, keyboard shortcuts, search in the query text, query response errors
- Each link is named the same as target entity
- Navigation between entities is bidirectional
- A single entity `PropertyValue` is used by both `Property` and `ClassificationProperty`
- Property names are in singular

Graph*i*QL: Original



```
{
  domain(namespaceUri: "https://identifier.buildingsm
    classification(namespaceUri:"https://identifier.b
      name
      properties{
        name
        propertyValueKind
        propertySet
      }
    }
  }
}
```

```
{
  "data": {
    "domain": {
      "classification": {
        "name": "IfcWall",
        "properties": [
          {
            "name": "AcousticRating",
            "propertyValueKind": "SINGLE",
            "propertySet": "Pset_WallCommon"
          },
          {
            "name": "Combustible",
            "propertyValueKind": "SINGLE",
            "propertySet": "Pset_WallCommon"
          },
          {
            "name": "Compartmentation",
            "propertyValueKind": "SINGLE",
            "propertySet": "Pset_WallCommon"
```

Attributes of a property of a classification. A property can be part of many classifications but the restrictions for the property can differ per classification

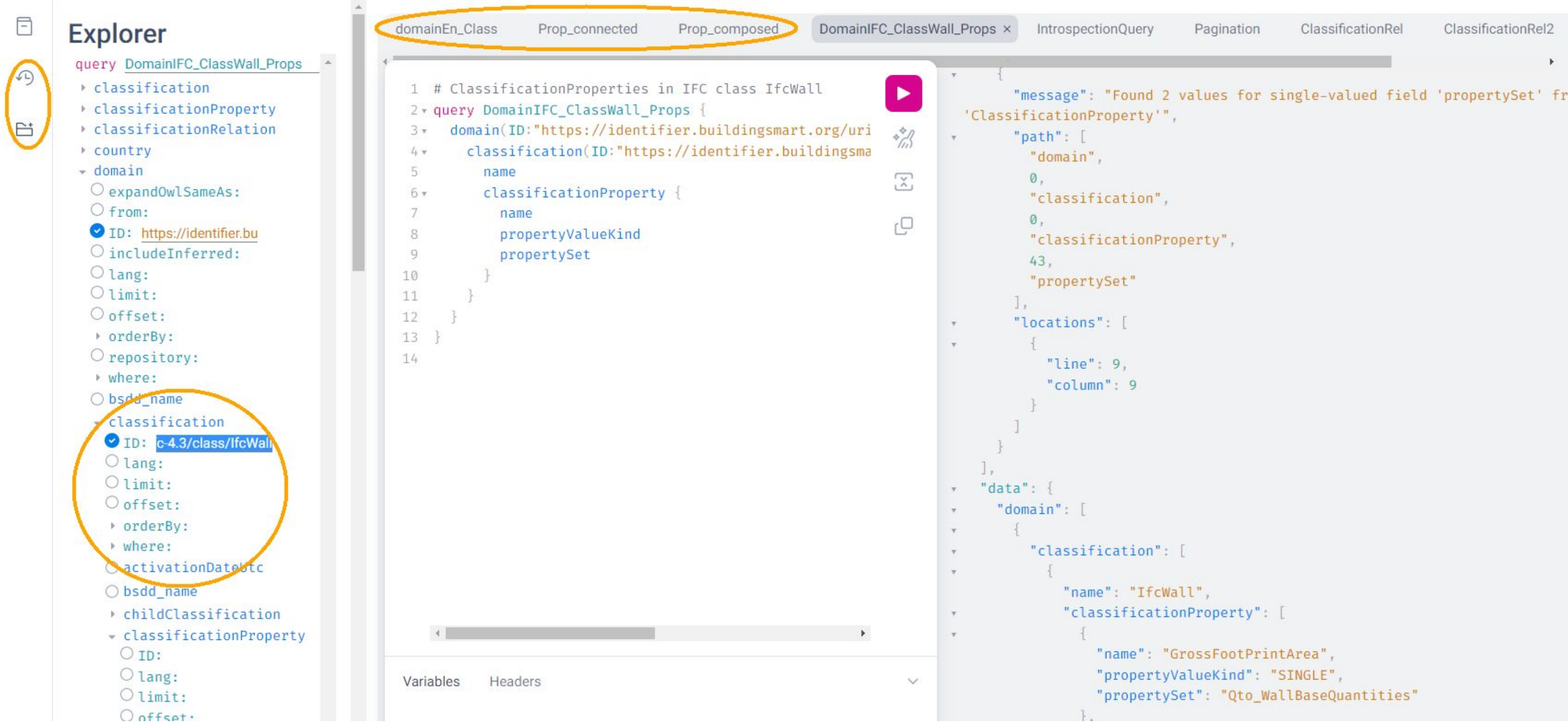
FIELDS

allowedValues: [ClassificationPropertyValue]

List of allowed values

dataType: String

Graph*i*QL: Refactored

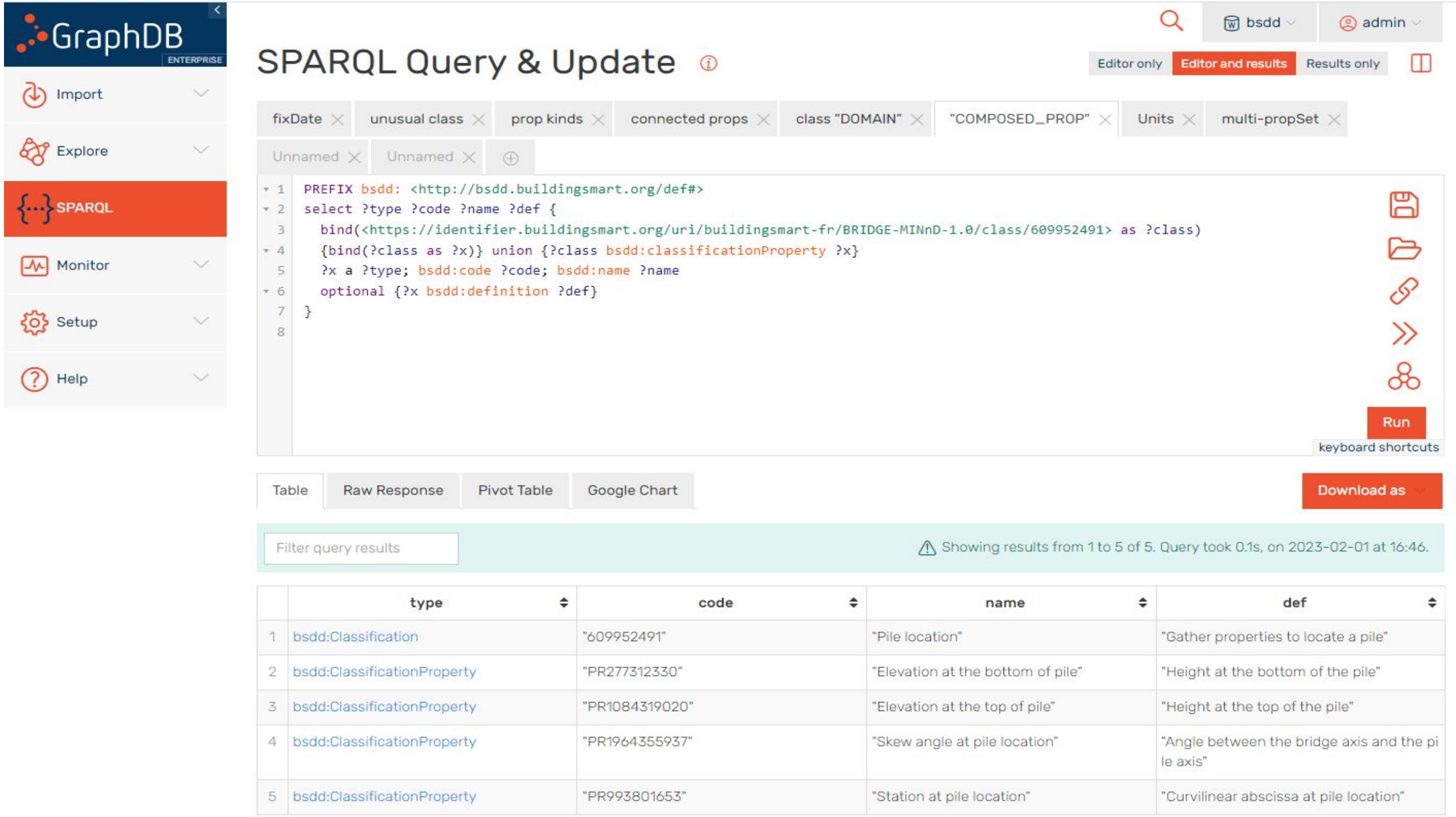


```
query DomainIFC_ClassWall_Props
▸ classification
▸ classificationProperty
▸ classificationRelation
▸ country
▾ domain
  ○ expandOwlSameAs:
  ○ from:
  ● ID: https://identifier.bu
  ○ includeInferred:
  ○ lang:
  ○ limit:
  ○ offset:
  ▸ orderBy:
  ○ repository:
  ▸ where:
  ○ bsdd_name
  ▾ classification
    ● ID: c-4.3/class/IfcWall
    ○ lang:
    ○ limit:
    ○ offset:
    ▸ orderBy:
    ▸ where:
    ○ activationDateUtc
    ○ bsdd_name
    ▸ childClassification
    ▾ classificationProperty
      ○ ID:
      ○ lang:
      ○ limit:
      ○ offset:
```

```
# ClassificationProperties in IFC class IfcWall
query DomainIFC_ClassWall_Props {
  domain(ID:"https://identifier.buildingsmart.org/uri
    classification(ID:"https://identifier.buildingsma
      name
      classificationProperty {
        name
        propertyValueKind
        propertySet
      }
    }
  }
}
```

```
    {
      "message": "Found 2 values for single-valued field 'propertySet' fr
'ClassificationProperty'",
      "path": [
        "domain",
        0,
        "classification",
        0,
        "classificationProperty",
        43,
        "propertySet"
      ],
      "locations": [
        {
          "line": 9,
          "column": 9
        }
      ]
    }
  ],
  "data": {
    "domain": [
      {
        "classification": [
          {
            "name": "IfcWall",
            "classificationProperty": [
              {
                "name": "GrossFootPrintArea",
                "propertyValueKind": "SINGLE",
                "propertySet": "Qto_WallBaseQuantities"
              },
```

Refactored bSDD: SPARQL Endpoint



```
PREFIX bsdd: <http://bsdd.buildingsmart.org/def#>
select ?type ?code ?name ?def {
  bind(<https://identifier.buildingsmart.org/uri/buildingsmart-fr/BRIDGE-MINnD-1.0/class/609952491> as ?class)
  {bind(?class as ?x)} union {?class bsdd:classificationProperty ?x}
  ?x a ?type; bsdd:code ?code; bsdd:name ?name
  optional {?x bsdd:definition ?def}
}
```

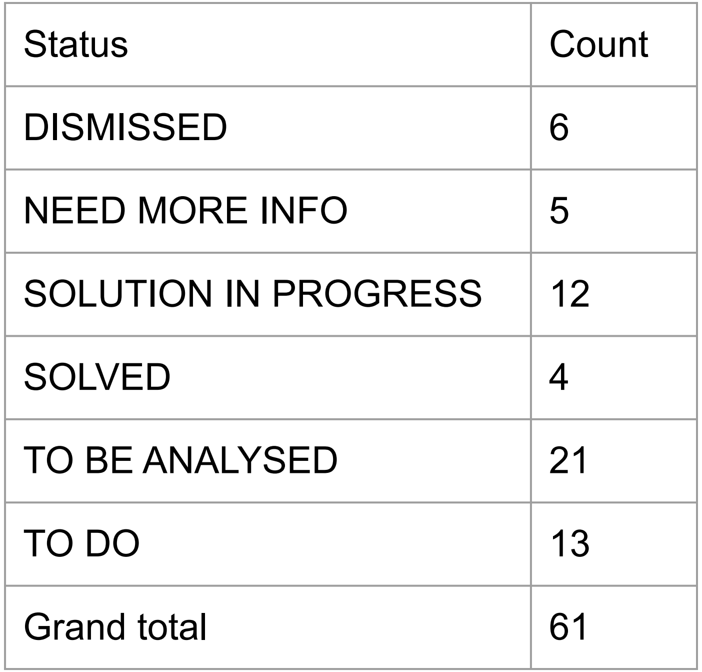
Showing results from 1 to 5 of 5. Query took 0.1s, on 2023-02-01 at 16:46.

	type	code	name	def
1	bsdd:Classification	"609952491"	"Pile location"	"Gather properties to locate a pile"
2	bsdd:ClassificationProperty	"PR277312330"	"Elevation at the bottom of pile"	"Height at the bottom of the pile"
3	bsdd:ClassificationProperty	"PR1084319020"	"Elevation at the top of pile"	"Height at the top of the pile"
4	bsdd:ClassificationProperty	"PR1964355937"	"Skew angle at pile location"	"Angle between the bridge axis and the pile axis"
5	bsdd:ClassificationProperty	"PR993801653"	"Station at pile location"	"Curvilinear abscissa at pile location"

SUGGESTED IMPROVEMENTS

buildingSMART Feedback

buildingSMART International started to analyse the suggested improvements



Status	Count
DISMISSED	6
NEED MORE INFO	5
SOLUTION IN PROGRESS	12
SOLVED	4
TO BE ANALYSED	21
TO DO	13
Grand total	61

Live spreadsheet with status/solution for each of suggested improvements

Presentation

- Uniform identification for the search
- Equal data retrieved from different API
- Improve URL structure and consistency

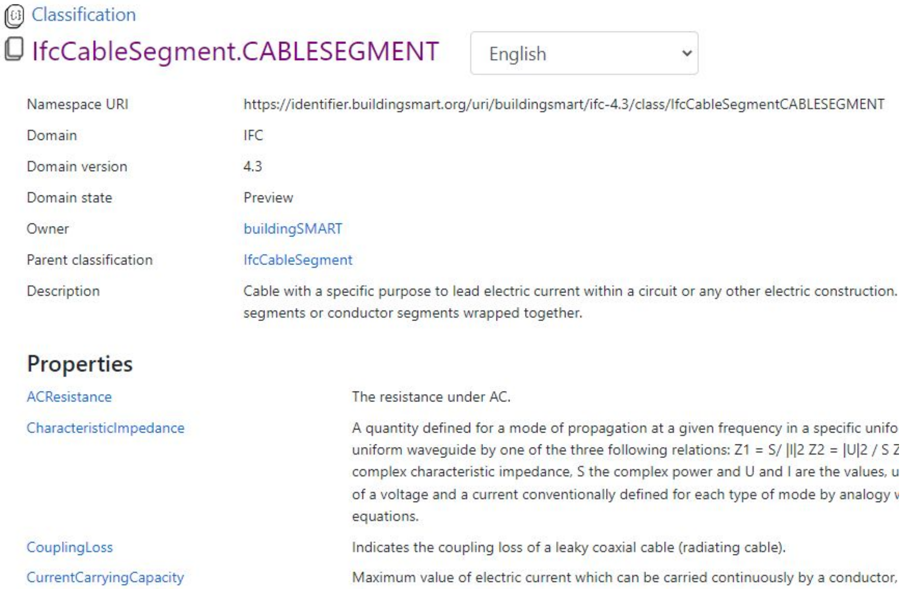
Uniform Identification

February 2023: **IfcCableSegment** in Web UI has URL:

https://search.bsdd.buildingsmart.org/Classification/Index/58453

May 2023: **IfcCableSegment** in Web UI has another URL:

https://search.bsdd.buildingsmart.org/Classification/Index/70992



Classification

IfcCableSegment.CABLESEGMENT English

Namespace URI	https://identifier.buildingsmart.org/uri/buildingsmart/ifc-4.3/class/IfcCableSegmentCABLESEGMENT
Domain	IFC
Domain version	4.3
Domain state	Preview
Owner	buildingSMART
Parent classification	IfcCableSegment
Description	Cable with a specific purpose to lead electric current within a circuit or any other electric construction. segments or conductor segments wrapped together.

Properties

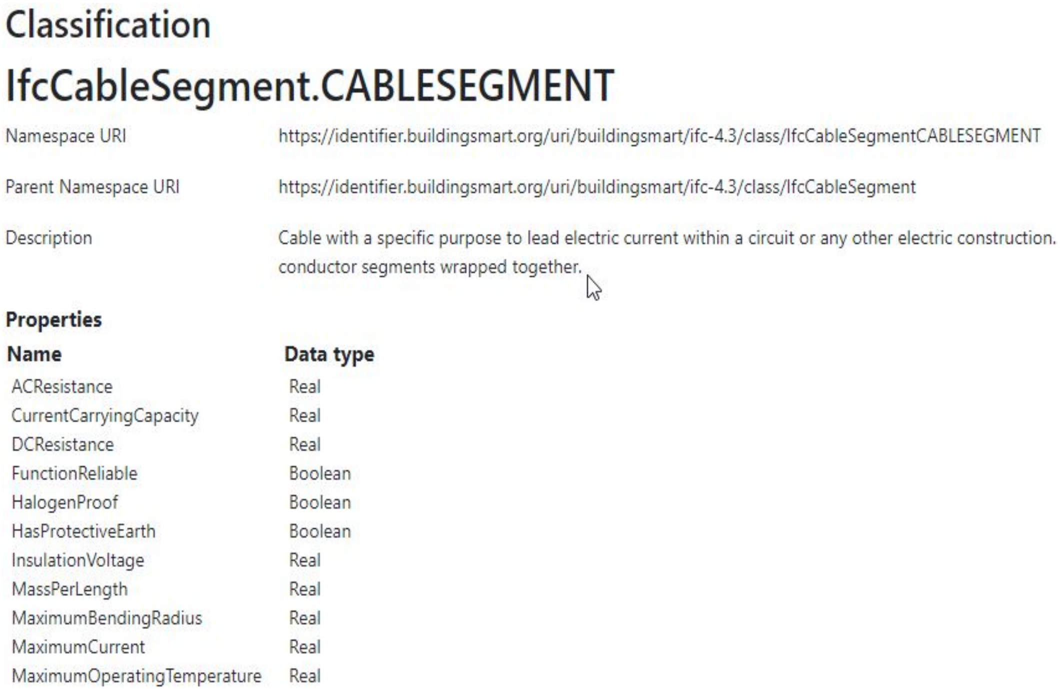
ACResistance	The resistance under AC.
CharacteristicImpedance	A quantity defined for a mode of propagation at a given frequency in a specific unifo uniform waveguide by one of the three following relations: Z1 = S/ |I|2 Z2 = |U|2 / S Z complex characteristic impedance, S the complex power and U and I are the values, u of a voltage and a current conventionally defined for each type of mode by analogy v equations.
CouplingLoss	Indicates the coupling loss of a leaky coaxial cable (radiating cable).
CurrentCarryingCapacity	Maximum value of electric current which can be carried continuously by a conductor,

Uniform Identification

IfcCableSegment has also **URI assigned by a data provider**:

https://identifier.buildingsmart.org/uri/buildingsmart/ifc-4.3/class/IfcCableSegmentCABLESEGMENT

CableSegment entity as displayed at the bSDD web site



Classification

IfcCableSegment.CABLESEGMENT

Namespace URI	https://identifier.buildingsmart.org/uri/buildingsmart/ifc-4.3/class/IfcCableSegmentCABLESEGMENT
Parent Namespace URI	https://identifier.buildingsmart.org/uri/buildingsmart/ifc-4.3/class/IfcCableSegment
Description	Cable with a specific purpose to lead electric current within a circuit or any other electric construction. conductor segments wrapped together.

Properties

Name	Data type
ACResistance	Real
CurrentCarryingCapacity	Real
DCResistance	Real
FunctionReliable	Boolean
HalogenProof	Boolean
HasProtectiveEarth	Boolean
InsulationVoltage	Real
MassPerLength	Real
MaximumBendingRadius	Real
MaximumCurrent	Real
MaximumOperatingTemperature	Real

Uniform Identification

Non-unique identification violates FAIR Findability principle

`F1: (Meta)data are assigned a globally unique and persistent identifier`

Equal Data Retrieved from Different API

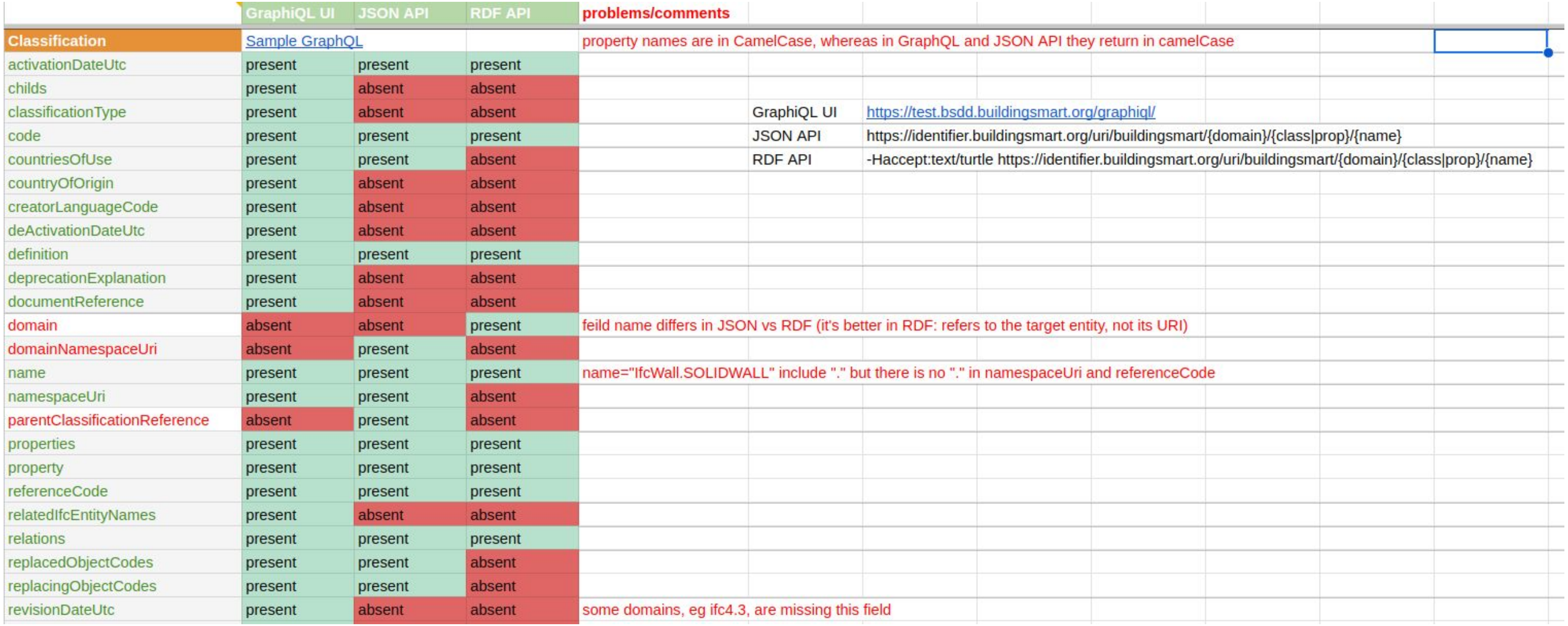
We have compared three representations returned by the bSDD server:

- JSON from the GraphQL API
  - https://test.bsdd.buildingsmart.org/graphiql/
- JSON from the REST (entity) API
  - `curl https://identifier.buildingsmart.org/uri/buildingsmart/<domain>/class|prop/<name>` and
- RDF from the REST (entity) API

  -
    ```
    curl -Haccept:text/turtle \
    https://identifier.buildingsmart.org/uri/buildingsmart/<domain>/class|prop/<name>
    ```

Equal Data Retrieved from Different API

We selected entities of each class that have the **maximum number of filled fields**, and compared the results returned by each API.



	GraphiQL UI	JSON API	RDF API	problems/comments		
Classification	Sample GraphQL			property names are in CamelCase, whereas in GraphQL and JSON API they return in camelCase		
activationDateUtc	present	present	present			
childs	present	absent	absent			
classificationType	present	absent	absent		GraphiQL UI	https://test.bsdd.buildingsmart.org/graphiql/
code	present	present	present		JSON API	https://identifier.buildingsmart.org/uri/buildingsmart/{domain}/{class|prop}/{name}
countriesOfUse	present	present	absent		RDF API	-Haccept:text/turtle https://identifier.buildingsmart.org/uri/buildingsmart/{domain}/{class|prop}/{name}
countryOfOrigin	present	absent	absent			
creatorLanguageCode	present	absent	absent			
deActivationDateUtc	present	absent	absent			
definition	present	present	present			
deprecationExplanation	present	absent	absent			
documentReference	present	absent	absent			
domain	absent	absent	present	feild name differs in JSON vs RDF (it's better in RDF: refers to the target entity, not its URI)		
domainNamespaceUri	absent	present	absent			
name	present	present	present	name="IfcWall.SOLIDWALL" include "." but there is no "." in namespaceUri and referenceCode		
namespaceUri	present	present	absent			
parentClassificationReference	absent	present	absent			
properties	present	present	present			
property	present	present	present			
referenceCode	present	present	present			
relatedIfcEntityNames	present	absent	absent			
relations	present	present	present			
replacedObjectCodes	present	present	absent			
replacingObjectCodes	present	present	absent			
revisionDateUtc	present	absent	absent	some domains, eg ifc4.3, are missing this field		

Improve URL Structure and Consistency

- Almost all bSDD domain URLs now have the same structure: `https://identifier.buildingsmart.org/uri/<org>/<domain>-<version>`
- URIs can be more “hackable”, allowing users to navigate the hierarchy by pruning the URI: `https://identifier.buildingsmart.org/uri/<org>/<domain>/<version>`
- In some cases, the `<org>` is repeated in the `<domain>` part

D. Garijo and M. Poveda-Villalón, ``Best practices for implementing FAIR vocabularies and ontologies on the web,'', 2020

L. Dodds and I. Davis, ``Linked data patterns: A pattern catalogue for modelling, publishing, and consuming linked data. Linked data patterns,'' Sep. 06, 2022.

Improve URL Structure and Consistency

- In some cases, the `<org>` name doesn't quite mesh with the domain name, perhaps due to the way bSDD allocates `<org>` identifiers to bSDD contributors
  - `bim-de/DINSPEC91400`: the publisher of this spec is DIN (the German standards organization), not the `bim-de` initiative
  - `digibase/volkerwesselsbv`: [bimregister.nl news from 2018]() suggest that `digibase` is a new company/initaitive within Volker Wessel
  - `digibase/nen2699`: the publisher of this spec is NEN (the Netherlands standards organization), not the `digibase` company/initiative
  - `digibase/digibasebouwlagen`: perhaps the org name `digibase` should not be repeated as the prefix of the domain `bouwlagen` (building layers)

Explicate domain versions

`https://identifier.buildingsmart.org/uri/acca/ACCAtest-0.1`

can become

`https://identifier.buildingsmart.org/uri/acca/ACCAtest/0.1`

A new entity `DomainVersion` can provide linking all versions of a domain to its master `Domain` entity.

Improve URL Structure and Consistency

- Declare URLs to be `ID` and use a mandatory field `id`
  - Most GraphQL implementations call this field simply `id`, whereas bSDD uses `namespaceUri`
  - Many nodes do not have their own `namespaceUri` field, or it is not fully populated

Entity Classes vs classificationTypes

The key field classificationType specifies the kind of classification.

E.g., there is the classification with name décret 2011-321 (23/03/2011) from ATALANE/REX-OBJ-1.0 domain **and** with classificationType="REFERENCE_DOCUMENT", that it is not in the list of ReferenceDocuments.

Why is it not a ReferenceDocument entity?

c	classificationType	overlaps with entity
29	"DOMAIN"	Domain
18	"REFERENCE_DOCUMENT"	Reference Document

All entities should have URL

All significant classes should have `ID`, which in the case of RDF data is the node URL.

However, many bSDD classes don’t have such a field:

- `Domain`, `Property`, `Classification` do have `namespaceUri`
- `Country`, `Language`, `Unit` don’t have an ID but have a field (`code`, `isocode`) that can be used to make an `ID`, when prepended with an appropriate prefix.

URL for ClassificationProperty

- `Property` and `ClassificationProperty` are two different classes, but the latter does not have a distinct URL(*) in GraphQL and JSON.
- The same URL is overloaded to identify entities of both classes.
- `ClassificationProperty` are not returned separately by the JSON or RDF entity API, but only as part of the respective `Classification`

E.g., IfcCableSegment.CABLESEGMENT classification has **ACResistance** as a ClassificationProperty, but

```
curl
https://identifier.buildingsmart.org/uri/buildingsmart/ifc-4.3/class/
IfcCableSegmentCABLESEGMENT/ACResistance
```

returns

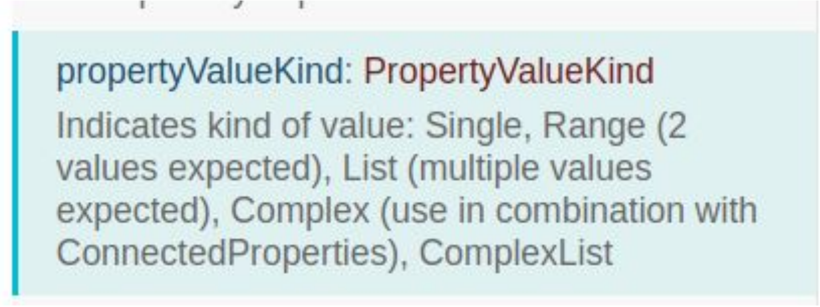
```
{"":["Classification with namespace URI
'https://identifier.buildingsmart.org/uri/buildingsmart/ifc-4.3/class/Ifc
CableSegmentCABLESEGMENT/ACResistance' not found"]}
```

(*) Artur Tomczak, 19 May 2023: “We’re adding identifiers to the resources lacking it, like the ClassificationProperty”

MODELLING ISSUES

Unify Solutions to Model Complex Properties

The key attribute propertyValueKind has values COMPLEX and COMPLEX_LIST used in combination with connectedProperties. These key values are defined for Property and ClassificationProperty



propertyValueKind: PropertyValueKind

Indicates kind of value: Single, Range (2 values expected), List (multiple values expected), Complex (use in combination with ConnectedProperties), ComplexList

- However, connectedPropertyCodes is defined only for Property
- More importantly, these key values are never used
- connectedProperty is used only on **7** Properties (and not ClassificationProperties)
- Instead of using connectedPropertyCodes to describe complex properties, some providers have used classifications with the type COMPOSED_PROPERTY.

Improve Modelling of Dynamic Properties

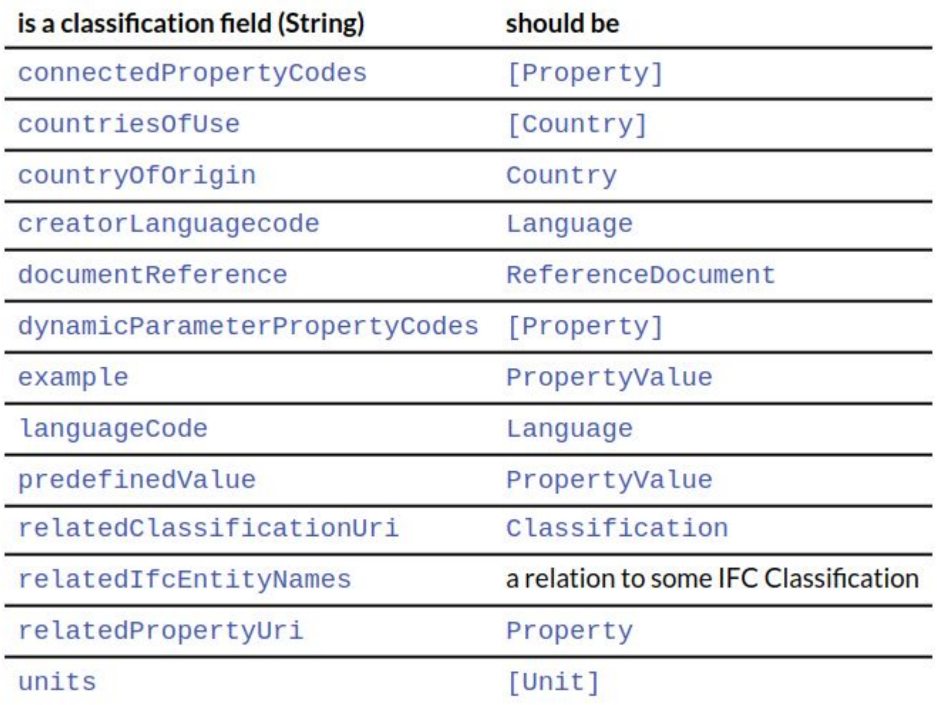
12385 `Properties` are declared with `isDynamic=true`

135250 are not.

However, the field `dynamicParameterPropertyCode` (used to compute the dynamic property) is **always** empty, so how can one know which “sub-properties” to use?

Additionally, `dynamicParameterPropertyCodes` is `String`, but should be `[Property]`, i.e. an array of `Properties`.

Improve Relations Between Entities



is a classification field (String)	should be
connectedPropertyCodes	[Property]
countriesOfUse	[Country]
countryOfOrigin	Country
creatorLanguagecode	Language
documentReference	ReferenceDocument
dynamicParameterPropertyCodes	[Property]
example	PropertyValue
languageCode	Language
predefinedValue	PropertyValue
relatedClassificationUri	Classification
relatedIfcEntityNames	a relation to some IFC Classification
relatedPropertyUri	Property
units	[Unit]

Add More Entities

bSDD includes numerous string attributes (codes or URLs) that should be converted to relations (object fields) to improve the connectedness of the bSDD GraphQL graph

is a classification field (String)	should be
`physicalQuantity`	(New) `PhysicalQuantity`
`propertySet`	(New) `PropertySet`
`subdivisionsOfUse`	(New) `CountrySubdivision`
`version`	(New) `DomainVersion`
`replaced/(-ing)ObjectCodes`	some kind of objects. Currently they are empty

Use Class Inheritance

`Property` and `ClassificationProperty`: have **46** fields in common, differ in only 5 fields:

belongs uniquely to `Property`	**belongs uniquely to `ClassificationProperty`**
`connectedPropertyCodes` (String)	`isRequired` (Boolean)
`relations` (PropertyRelation)	`isWritable` (Boolean)
	`predefinedValue` (String)
	`propertySet` (String)
	`symbol` (String)

Since there are *no rules* on which fields of `Property` to reuse in `ClassificationProperty`, the latter type copies most of the fields from the former

Improve `PropertyValues`

- `PropertyValue` and `ClassificationPropertyValue` are structured values with rich fields:

`code`, `value`, `namespaceUri`, `description`, `sortNumber`

- However, most structured values we've seen have only

`code`, `value`

- This has multiple problems:
  - Individual values have no description (`description` is not filled out)
  - Some values are described in the property definition, intermingling multiple descriptions together
  - The "standard" values NOTKNOWN, OTHER, UNSET are not described at all.
  - Values have no `namespaceUri`, precluding unique identification.

Improve `predefinedValue`

- `allowedValues` store structured values (`ClassificationPropertyValue`)
- However, their “sibling” property `predefinedValue` holds just a String, which means that even in the future, `predefinedValue` cannot be an enumeration value identified globally with a URL

Improve Multilingual Support

- bSDD is advertised as a multilingual dictionary
- In the GraphQL API, one can specify a desired language(*) when fetching classifications and properties
- However, currently most domains are present in one language only (*unilingual*).

(*) Artur Tomczak, 26 April 2023 Proper way to access translations of IFC entities: language header is working

DATA QUALITY

Data Quality Issues

- Leading, trailing, consecutive whitespace
- Improve physical quantities and units
- No rules on missing data
- Unicode problems
- Unresolved HTML entities
- Bad classification relations (broken links)

Implementing Improvements

We implemented a lot (but not all) of the improvements suggested above by using the following process:

- Fetch bSDD data as JSON
- Draft SOML schema
- Convert it to RDF using SPARQL Anything
- Load it to GraphDB
- Refactor the RDF using SPARQL Update

The results are available at the SPARQL endpoint and in GraphQL

Conclusions and Future Work

Here are further ideas for improvement:

- improve bSDD ontology
- implement more radical data model refactoring to convert “strings” (countries, reference documents, etc.) into “things”
- link bSDD units of measure to QUDT ontology
- perform deeper data quality analysis using SHACL shapes generation and validation provided by Ontotext Platform Semantic Objects
- address and resolve more data quality issues, including
  - seek correlation between dimension vectors, units of measure and physical quantity,
  - parse out enumeration values from `Property/ClassificationProperty` descriptions and create corresponding `PropertyValue` lists
- make more graph visualizations
- obtain more interesting statistics using SPARQL

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