A Method to Unify Custom Properties in IFC to Linked Building Data Conversion

13th July 2024

LDAC 2024

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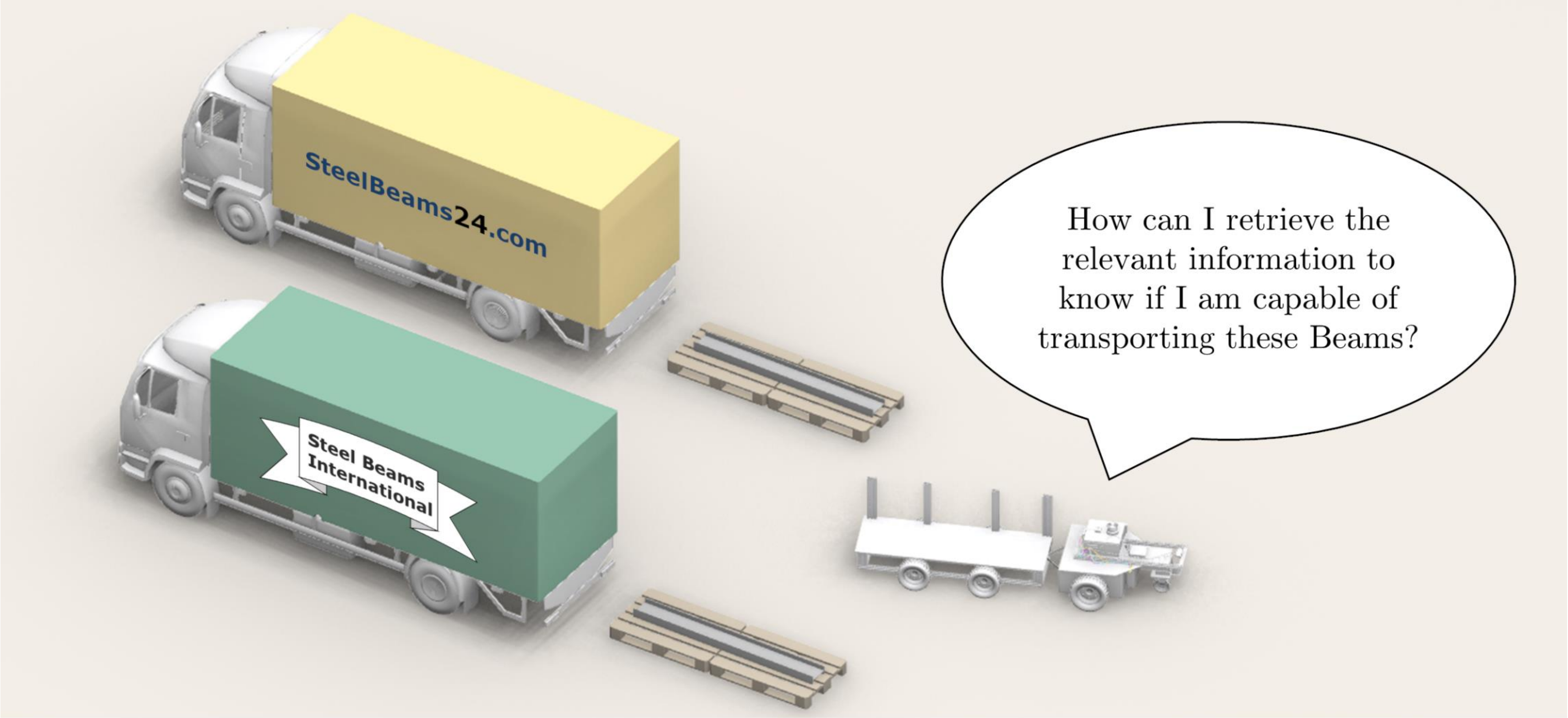
Sigrid Brell-Cokcan

Introduction

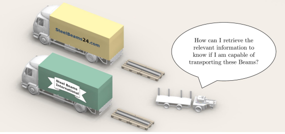

SteelBeams24.com
Steel Beams International
How can I retrieve the relevant information to know if I am capable of transporting these Beams?

Consistent data helps when creating autonomous robots.

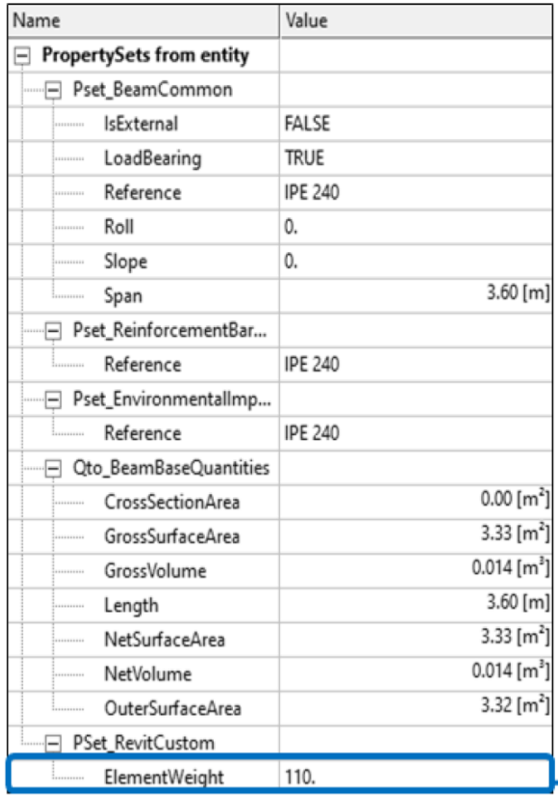
How to handle and align user-defined and software-specific property sets?

How to overcome inconsistent property naming between domain-specific software to enable generalised queries?

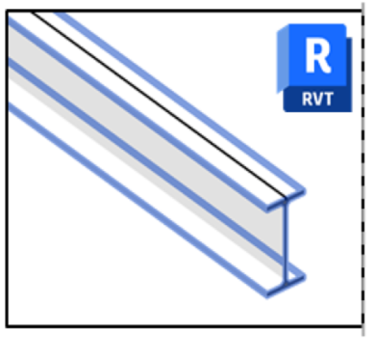
IFC Export and Resulting Graph

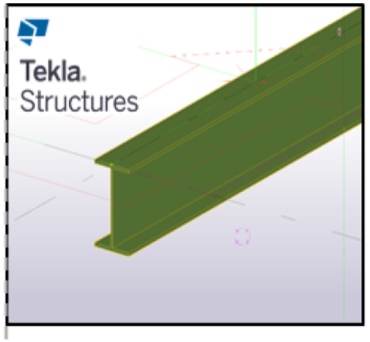

SteelBeams24.com
Steel Beams International
How can I retrieve the relevant information to know if I am capable of transporting these Beams?

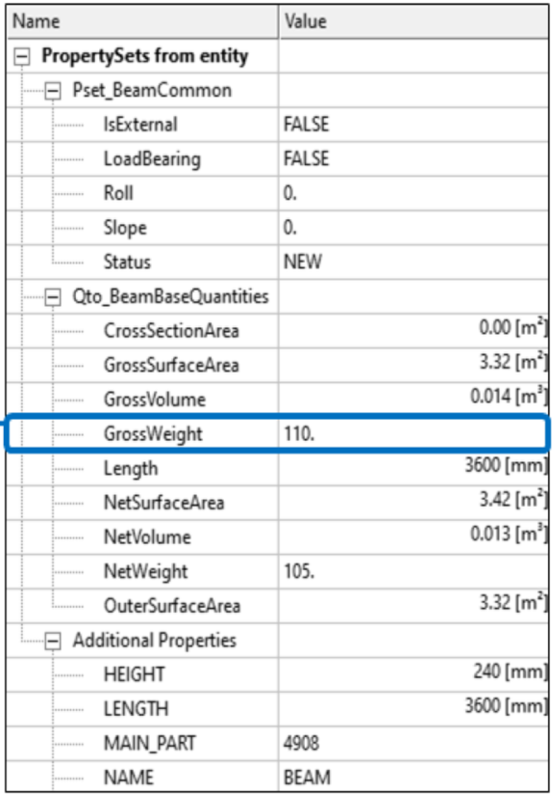
IFC 4.0 (SPF)



Name	Value
PropertySets from entity	
Pset_BeamCommon	
IsExternal	FALSE
LoadBearing	TRUE
Reference	IPE 240
Roll	0.
Slope	0.
Span	3.60 [m]
Pset_ReinforcementBar...	
Reference	IPE 240
Pset_EnvironmentalImp...	
Reference	IPE 240
Qto_BeamBaseQuantities	
CrossSectionArea	0.00 [m^2]
GrossSurfaceArea	3.33 [m^2]
GrossVolume	0.014 [m^3]
Length	3.60 [m]
NetSurfaceArea	3.33 [m^2]
NetVolume	0.014 [m^3]
OuterSurfaceArea	3.32 [m^2]
PSet_RevitCustom	
ElementWeight	110.







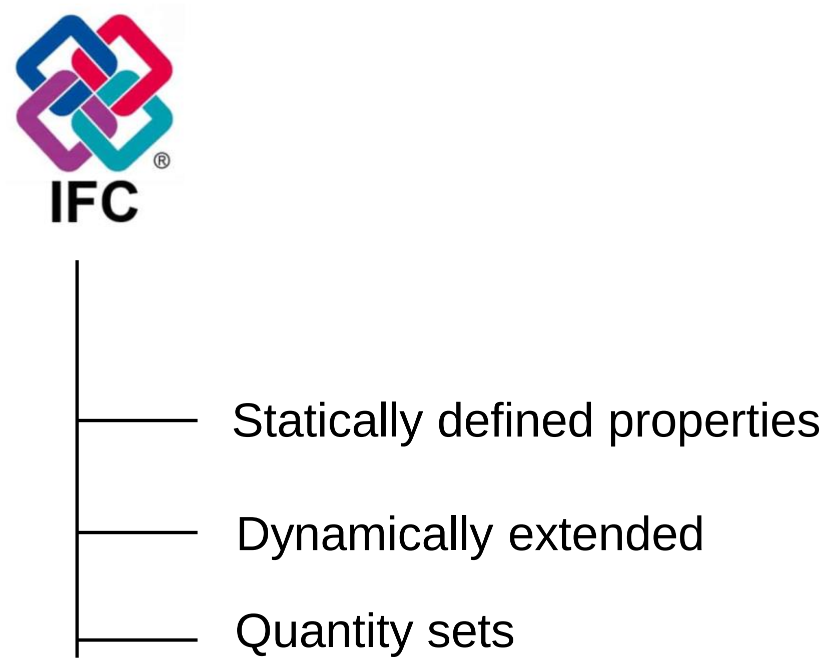
Name	Value
PropertySets from entity	
Pset_BeamCommon	
IsExternal	FALSE
LoadBearing	FALSE
Roll	0.
Slope	0.
Status	NEW
Qto_BeamBaseQuantities	
CrossSectionArea	0.00 [m^2]
GrossSurfaceArea	3.32 [m^2]
GrossVolume	0.014 [m^3]
GrossWeight	110.
Length	3600 [mm]
NetSurfaceArea	3.42 [m^2]
NetVolume	0.013 [m^3]
NetWeight	105.
OuterSurfaceArea	3.32 [m^2]
Additional Properties	
HEIGHT	240 [mm]
LENGTH	3600 [mm]
MAIN_PART	4908
NAME	BEAM

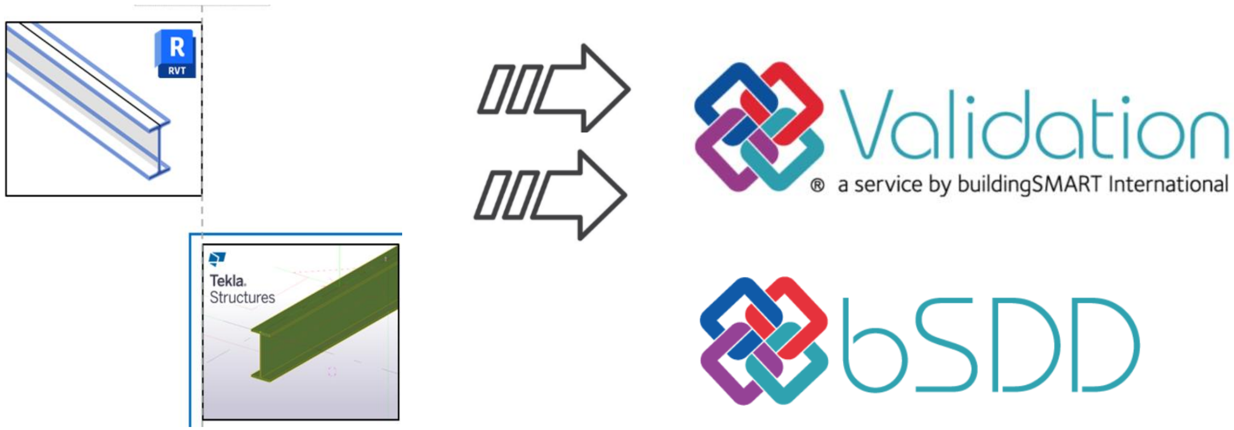
RDF (Turtle)

```
inst:beam_4535fbce a beo:Beam, bot:Element ;
        props:elementWeight      inst:elementWeight_4535f ;
        .....
```

```
inst:beam_4535fbce a beo:Beam, bot:Element ;
        props:GrossWeight      inst:elementWeight_4535f ;
        .....
```

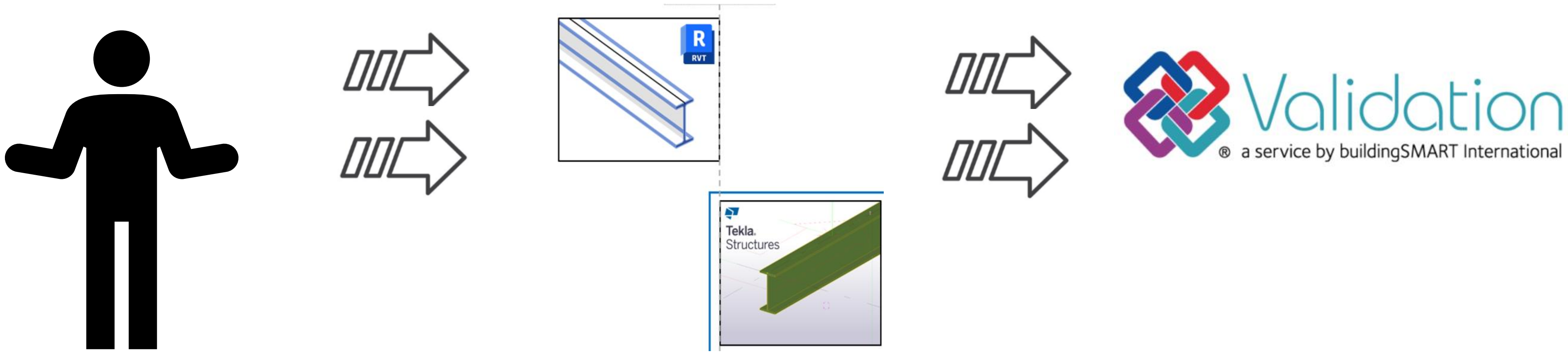
Standards



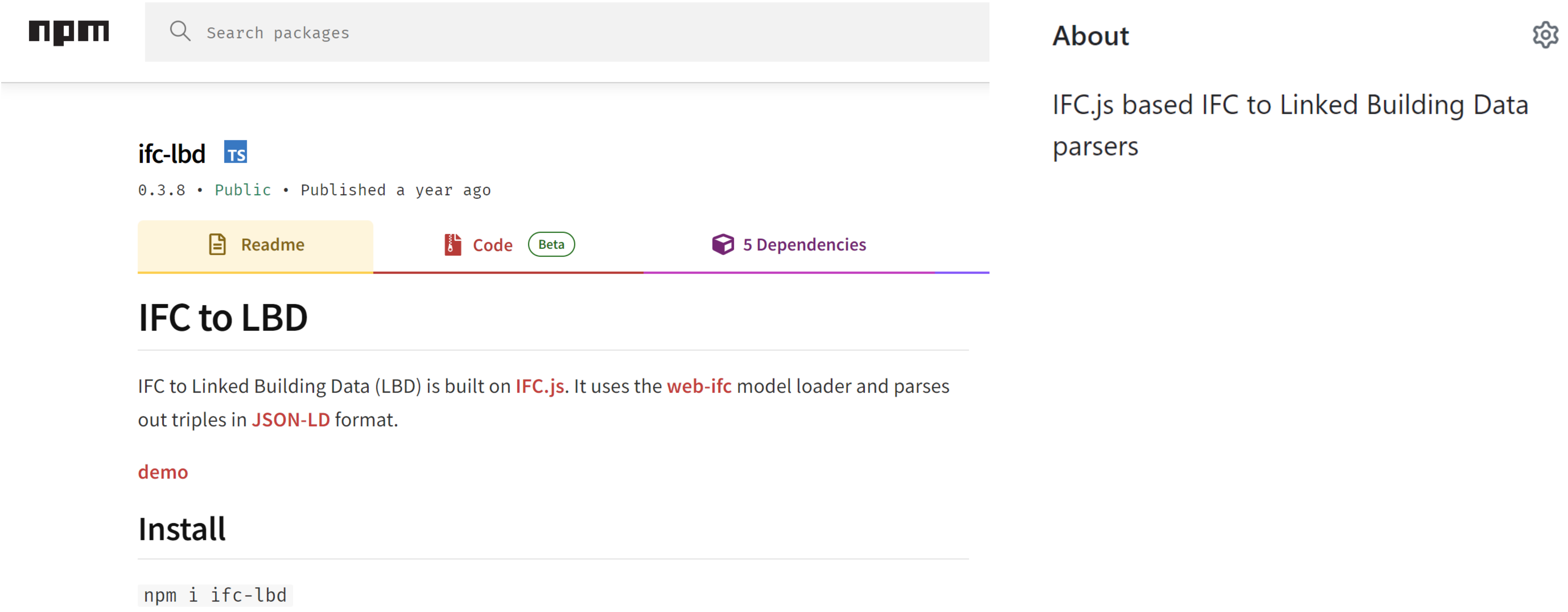


Alexiev et al. 2023

Standards


R
RVT
Tekla.
Structures
Validation
® a service by buildingSMART International

Related work: Converters



Search packages

ifc-lbd TS

0.3.8 • Public • Published a year ago

Readme | Code Beta | 5 Dependencies

IFC to LBD

IFC to Linked Building Data (LBD) is built on IFC.js. It uses the web-ifc model loader and parses out triples in JSON-LD format.

demo

Install

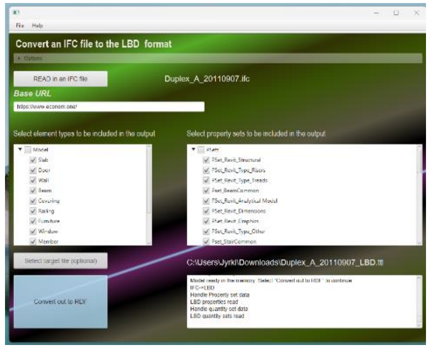
```
npm i ifc-lbd
```

About

IFC.js based IFC to Linked Building Data parsers

Related work: Converters

IFCtoLBD



Convert an IFC file to the LBD format

Duplex_A_20110907.ifc

Base URL

https://www.econom.one/

Select element types to be included in the output

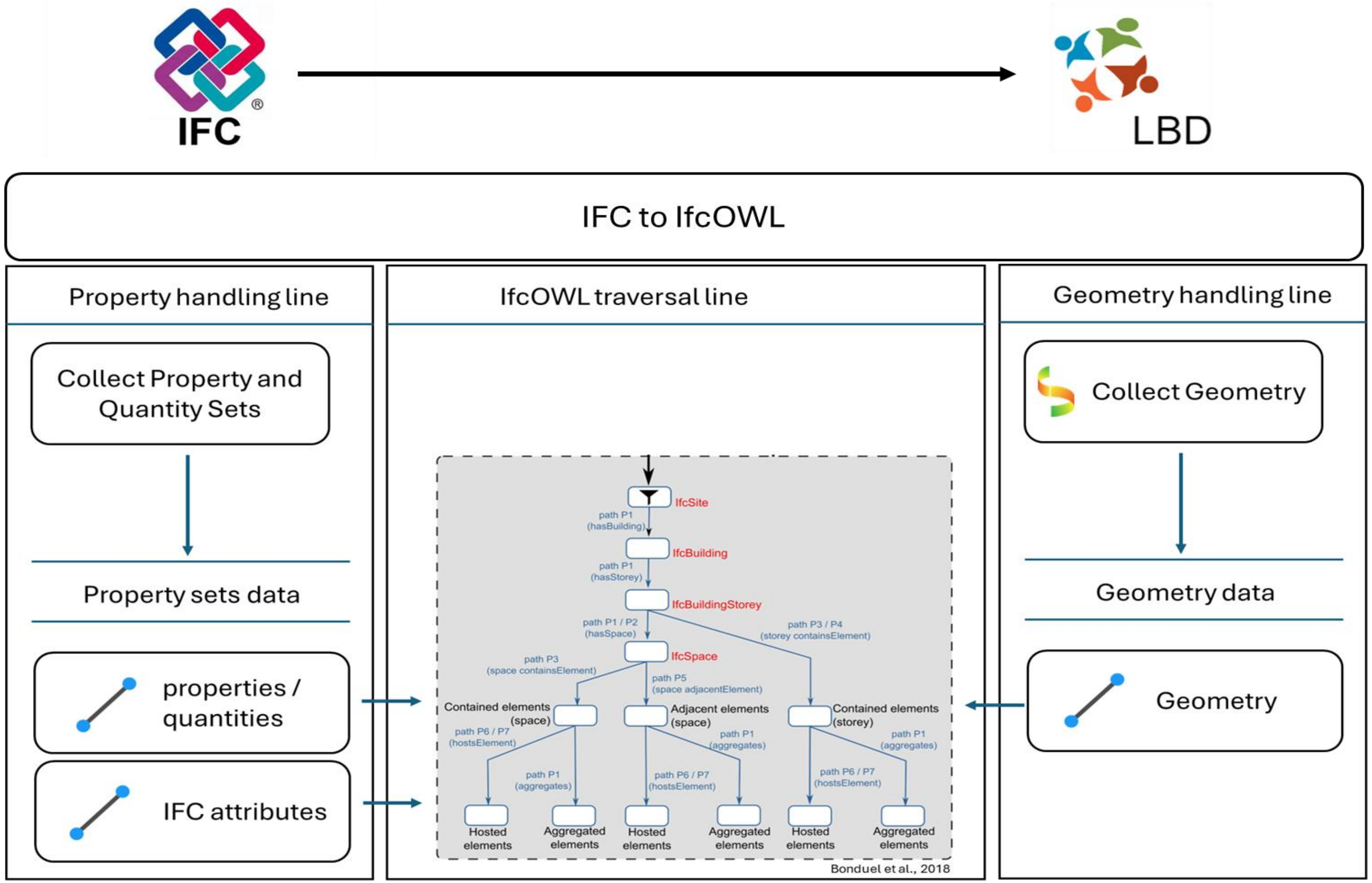
- ▼ □ Model
  - ☑ Slab
  - ☑ Door
  - ☑ Wall
  - ☑ Beam
  - ☑ Covering
  - ☑ Railing
  - ☑ Furniture
  - ☑ Window
  - ☑ Member

Select property sets to be included in the output

- ▼ □ PSets
  - ☑ PSet_Revit_Structural
  - ☑ PSet_Revit_Type_Risers
  - ☑ PSet_Revit_Type_Treads
  - ☑ Pset_BeamCommon
  - ☑ PSet_Revit_Analytical Model
  - ☑ PSet_Revit_Dimensions
  - ☑ PSet_Revit_Graphics
  - ☑ PSet_Revit_Type_Other
  - ☑ Pset_StairCommon

C:\Users\Jyrki\Downloads\Duplex_A_20110907_LBD.ttl

```
Model ready in the memory. Select "Convert out to RDF" to continue
IFC->LBD
Handle Property set data
LBD properties read
Handle quantity set data
LBD quantity sets read
```



Bonduel et al., 2018

Command line Interface

OpenAPI

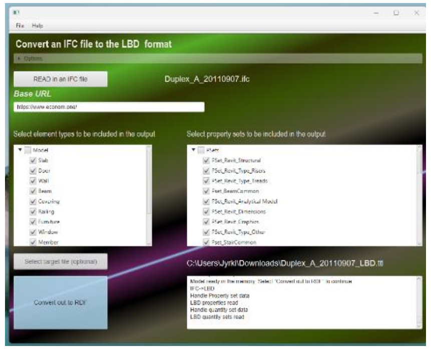
Desktop App

Python Library

CC link icon: Fabián Alexis

Related work

IFCtoLBD



Convert an IFC file to the LBD format

Duplex_A_20110907.ifc

Base URL

https://www.econom.one/

Select element types to be included in the output

- ☐ Model
  - ☑ Slab
  - ☑ Door
  - ☑ Wall
  - ☑ Beam
  - ☑ Covering
  - ☑ Railing
  - ☑ Furniture
  - ☑ Window
  - ☑ Member

Select property sets to be included in the output

- ☐ PSets
  - ☑ PSet_Revit_Structural
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  - ☑ Pset_BeamCommon
  - ☑ PSet_Revit_Analytical Model
  - ☑ PSet_Revit_Dimensions
  - ☑ PSet_Revit_Graphics
  - ☑ PSet_Revit_Type_Other
  - ☑ Pset_StairCommon

C:\Users\Jyrki\Downloads\Duplex_A_20110907_LBD.ttl

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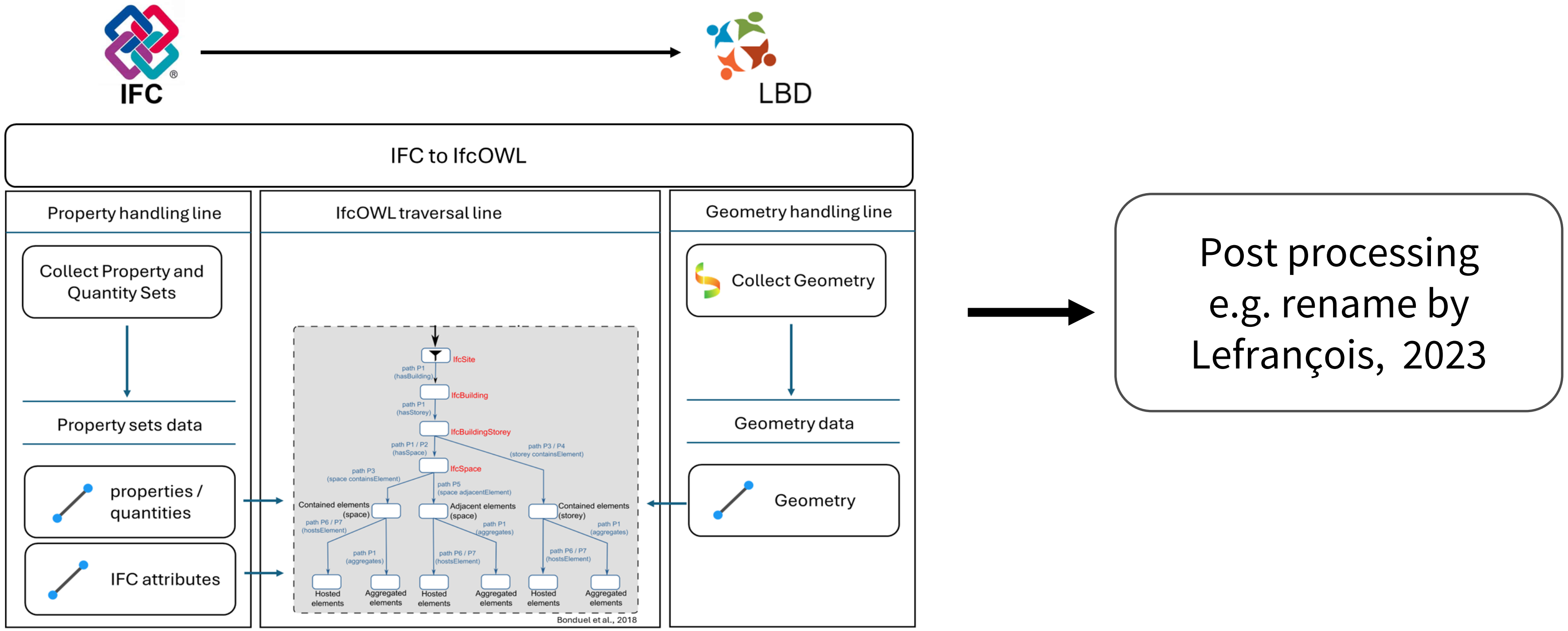


Post processing e.g. rename by Lefrançois, 2023

Bonduel et al., 2018

CC link icon: Fabián Alexis

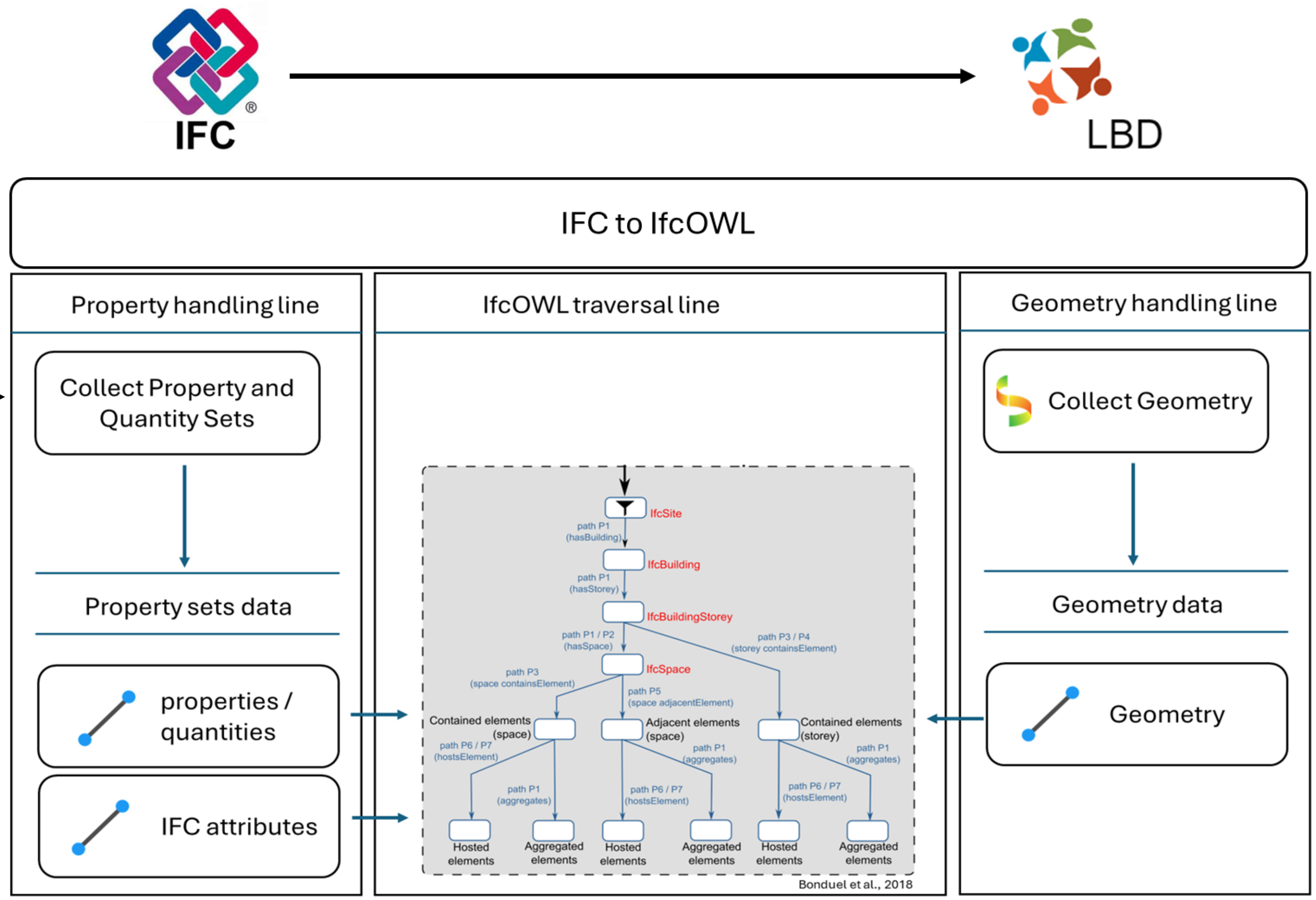
Solution 1: Lightweight Mapping

{JSON}

Mapping description

- User specific
- Software specific

{   "http://lbd.arch.rwth-aachen.de/props#grossWeight": "http://lbd.arch.rwth-aachen.de/props#elementWeight"}



IFC

LBD

IFC to IfcOWL

Property handling line

Collect Property and Quantity Sets

Property sets data

properties / quantities

IFC attributes

IfcOWL traversal line

Bonduel et al., 2018

Geometry handling line

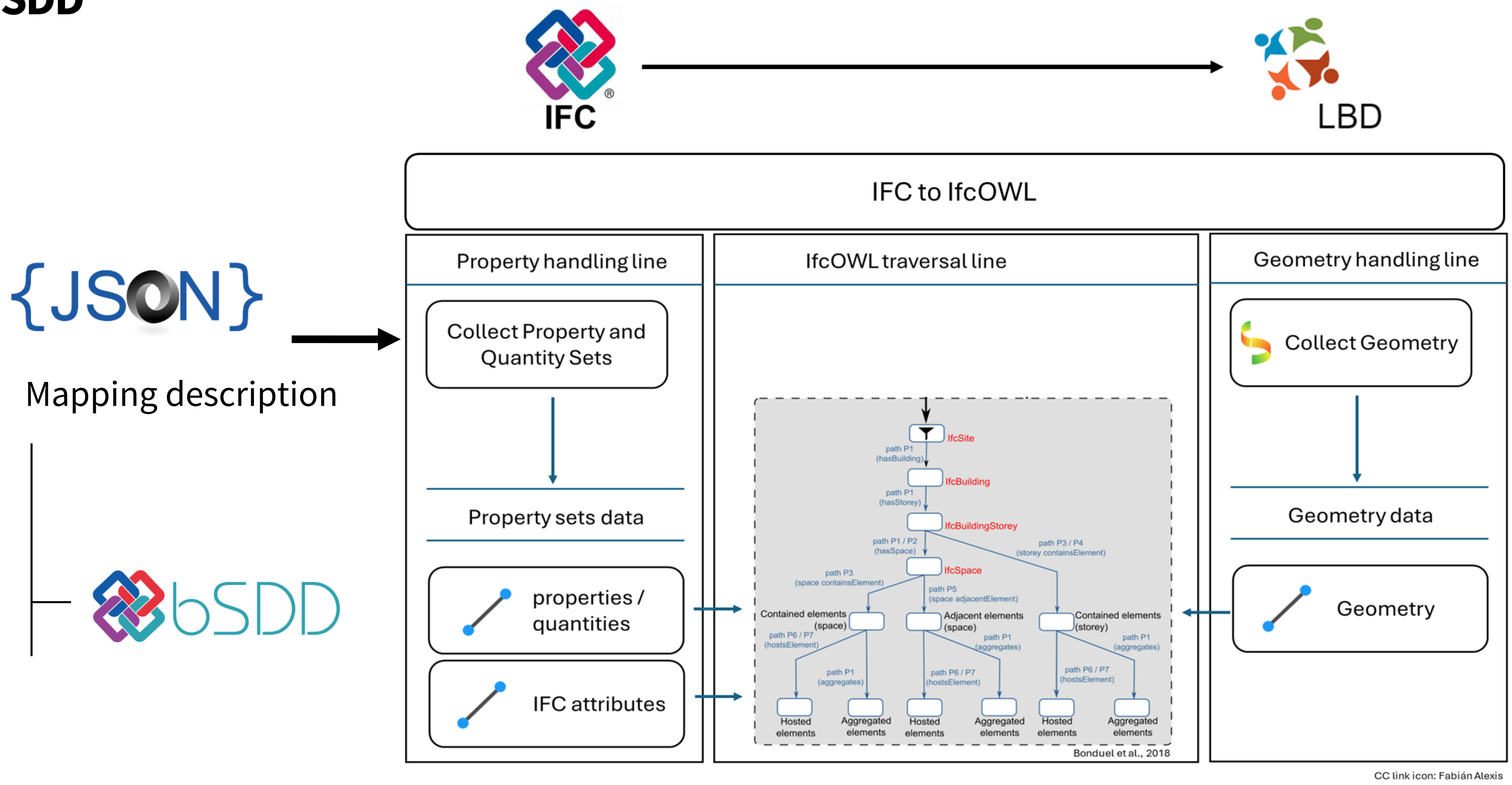
Collect Geometry

Geometry data

Geometry

CC link icon: Fabián Alexis

Solution 2: bSDD



IFC → LBD

{JSON} Mapping description

bSDD

IFC to IfcOWL

Property handling line

Collect Property and Quantity Sets

Property sets data

properties / quantities

IFC attributes

IfcOWL traversal line

Bonduel et al., 2018

Geometry handling line

Collect Geometry

Geometry data

Geometry

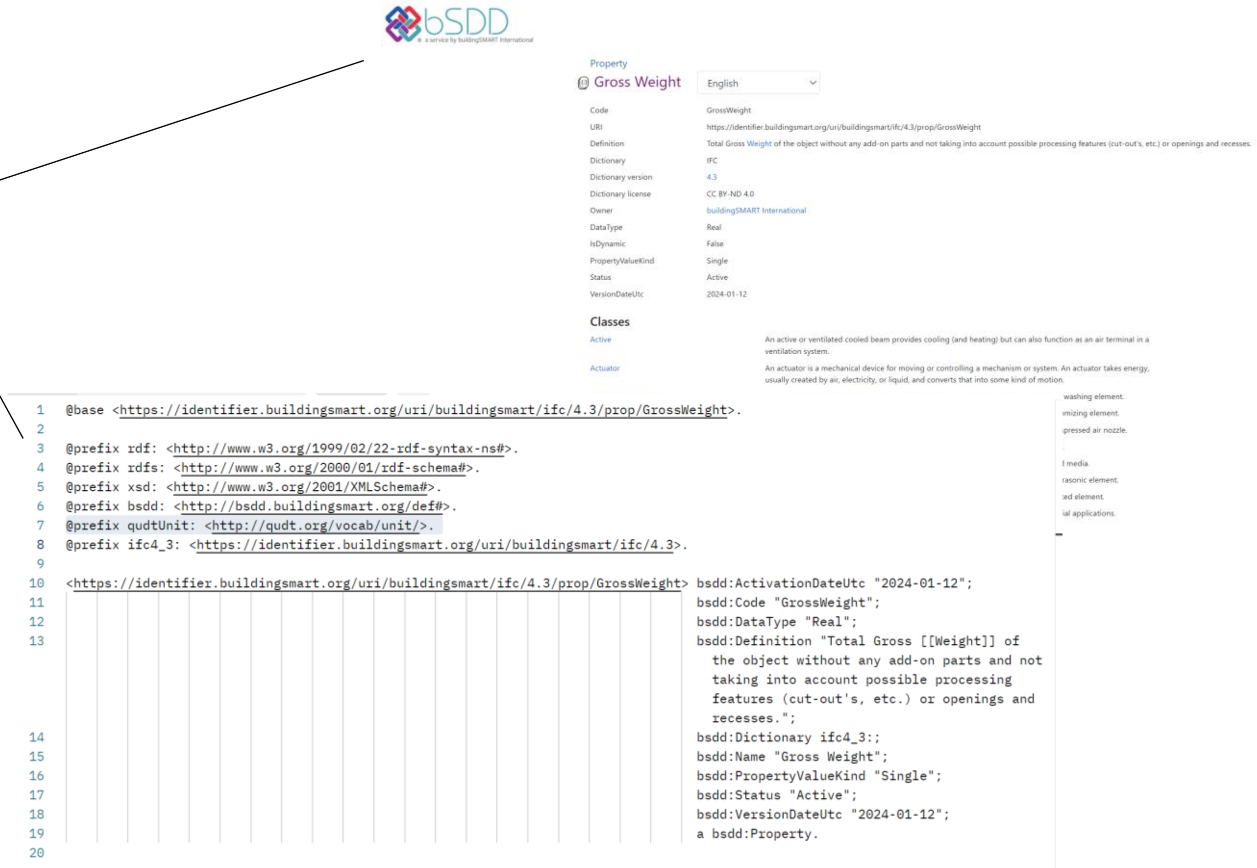
CC link icon: Fabián Alexis

Using Linked Building Data with buildingSMART Data Dictionary

IFC/terms	bSDD search
	bSDD API
LBD	human readable bSDD Ontology
	machine readable bSDD Ontology

LBD

- URIs to name things
- Derefenceable addressing
- When look up, provide useful information
- Links to other links



bSDD

Property

Gross Weight

English

Code	GrossWeight
URI	https://identifier.buildingsmart.org/uri/buildingsmart/ifc/4.3/prop/GrossWeight
Definition	Total Gross Weight of the object without any add-on parts and not taking into account possible processing features (cut-out's, etc.) or openings and recesses.
Dictionary	IFC
Dictionary version	4.3
Dictionary license	CC BY-ND 4.0
Owner	buildingSMART International
DataType	Real
IsDynamic	False
PropertyValueKind	Single
Status	Active
VersionDateUtc	2024-01-12

Classes

Active	An active or ventilated cooled beam provides cooling (and heating) but can also function as an air terminal in a ventilation system.
Actuator	An actuator is a mechanical device for moving or controlling a mechanism or system. An actuator takes energy, usually created by air, electricity, or liquid, and converts that into some kind of motion.

washing element.
mizing element.
pressed air nozzle.
l media.
rasonic element.
ted element.
ial applications.

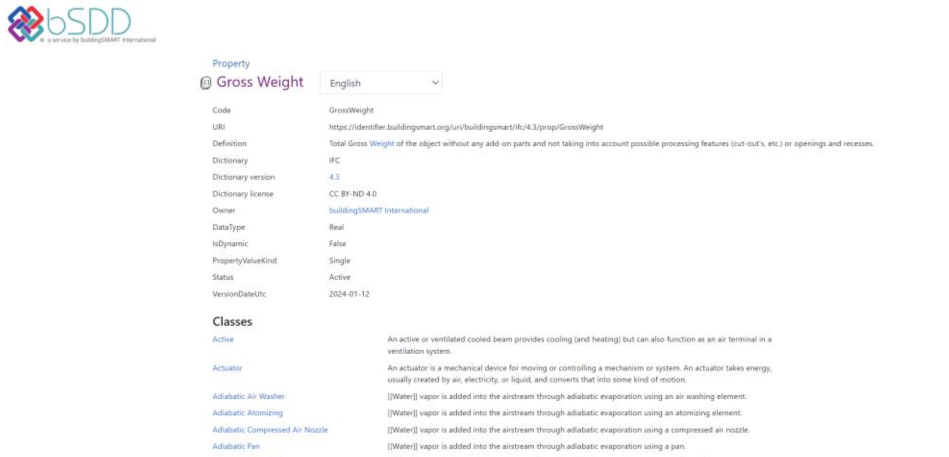
```
@base <https://identifier.buildingsmart.org/uri/buildingsmart/ifc/4.3/prop/GrossWeight>.

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.
@prefix bsdd: <http://bsdd.buildingsmart.org/def#>.
@prefix qudtUnit: <http://qudt.org/vocab/unit/>.
@prefix ifc4_3: <https://identifier.buildingsmart.org/uri/buildingsmart/ifc/4.3>.

<https://identifier.buildingsmart.org/uri/buildingsmart/ifc/4.3/prop/GrossWeight> bsdd:ActivationDateUtc "2024-01-12";
                                                                                  bsdd:Code "GrossWeight";
                                                                                  bsdd:DataType "Real";
                                                                                  bsdd:Definition "Total Gross [[Weight]] of
                                                                                    the object without any add-on parts and not
                                                                                    taking into account possible processing
                                                                                    features (cut-out's, etc.) or openings and
                                                                                    recesses.";
                                                                                  bsdd:Dictionary ifc4_3:;
                                                                                  bsdd:Name "Gross Weight";
                                                                                  bsdd:PropertyValueKind "Single";
                                                                                  bsdd:Status "Active";
                                                                                  bsdd:VersionDateUtc "2024-01-12";
                                                                                  a bsdd:Property.
```

Using Linked Building Data with buildingSMART Data Dictionary

IFC/terms	bSDD search
	bSDD API
LBD	human readable bSDD Ontology
	machine readable bSDD Ontology



Property

Gross Weight

English

Code	GrossWeight
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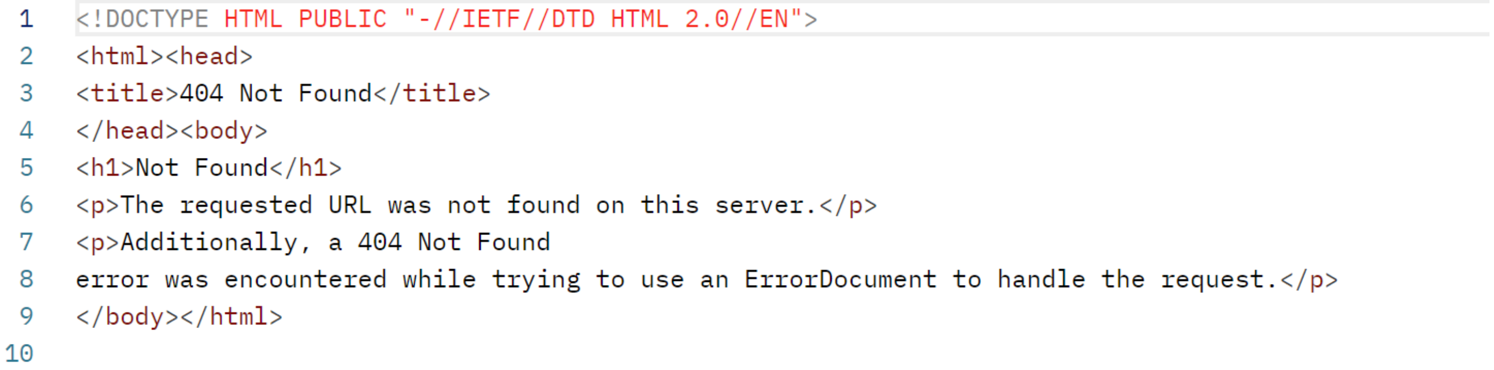
Definition	Total Gross Weight of the object without any add-on parts and not taking into account possible processing features (cut-out's, etc.) or openings and recesses.
Dictionary	IFC
Dictionary version	4.3
Dictionary license	CC BY-ND 4.0
Owner	buildingSMART International
DataType	Real
IsDynamic	False
PropertyValueKind	Single
Status	Active
VersionDateUtc	2024-01-12

Classes

Active	An active or ventilated cooled beam provides cooling (and heating) but can also function as an air terminal in a ventilation system.
Actuator	An actuator is a mechanical device for moving or controlling a mechanism or system. An actuator takes energy, usually created by air, electricity, or liquid, and converts that into some kind of motion.
Adiabatic Air Washer	[[Water]] vapor is added into the airstream through adiabatic evaporation using an air washing element.
Adiabatic Atomizing	[[Water]] vapor is added into the airstream through adiabatic evaporation using an atomizing element.
Adiabatic Compressed Air Nozzle	[[Water]] vapor is added into the airstream through adiabatic evaporation using a compressed air nozzle.
Adiabatic Pan	[[Water]] vapor is added into the airstream through adiabatic evaporation using a pan.



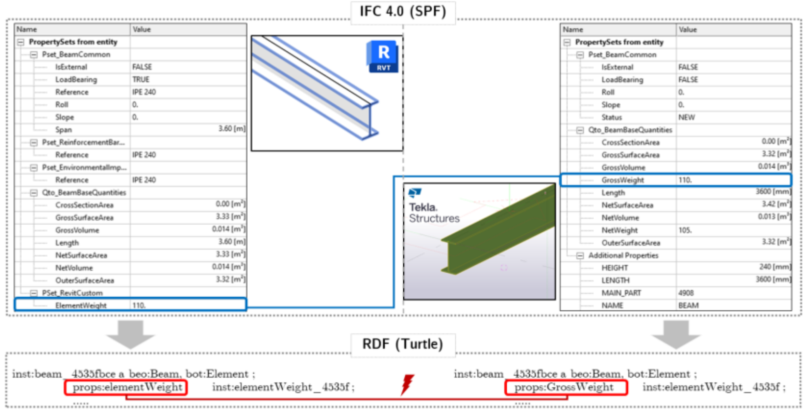
```
<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html><head>
<title>404 Not Found</title>
</head><body>
<h1>Not Found</h1>
<p>The requested URL was not found on this server.</p>
<p>Additionally, a 404 Not Found
error was encountered while trying to use an ErrorDocument to handle the request.</p>
</body></html>

```

Recommendations:

1. Use bSDD Ontology for properties, when possible, in the IFC data context.
2. Consistent access methods.
3. Ontology IRIs should be dereferenceable.

Evaluation: Queries

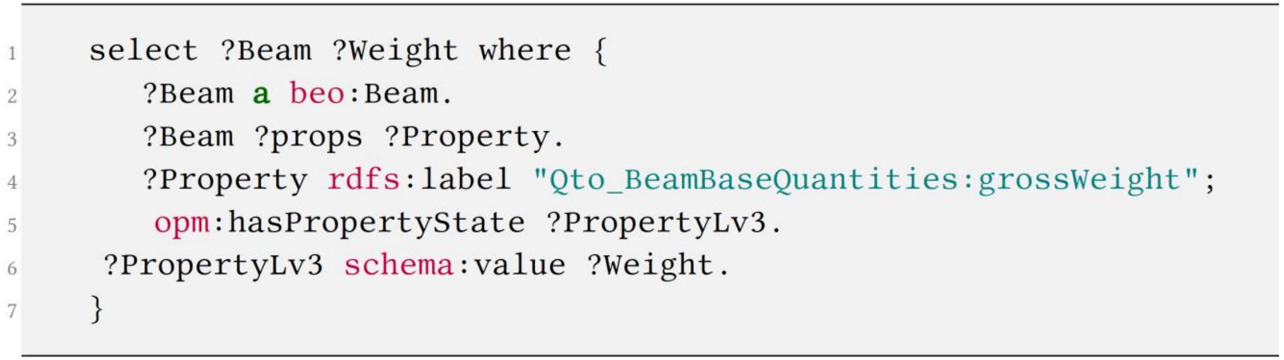


Name	Value
PropertySets from entity	
Pset_BeamCommon	
IsExternal	FALSE
LoadBearing	TRUE
Reference	IPE 240
Roll	0.
Slope	0.
Span	3.60 [m]
Pset_ReinforcementBar...	
Reference	IPE 240
Pset_EnvironmentalImp...	
Reference	IPE 240
Qto_BeamBaseQuantities	
CrossSectionArea	0.00 [m²]
GrossSurfaceArea	3.33 [m²]
GrossVolume	0.014 [m³]
Length	3.60 [m]
NetSurfaceArea	3.33 [m²]
NetVolume	0.014 [m³]
OuterSurfaceArea	3.32 [m²]
PSet_RevitCustom	
ElementWeight	110.

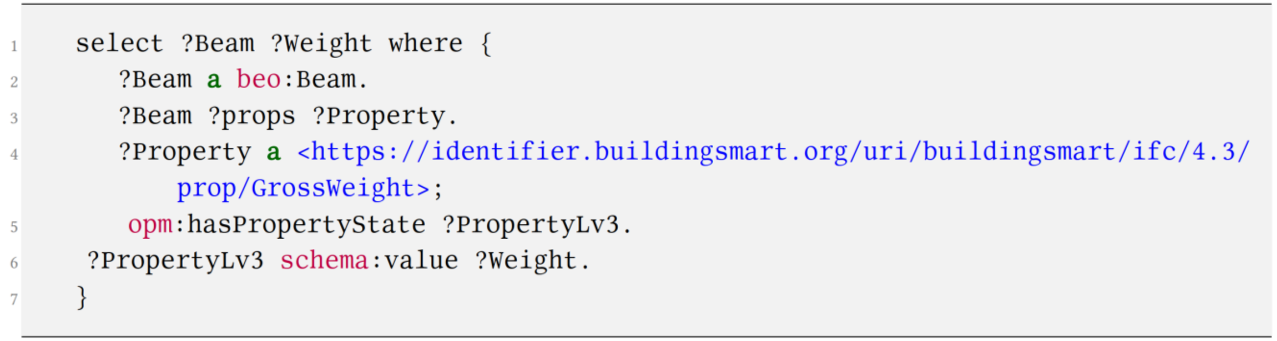
Name	Value
PropertySets from entity	
Pset_BeamCommon	
IsExternal	FALSE
LoadBearing	FALSE
Roll	0.
Slope	0.
Status	NEW
Qto_BeamBaseQuantities	
CrossSectionArea	0.00 [m²]
GrossSurfaceArea	3.32 [m²]
GrossVolume	0.014 [m³]
GrossWeight	110.
Length	3600 [mm]
NetSurfaceArea	3.42 [m²]
NetVolume	0.013 [m³]
NetWeight	105.
OuterSurfaceArea	3.32 [m²]
Additional Properties	
HEIGHT	240 [mm]
LENGTH	3600 [mm]
MAIN_PART	4908
NAME	BEAM

```
inst:beam_4535fbce a beo:Beam, bot:Element ;
        props:elementWeight    inst:elementWeight_4535f ;
        .....
```

```
inst:beam_4535fbce a beo:Beam, bot:Element ;
        props:GrossWeight    inst:elementWeight_4535f ;
        .....
```



```
select ?Beam ?Weight where {
   ?Beam a beo:Beam.
   ?Beam ?props ?Property.
   ?Property rdfs:label "Qto_BeamBaseQuantities:grossWeight";
    opm:hasPropertyState ?PropertyLv3.
 ?PropertyLv3 schema:value ?Weight.
}
```

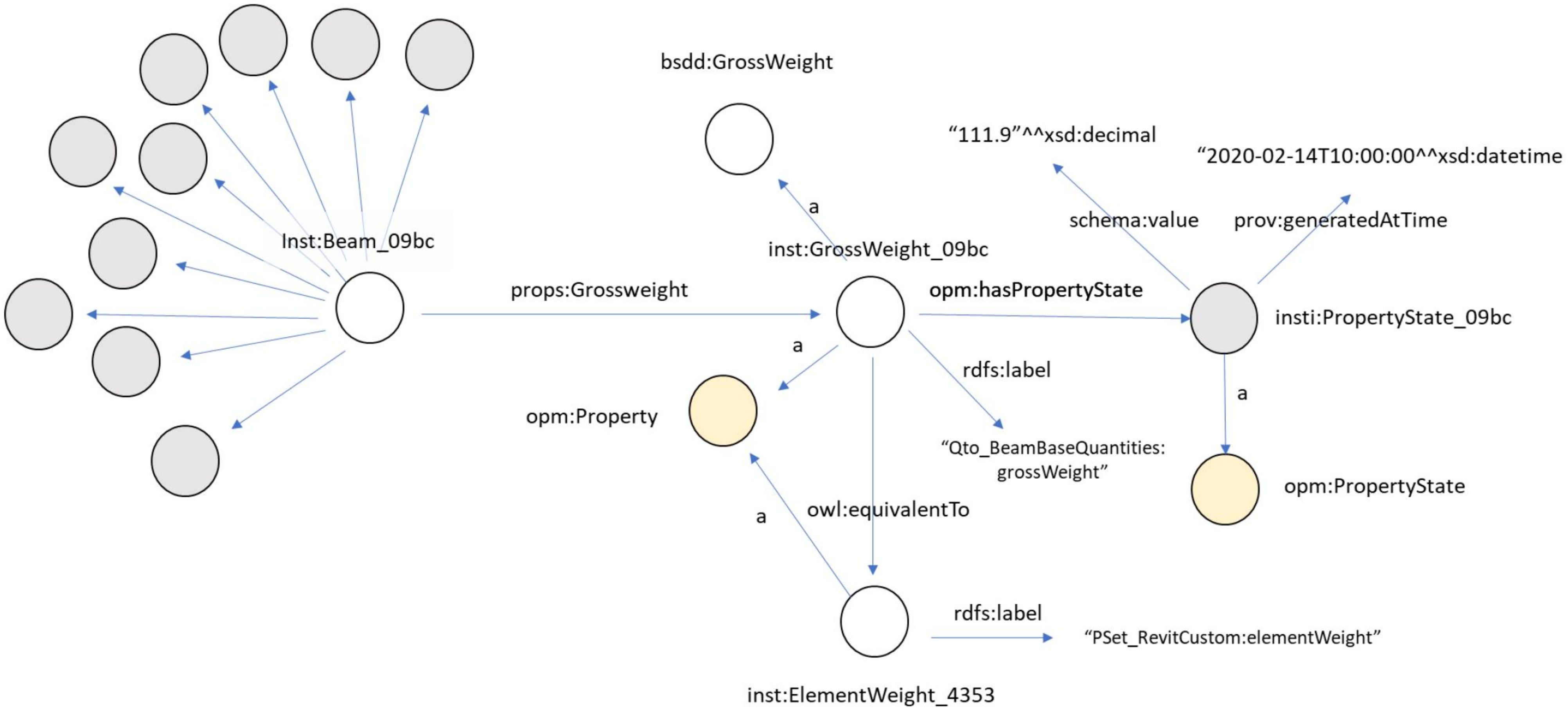


```
select ?Beam ?Weight where {
   ?Beam a beo:Beam.
   ?Beam ?props ?Property.
   ?Property a <https://identifier.buildingsmart.org/uri/buildingsmart/ifc/4.3/prop/GrossWeight>;
    opm:hasPropertyState ?PropertyLv3.
 ?PropertyLv3 schema:value ?Weight.
}
```

Result:

One query, same output for both inputs.

Solution 3: Keep original mapping

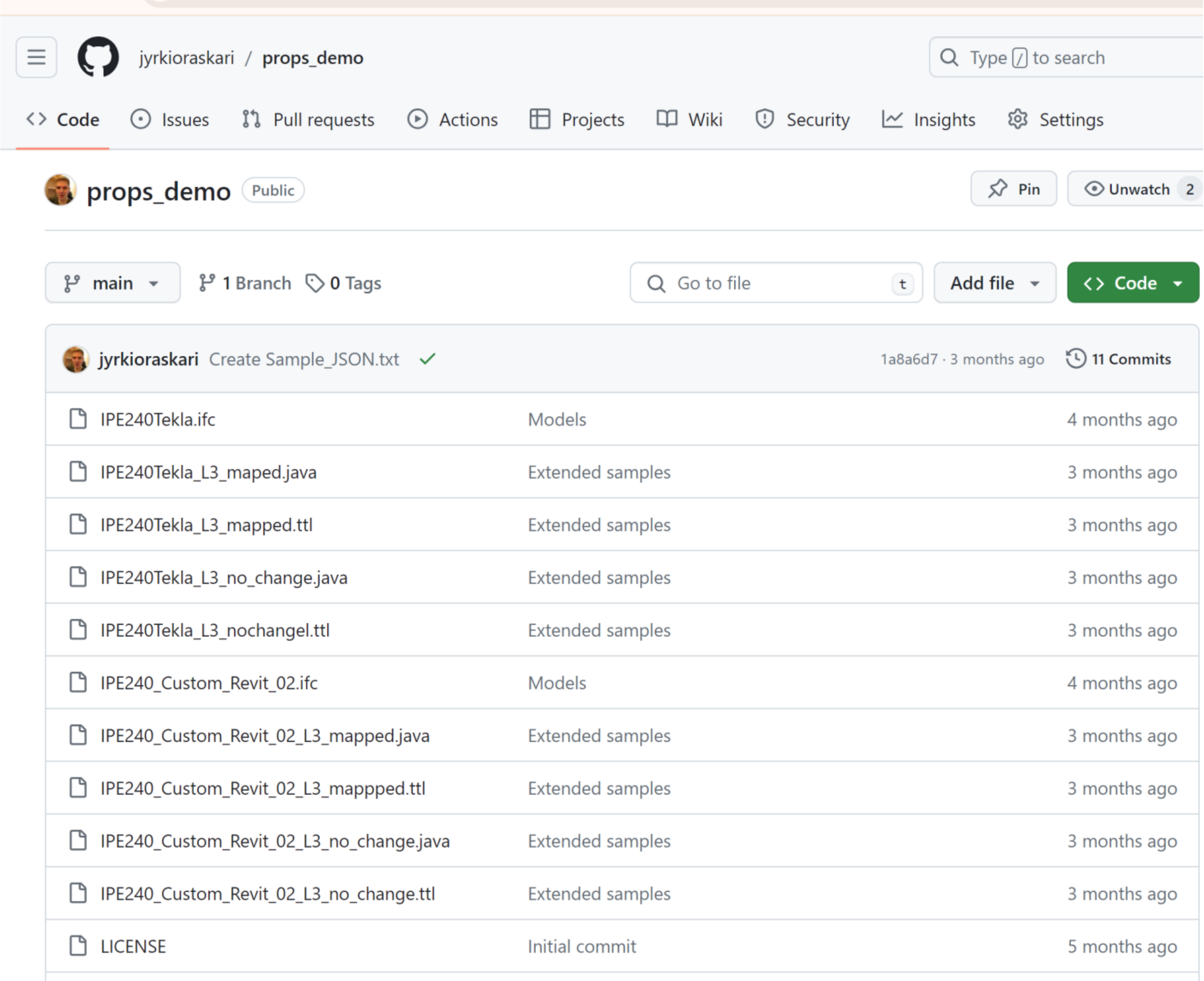


Comparison

owl:equivalentTo

Rename function	Solution 1	Solution 2	Solution 3
Post-process IRIs.	Commonly shared properties for a group collaboration.	Map to propeties of standard dictionaries like buildinSMART Data Dictionary.	Instead of replacing properties, add new so that provenance is kept.
Converter independent. Extra processing step.	Lightweight. Can be used in projects and smaller groups.	Scales well. Benefits of the dictionary definitions. Depends on the buildingSMART implementation	When it is important to know the original naming of the proerty. Debugging.
Software function	Mapping Shared as JSON	Mapping Shared as JSON	Mapping Shared as JSON

Data is available



jyrkioraskari Create Sample_JSON.txt ✓ 1a8a6d7 · 3 months ago 11 Commits

IPE240Tekla.ifc	Models	4 months ago
IPE240Tekla_L3_maped.java	Extended samples	3 months ago
IPE240Tekla_L3_mapped.ttl	Extended samples	3 months ago
IPE240Tekla_L3_no_change.java	Extended samples	3 months ago
IPE240Tekla_L3_nochangel.ttl	Extended samples	3 months ago
IPE240_Custom_Revit_02.ifc	Models	4 months ago
IPE240_Custom_Revit_02_L3_mapped.java	Extended samples	3 months ago
IPE240_Custom_Revit_02_L3_mappped.ttl	Extended samples	3 months ago
IPE240_Custom_Revit_02_L3_no_change.java	Extended samples	3 months ago
IPE240_Custom_Revit_02_L3_no_change.ttl	Extended samples	3 months ago
LICENSE	Initial commit	5 months ago

https://github.com/jyrkioraskari/props_demo

Conclusion

- Inconsistent property naming and classifications are common and hamper interoperability
- The proposed solution: to share RDF property mapping of
  - user-defined properties
  - software-specific properties
- **Observation**:
  - We recommend using buildingSMART Data Dictionary, but the Linked Data implementation has limitations

Future work:

- unifying measurement units
- conflicting values
- more complex mappings

Acknowledgements

This work is part of the EConoM research project funded by the Federal Ministry for Digital and Transport of Germany within the initiative InnoNT (funding number 19OI22009F). It was supported within the TARGET-X framework, a project funded by the Smart Networks and Services Joint Undertaking (SNS JU) under Horizon Europe (funding number 101096614). The authors are responsible for the content.

EConoM

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INNOVATIVE
NETZTECHNOLOGIEN

Gefördert durch:
Bundesministerium
für Digitales
und Verkehr

aufgrund eines Beschlusses
des Deutschen Bundestages

TARGET-X

European Commission
Horizon Europe
2021-2027

Co-funded by
the European Union

6GSNS