How much OWL do you need to know to make sense of building ontologies?

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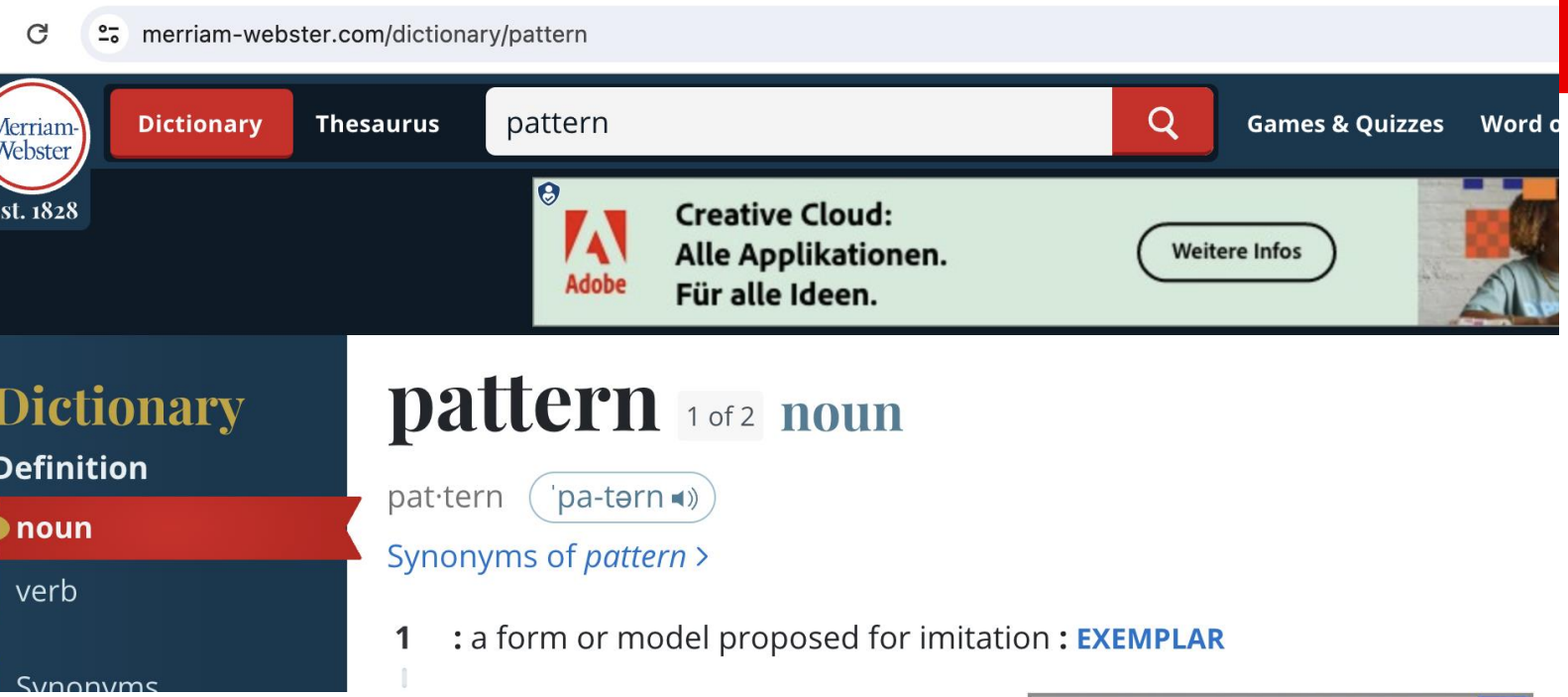
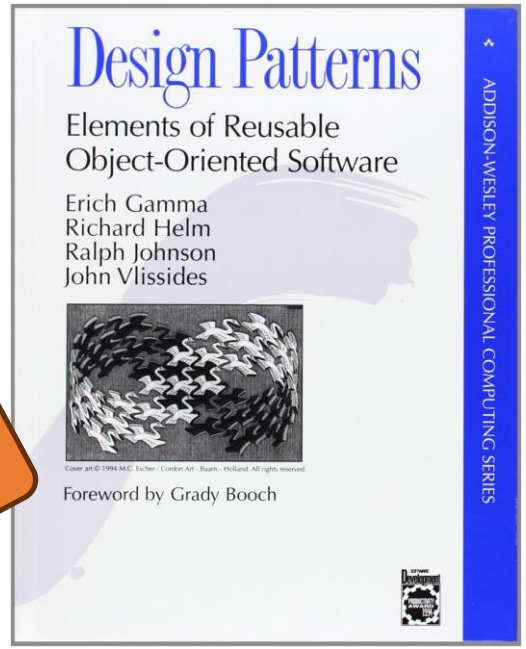
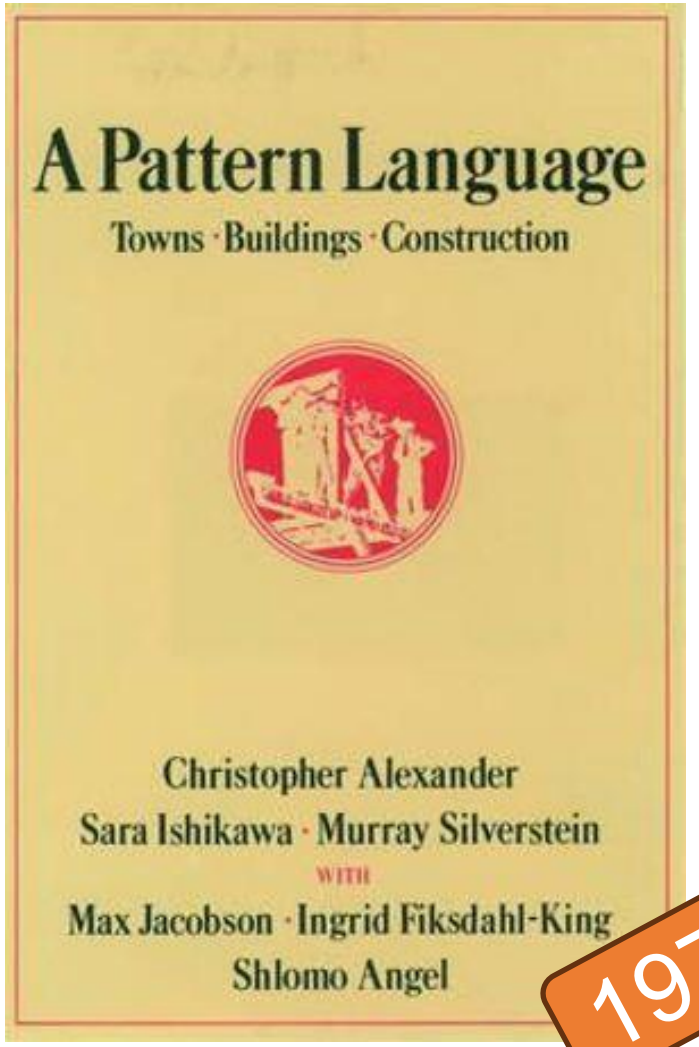
Patterns





1994



1977

Patterns

merriam-webster.com/dictionary/pattern

Merriam-Webster st. 1828 | Dictionary | Thesaurus | pattern | Games & Quizzes | Word

Dictionary
Definition
noun
verb
Synonyms
Synonym Chooser

pattern 1 of 2 **noun**

pat·tern 'pa-tərn

Synonyms of *pattern* >

1 : a form or model proposed for imitation : **EXEMPLAR**

2 : something designed or used as a model for making things
a dressmaker's *pattern*

- Replicable solutions that really work!

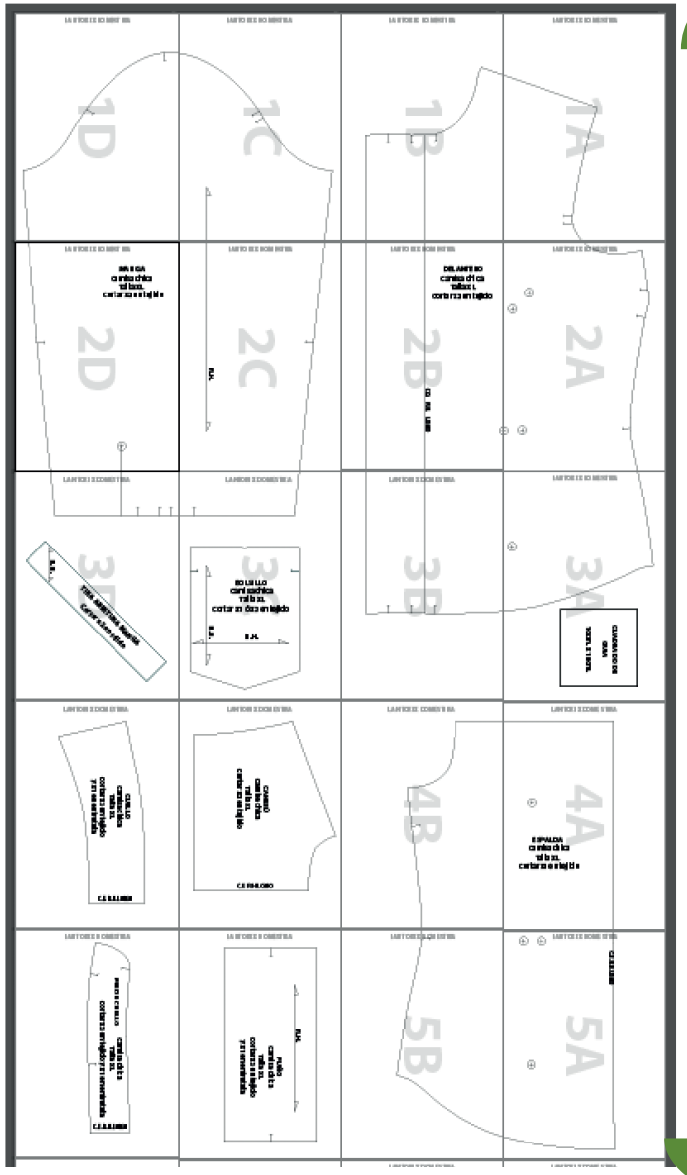
1954

Today's random piece of information:

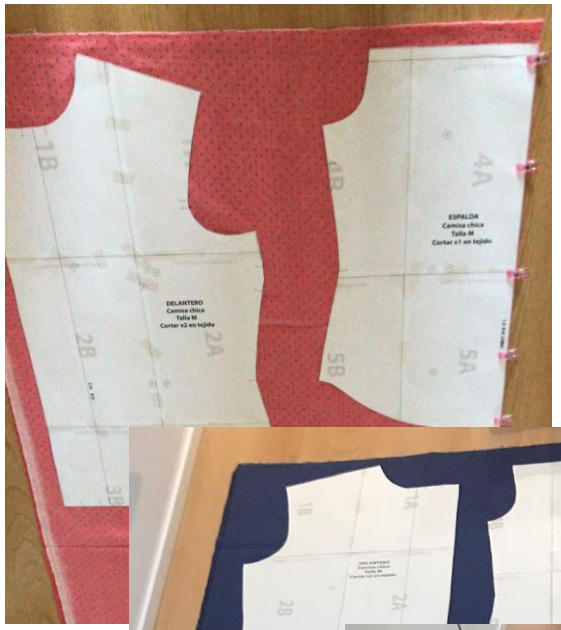
- Aenne Burda, 1909 Offenburg
- 1952: Burda Moden includes printed patterns
- Symbol of German economic miracle

https://www.burdastyle.com/70-years-burda

Replicability



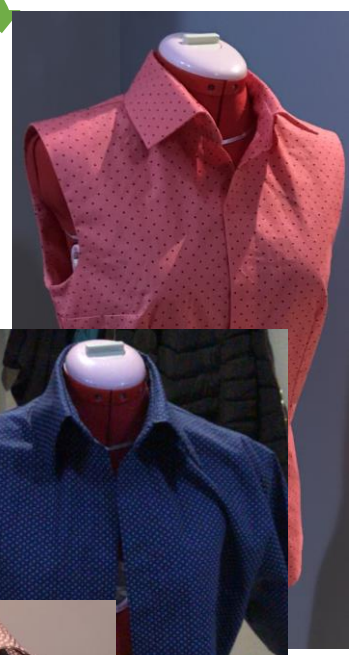
copy



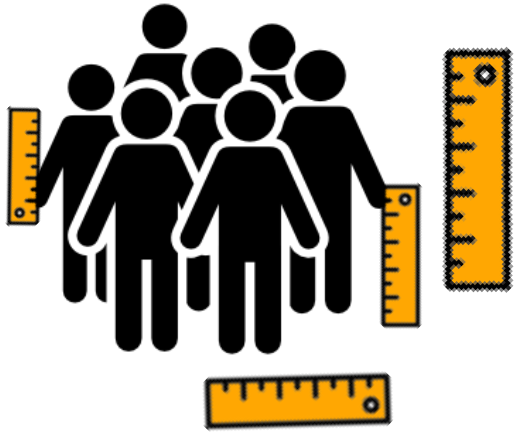
cut

Adapt & copy

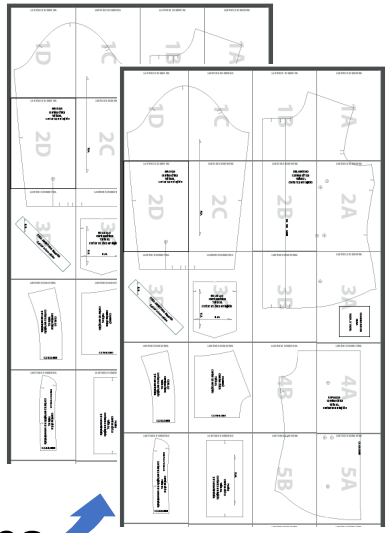
sew



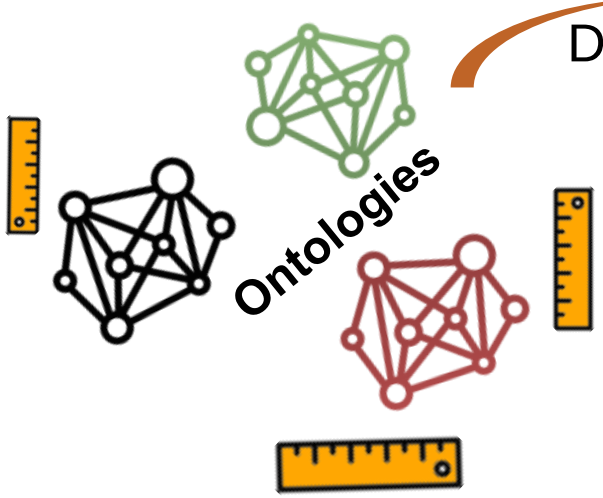
Building a pattern library



Define patterns



Compile & Use



Define ODP

Pattern 2

owl:Class
 lrdfs:subClassOf
 I lowl:Restriction
 I I lowl:onProperty
 I I I lowl:ObjectProperty
 I I lowl:someValuesFrom
 I I I lowl:Class
 I I I I lowl:unionOf

Compile & Use

Pattern 2

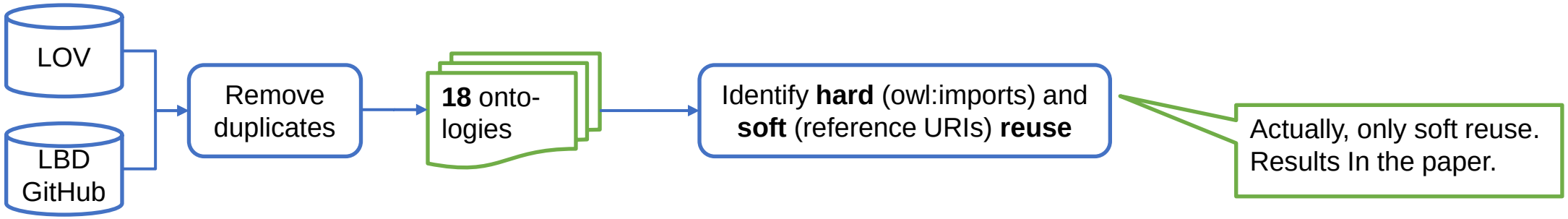
Pattern 3

Pattern 6

owl:Class
 lrdfs:subClassOf
 I lowl:Restriction
 I I lowl:onProperty
 I I I lowl:FunctionalProperty, owl:ObjectProperty
 I I lowl:someValuesFrom
 I I I lowl:Class

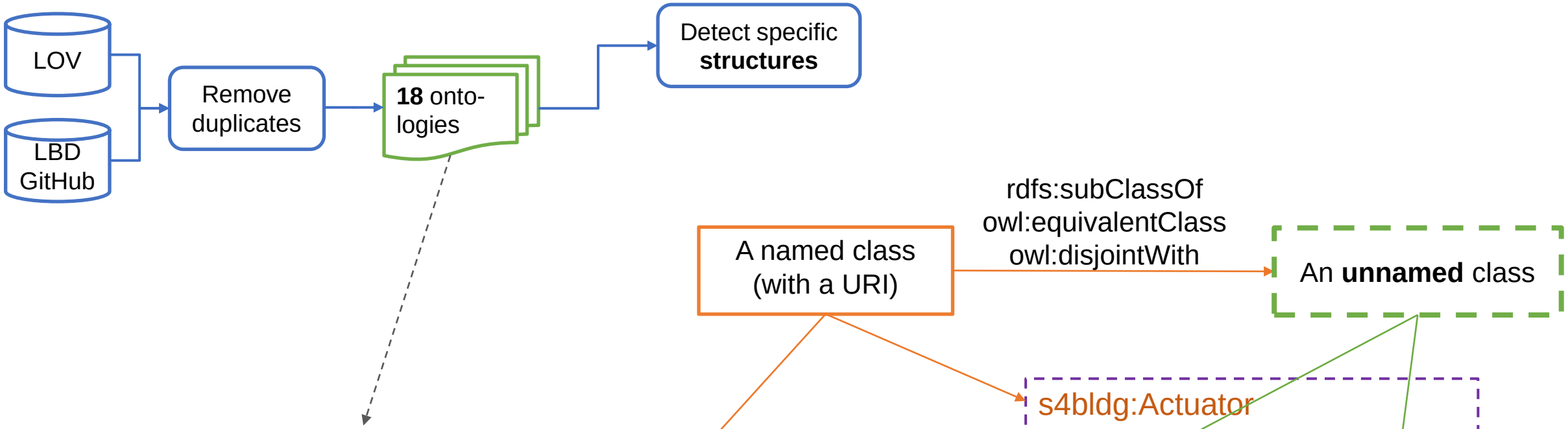
*ODP = Ontology Design Patterns

Process – Collect data



Prefix	Ontology Title Ontology	URI
bcom	Building Concrete Monitoring Ontology	https://w3id.org/bcom
beo	Building Element Ontology	https://pi.pauwel.be/voc/buildingelement
bimerr-op	Occupancy Profile ontology	http://bimerr.iot.linkeddata.es/def/occupancy-profile#
bpo	Building Product Ontology	https://w3id.org/bpo
bot	Building Topology Ontology	https://w3id.org/bot#
brick	Brick	https://brickschema.org/schema/Brick#
fog	File Ontology for Geometry formats	https://w3id.org/fog
ifcOWL	ontology (IFC4_ADD1)	https://w3id.org/ifc/IFC4_ADD1
IFifcC4	list of properties extracted from IFC4 psets	https://w3id.org/product/props/
jup	Ontology of Building Accessibility	http://w3id.org/charta77/jup
mep	Distribution Element Ontology	https://pi.pauwel.be/voc/distributionelement
omg	Ontology for Managing Geometry	https://w3id.org/omg#
rami	Reference Architecture Model	http://iais.fraunhofer.de/vocabs/rami#
rec	RealEstateCore	https://w3id.org/rec
rooms	Buildings and Rooms Vocabulary	http://vocab.deri.ie/rooms
s4bldg	SAREF extension for building	https://saref.etsi.org/saref4bldg/
sbeo	Smart Building Evacuation Ontology	https://w3id.org/sbeo
seasbo	The SEAS Building Ontology	https://w3id.org/seas/BuildingOntology

Process – Identify structures




```
<owl:Class rdf:about="https://saref.etsi.org/saref4bldg/Actuator">
<rdfs:subClassOf>
    <owl:Restriction>
      <owl:allValuesFrom rdf:resource="http://www.w3.org/2001/XMLSchema#boolean"/>
      <owl:onProperty>
        <owl:DatatypeProperty rdf:about="https://saref.etsi.org/saref4bldg/manualOverride"/>
      </owl:onProperty>
    </owl:Restriction>
  </rdfs:subClassOf>
```

```
s4bldg:Actuator
  |rdfs:subClassOf
  |  |owl:Restriction
  |  |  |owl:allValuesFrom
  |  |  |  |xsd:boolean
  |  |  |owl:onProperty
  |  |  |  |s4bldg:manualOverride
```

Process – Identify structures

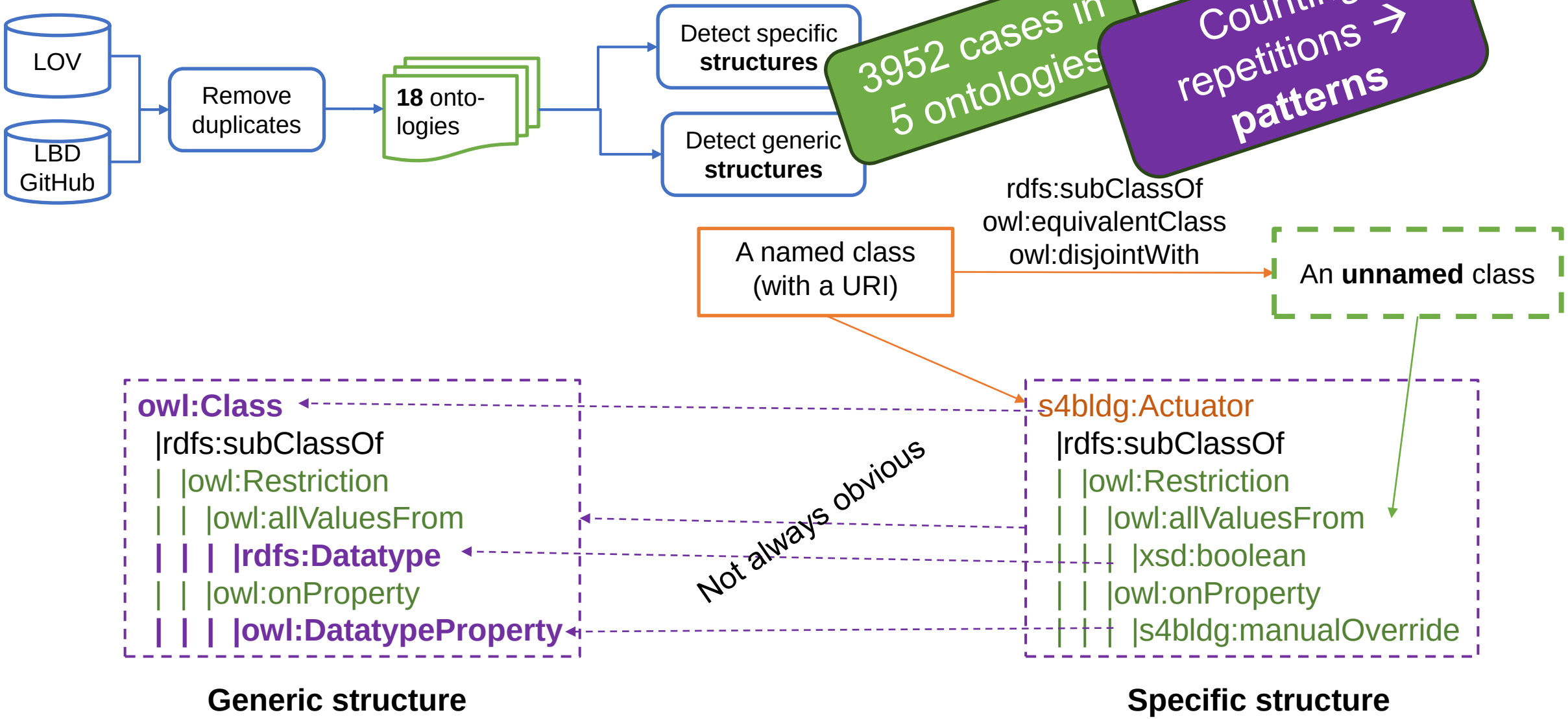
```
<owl:Class rdf:about="https://saref.etsi.org/saref4bldg/Actuator">
<rdfs:subClassOf>
    <owl:Restriction>
     <owl:allValuesFrom rdf:resource="http://www.w3.org/2001/XMLSchema#boolean"/>
     <owl:onProperty>
       <owl:DatatypeProperty rdf:about="https://saref.etsi.org/saref4bldg/manualOverride"/>
     </owl:onProperty>
    </owl:Restriction>
  </rdfs:subClassOf>
```

```
<owl:Class rdf:about="https://saref.etsi.org/saref4bldg/Actuator">
<rdfs:subClassOf>
    <owl:Restriction>
     <owl:onProperty>
      <owl:DatatypeProperty rdf:about="https://saref.etsi.org/saref4bldg/manualOverride"/>
     </owl:onProperty>
     <owl:allValuesFrom rdf:resource="http://www.w3.org/2001/XMLSchema#boolean"/>
    </owl:Restriction>
  </rdfs:subClassOf>
```

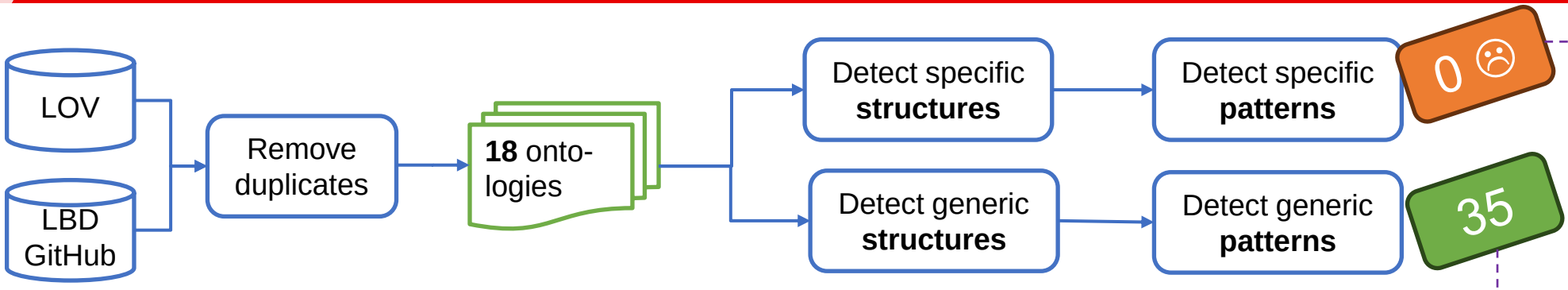
What about the triples order? In RDF it does not matter

```
s4bldg:Actuator
  |rdfs:subClassOf
  |  |owl:Restriction
  |  |  |owl:allValuesFrom
  |  |  |  |xsd:boolean
  |  |  |owl:onProperty
  |  |  |  |s4bldg:manualOverride
```

Does not matter, this is rendered in alphabetical order. ☺


LOV
LBD GitHub
Remove duplicates
18 onto-logies
Detect specific structures
Detect generic structures
3952 cases in 5 ontologies
Counting repetitions → patterns
rdfs:subClassOf
owl:equivalentClass
owl:disjointWith
A named class (with a URI)
An unnamed class
owl:Class
|rdfs:subClassOf
| |owl:Restriction
| | |owl:allValuesFrom
| | | |rdfs:Datatype
| | |owl:onProperty
| | | |owl:DatatypeProperty
Not always obvious
s4bldg:Actuator
|rdfs:subClassOf
| |owl:Restriction
| | |owl:allValuesFrom
| | | |xsd:boolean
| | |owl:onProperty
| | | |s4bldg:manualOverride
Generic structure
Specific structure

Process – Calculate patterns



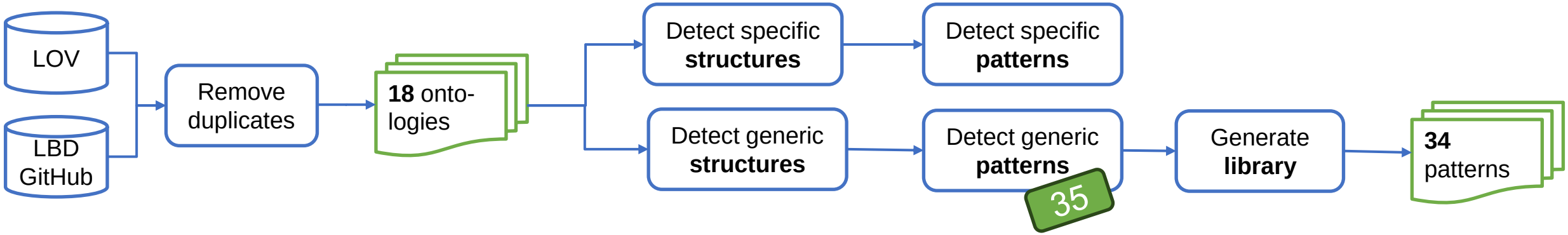
owl:Class
|rdfs:subClassOf
| |owl:Restriction
| | |owl:allValuesFrom
| | | |rdfs:Datatype
| | |owl:onProperty
| | | |owl:DatatypeProperty

Generic structure → repetitions → patterns

s4bldg:Actuator
|rdfs:subClassOf
| |owl:Restriction
| | |owl:allValuesFrom
| | | |xsd:boolean
| | |owl:onProperty
| | | |s4bldg:manualOverride

Specific structure → repetitions → patterns

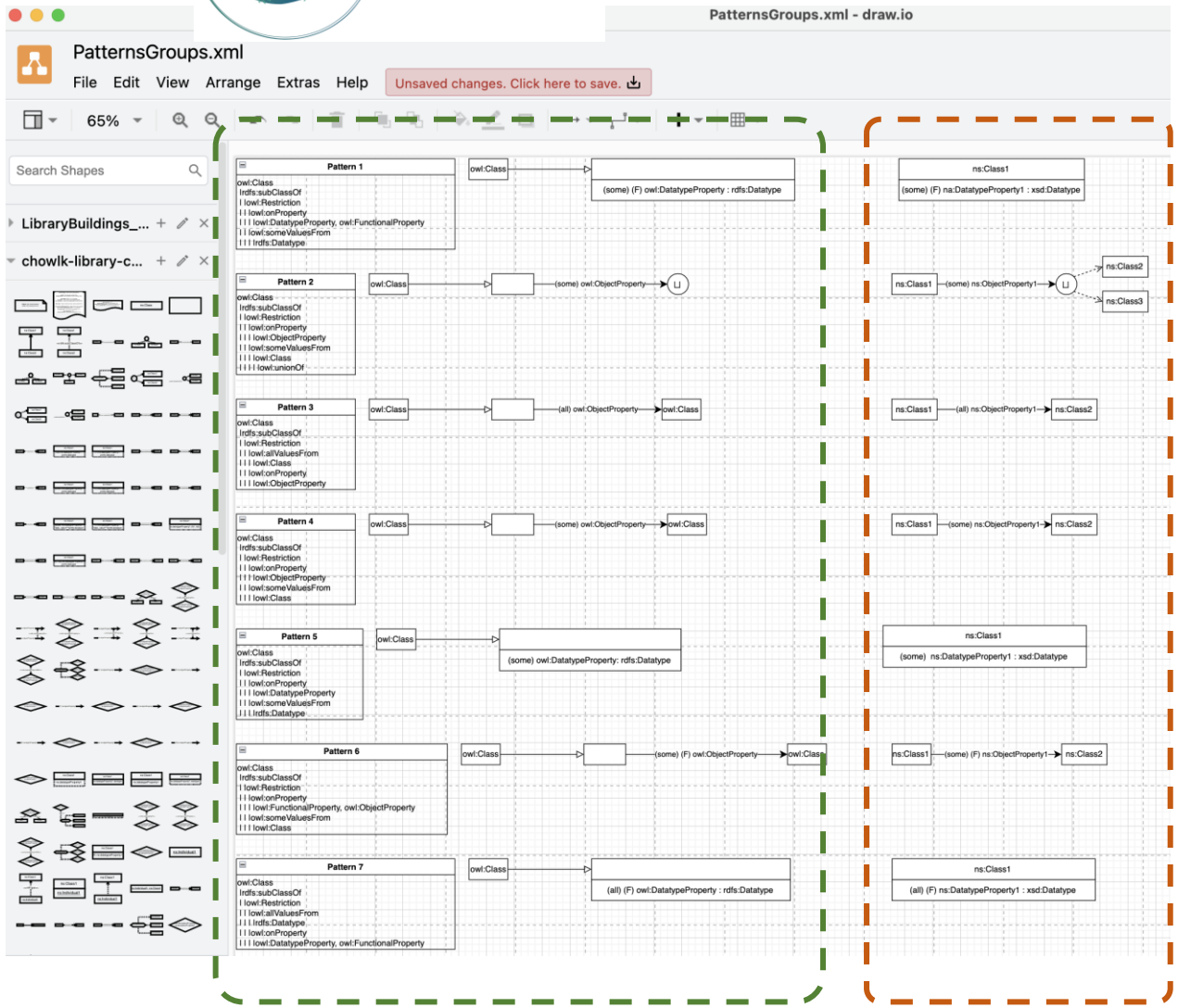
Process – Generate library



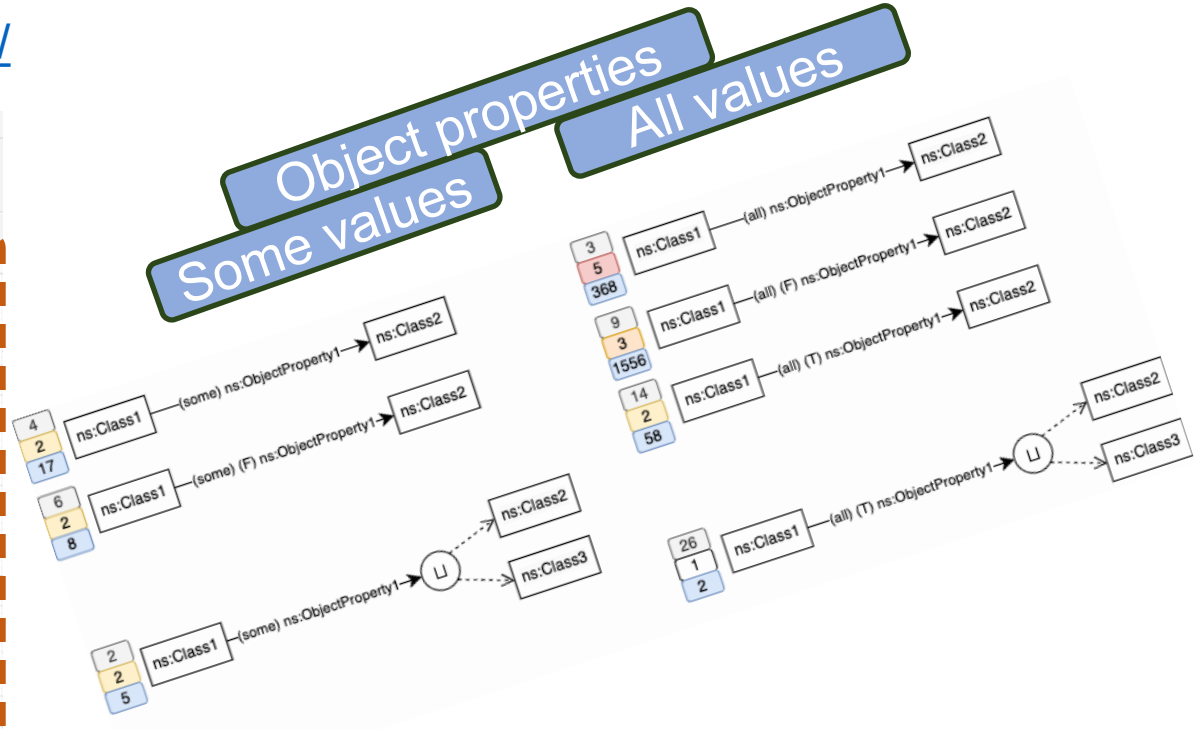
Process – Generate library – Generate diagrams & grouping

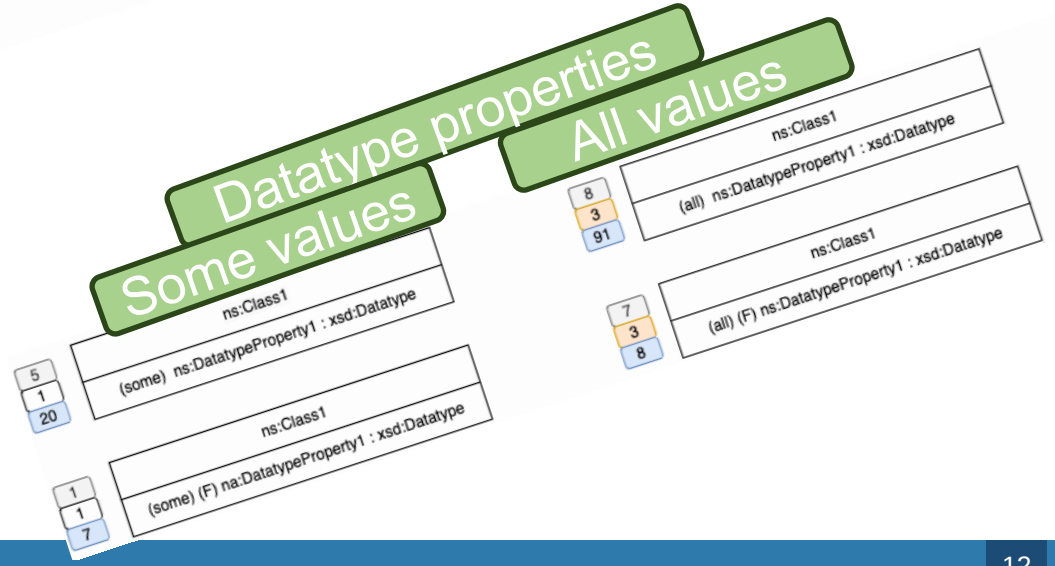
Chowlk

https://chowlk.linkeddata.es/



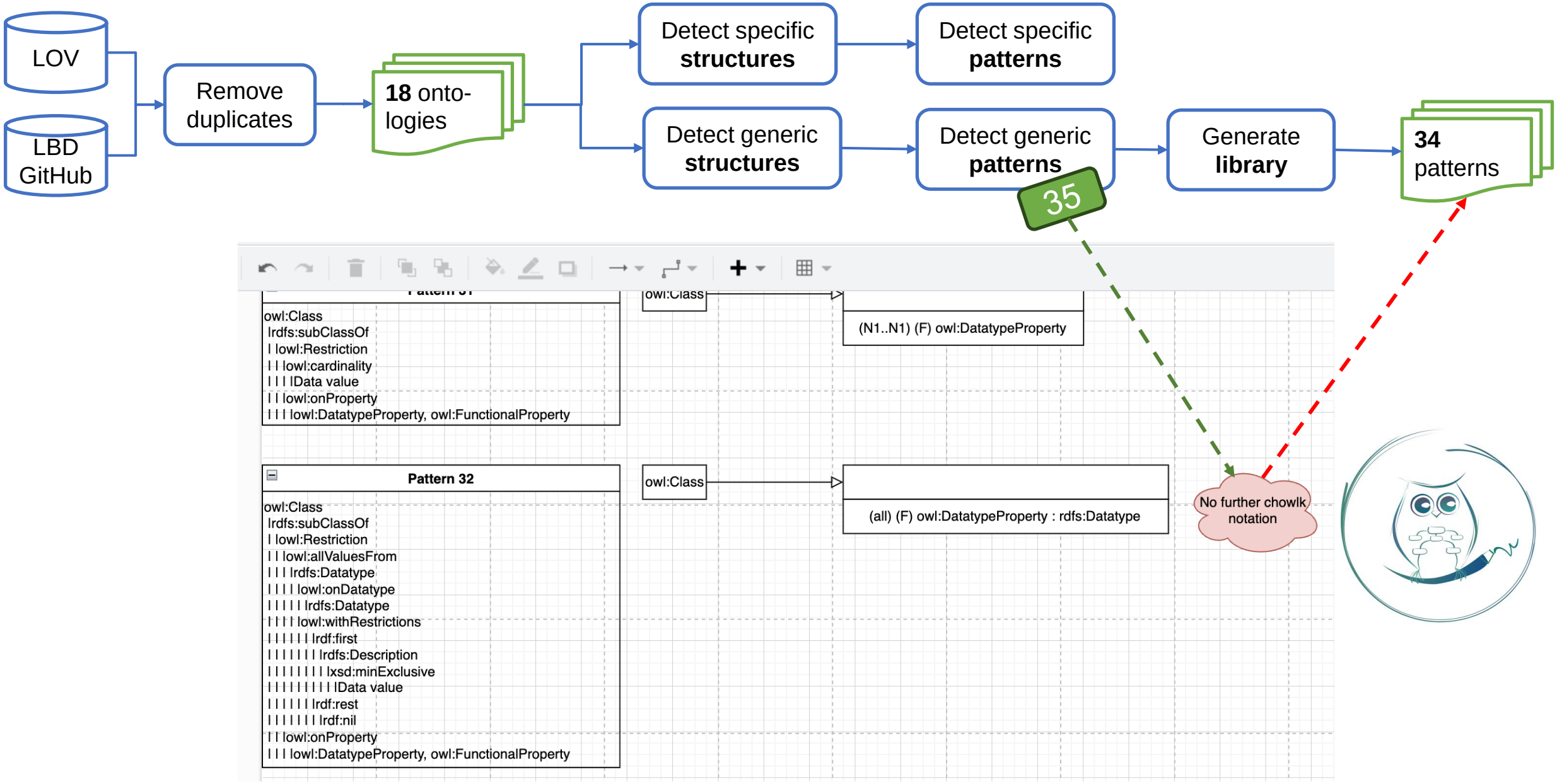
Automated



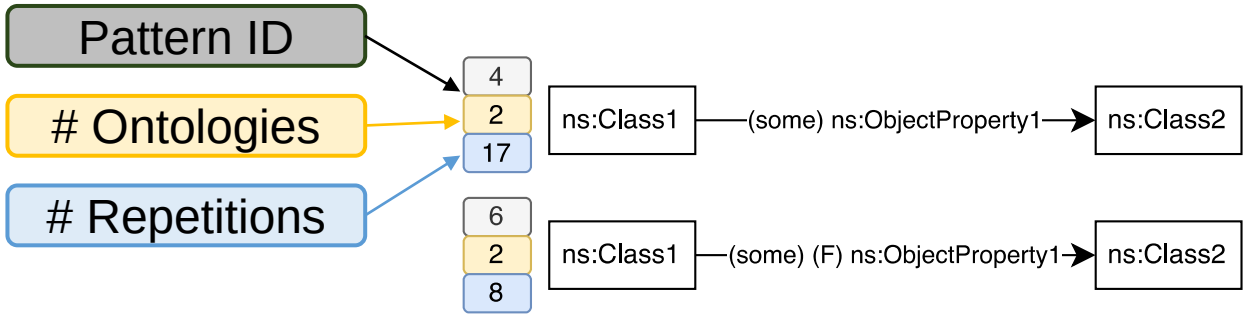


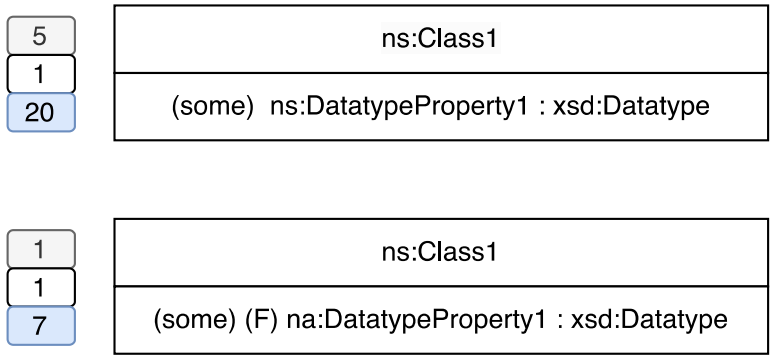
Manual Compacting

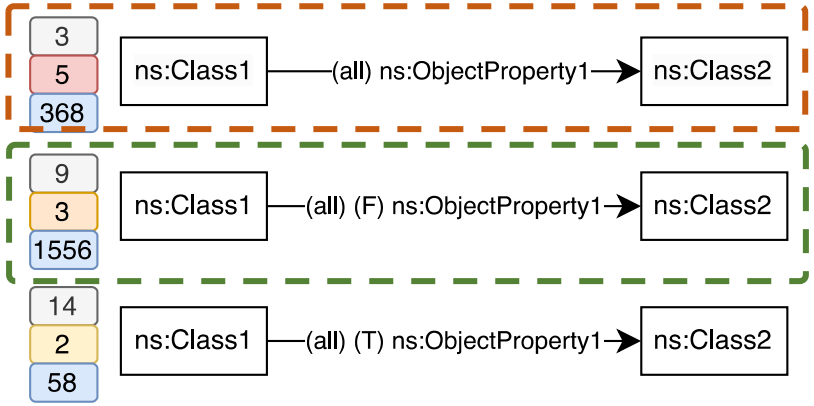
Process – Generate library

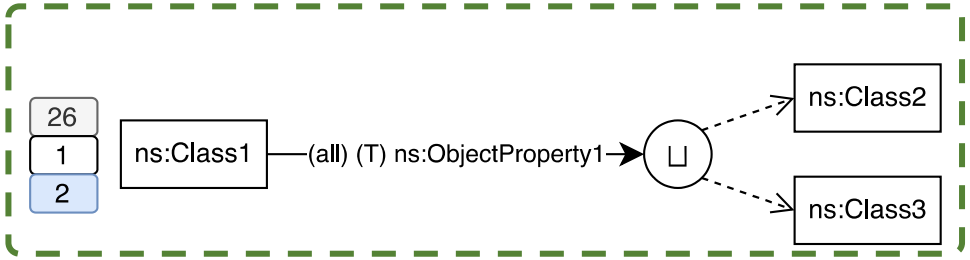


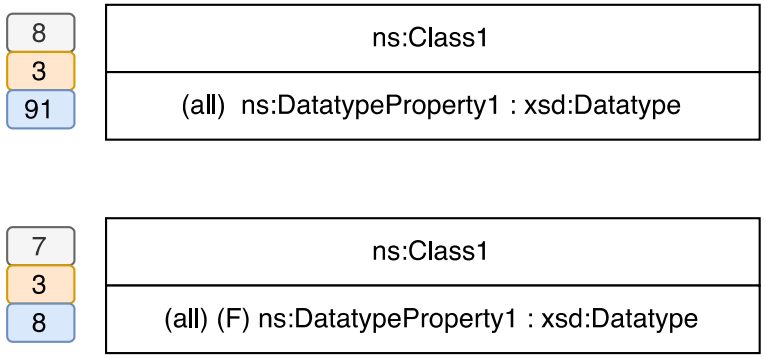
patterns involving existential and universal restrictions

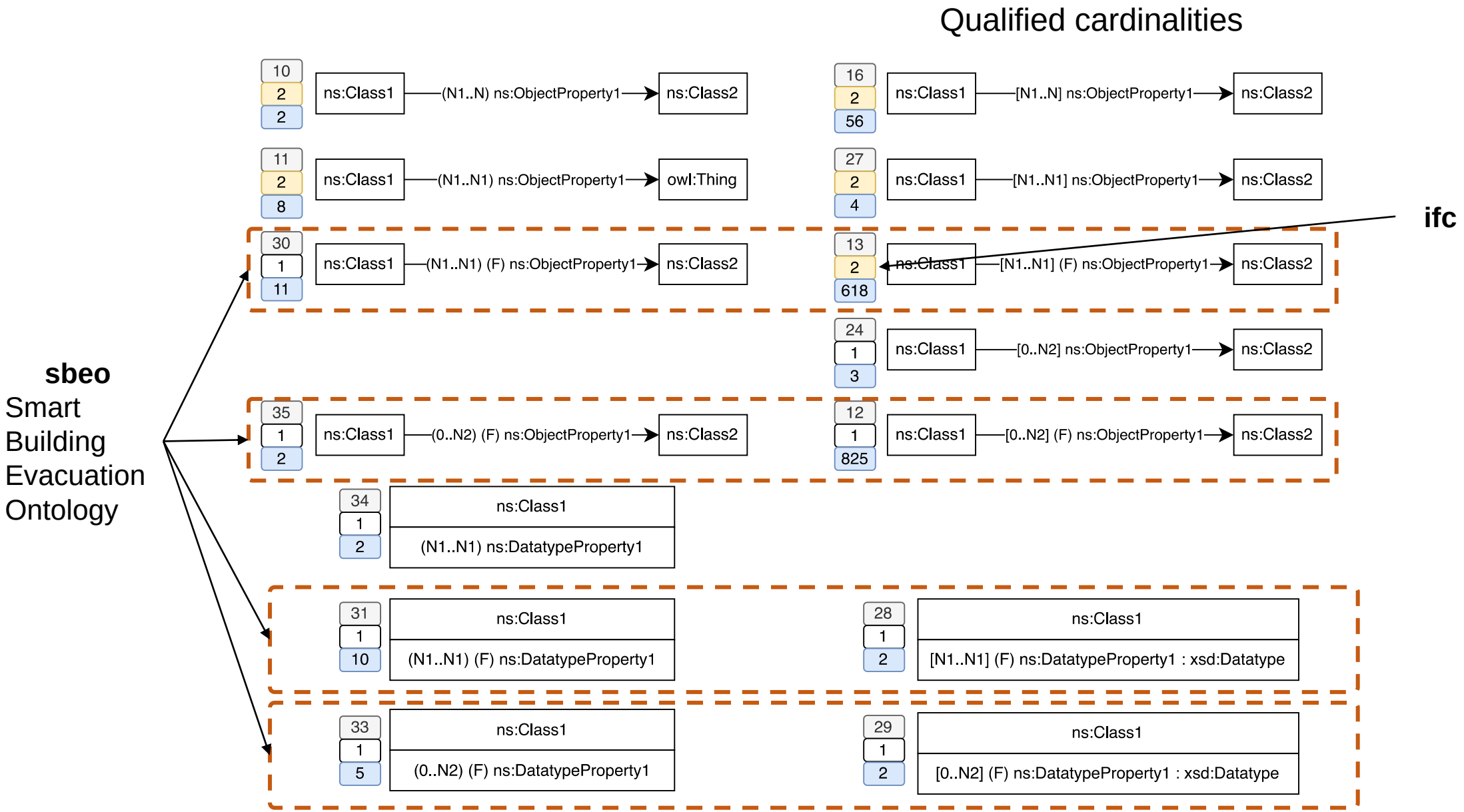






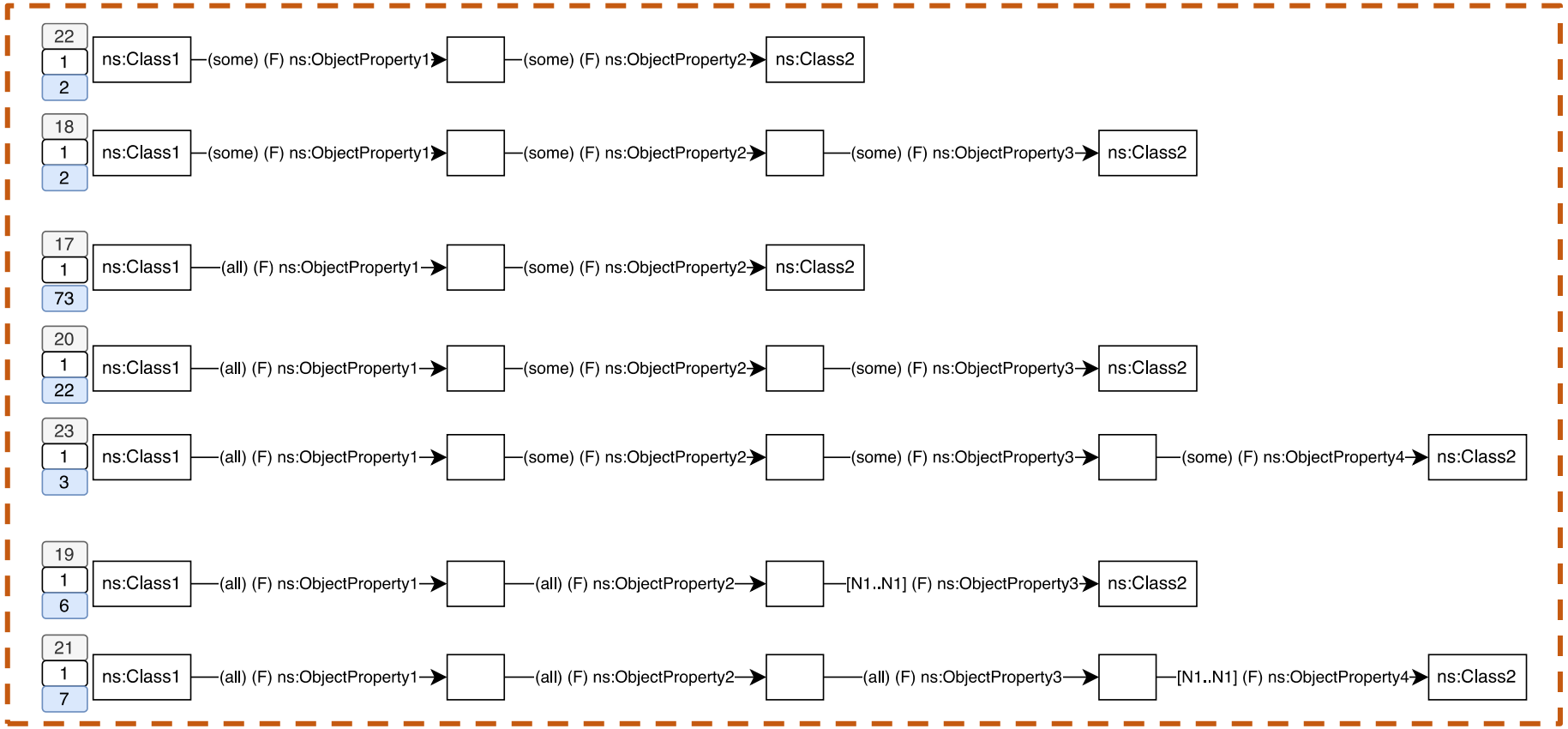


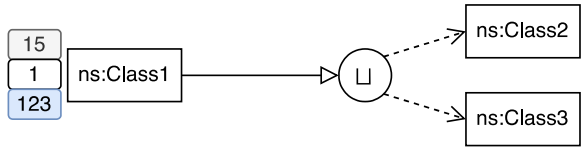


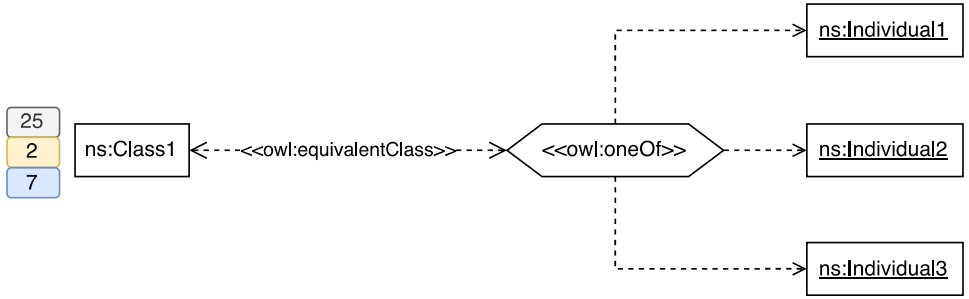

Qualified cardinalities
sbeo
Smart
Building
Evacuation
Ontology
ifc
10
2
2
ns:Class1
(N1..N) ns:ObjectProperty1
ns:Class2
16
2
56
ns:Class1
[N1..N] ns:ObjectProperty1
ns:Class2
11
2
8
ns:Class1
(N1..N1) ns:ObjectProperty1
owl:Thing
27
2
4
ns:Class1
[N1..N1] ns:ObjectProperty1
ns:Class2
30
1
11
ns:Class1
(N1..N1) (F) ns:ObjectProperty1
ns:Class2
13
2
618
ns:Class1
[N1..N1] (F) ns:ObjectProperty1
ns:Class2
24
1
3
ns:Class1
[0..N2] ns:ObjectProperty1
ns:Class2
35
1
2
ns:Class1
(0..N2) (F) ns:ObjectProperty1
ns:Class2
12
1
825
ns:Class1
[0..N2] (F) ns:ObjectProperty1
ns:Class2
34
1
2
ns:Class1
(N1..N1) ns:DatatypeProperty1
31
1
10
ns:Class1
(N1..N1) (F) ns:DatatypeProperty1
28
1
2
ns:Class1
[N1..N1] (F) ns:DatatypeProperty1 : xsd:Datatype
33
1
5
ns:Class1
(0..N2) (F) ns:DatatypeProperty1
29
1
2
ns:Class1
[0..N2] (F) ns:DatatypeProperty1 : xsd:Datatype

patterns involving nested existential and universal restrictions and others

Same ontology

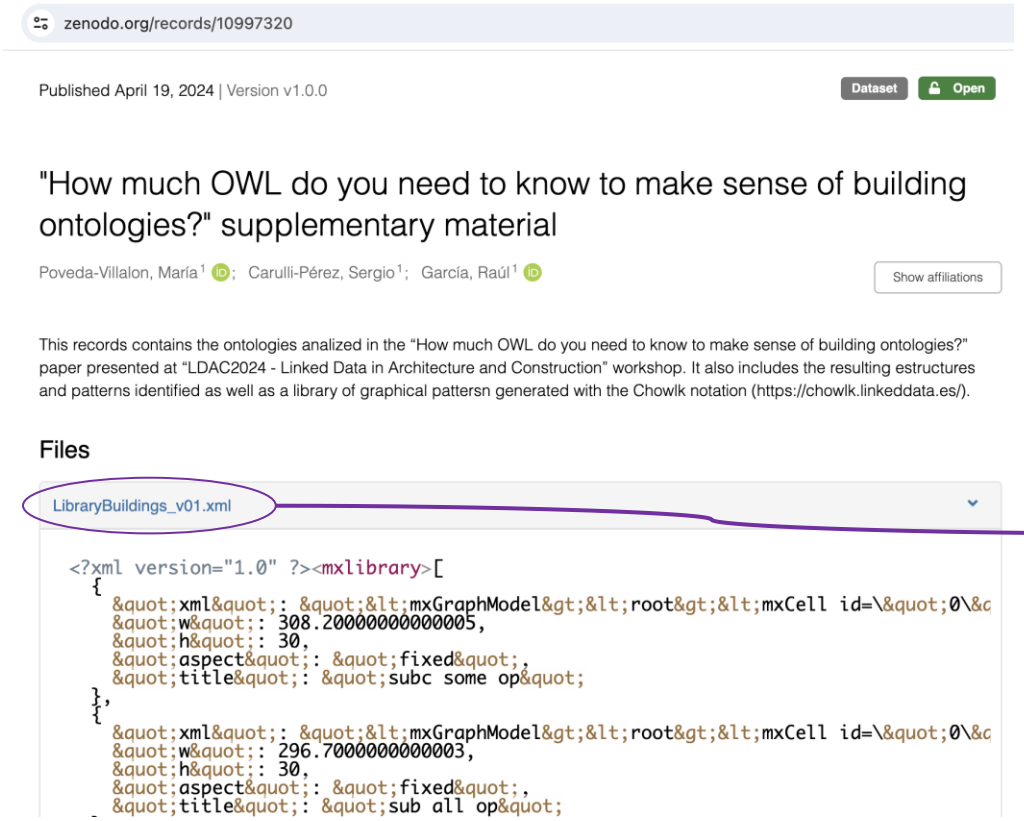




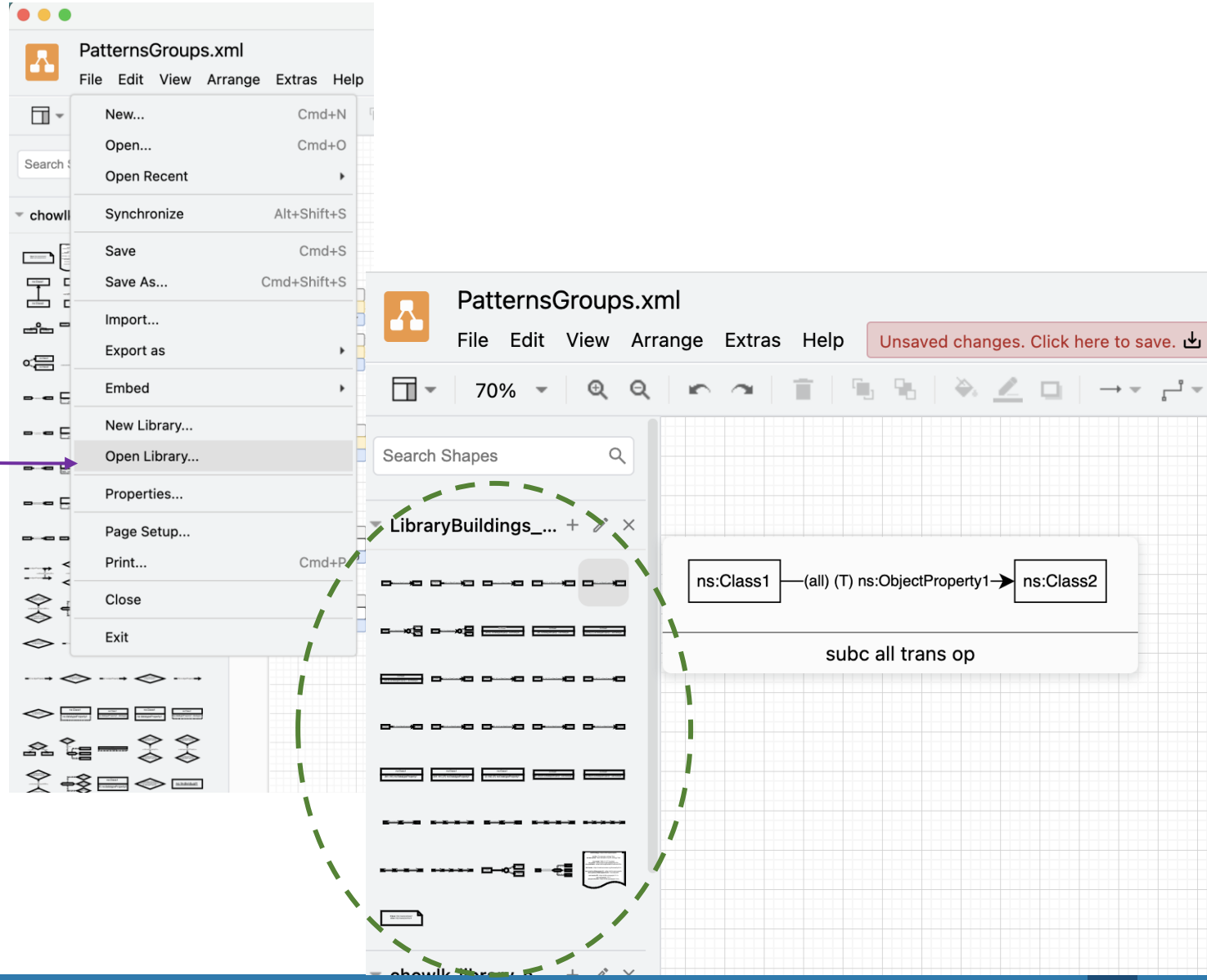


Process – Generate library – The library

https://zenodo.org/records/10997320



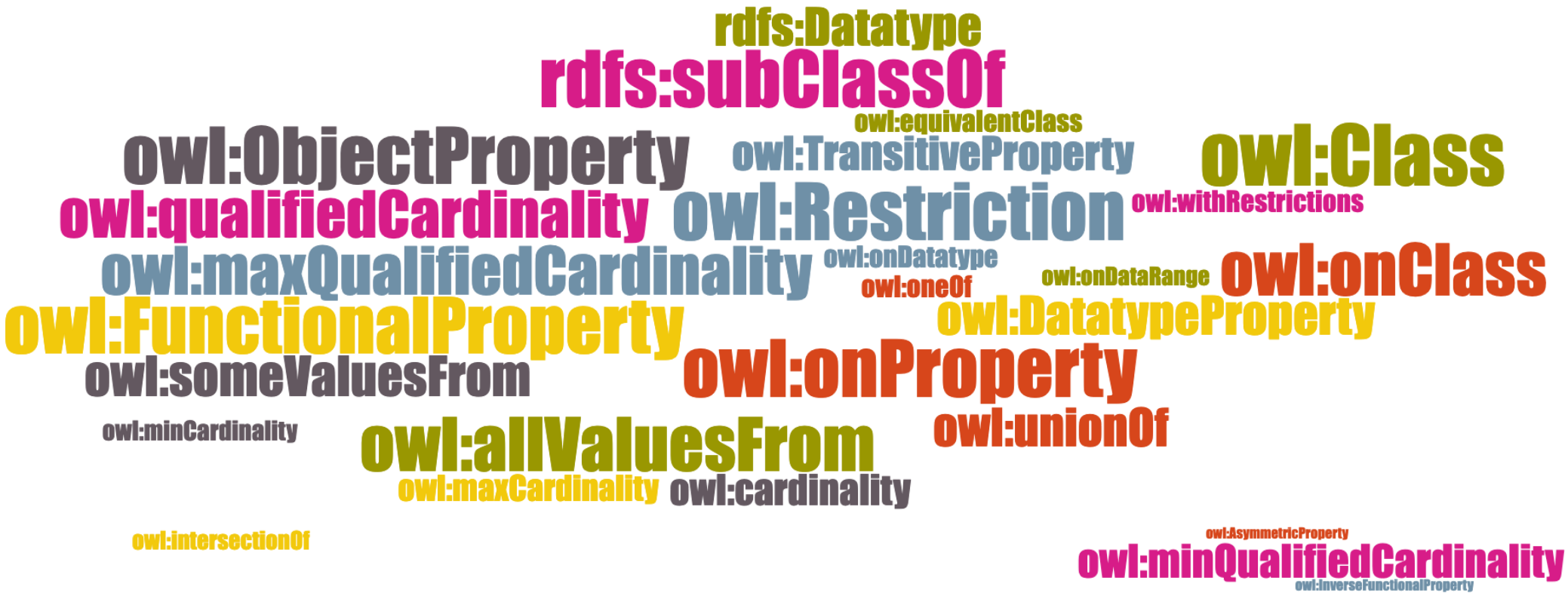
Draw.io or diagrams.net



Conclusions and future work

- No much reuse
  - Not new
  - Analyze whether the reused terms are from other domains
- Chowlk **library available** for reuse → https://zenodo.org/records/10997320
  - Pattern 32 couldn't be visualized → Discovered notation **limitations** in real examples
- **Results only** for **5** out of 18 **ontologies**
- **Align** elements **labels** to find **specific patterns** instead of matching URIs
- Stop at **properties** characteristics
  - Combine with **subproperty** of? I**nverse** of? **equivalent**?
  - Domain and range?
  - And where to stop

- By the way
  - This is the amount of OWL you need to know:



How much OWL do you need to know to make sense of building ontologies?

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