



FAIR principles application to Semantic Web and ontologies

Towards Implementations of Materials and Manufacturing Commons Workshop

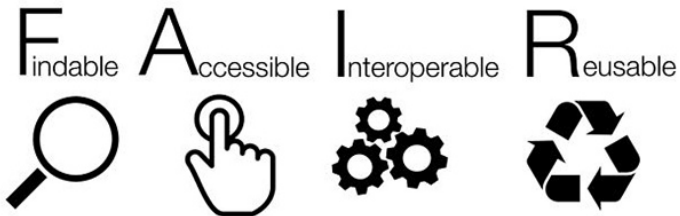
María Poveda-Villalón, Ontology Engineering Group

ETSI Informáticos

Universidad Politécnica de Madrid, Spain

1. Use URIs as names for things
2. Use HTTP URIs so that people can look up those names.
3. When someone looks up a URI, provide useful information, using the standards (RDF*, SPARQL)
4. Include links to other URIs. so that they can discover more things.

Linked Data principles



Wilkinson, M. D. *et al.* The FAIR Guiding Principles for scientific data management and stewardship. <https://doi.org/10.1038/sdata.2016.18> (2016)
<https://www.nature.com/articles/sdata201618>

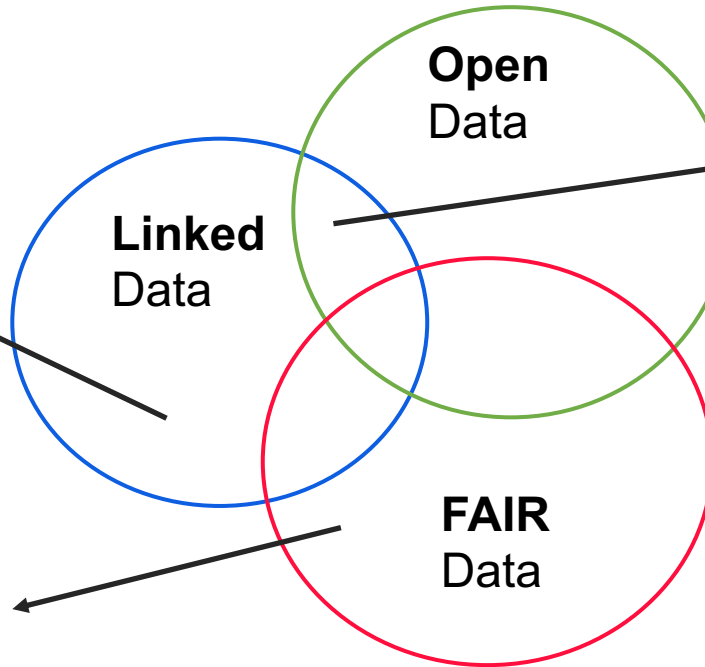


Image taken from <https://www.w3.org/DesignIssues/LinkedData.html>

Adoption:

- EOSC interoperability framework
- Research Data Alliance

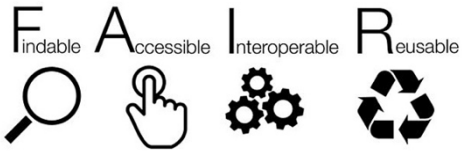
There is a clear movement towards **expanding** the application of the **FAIR** principles **beyond** research **data** [EOSC Interoperability Framework]

Ontologies are often the **result** of research activities or fundamental **components** in many **research** areas

Some initiatives (FAIRsFAIR EU Project recommendations, GO-FAIR implementation network GO-INTER, RDA Vocabulary Services Interest Group, “Best Practices for Implementing FAIR Vocabularies and Ontologies on the Web”...)

How do these works fit with the Ontology Engineering community and the Semantic Web practices?

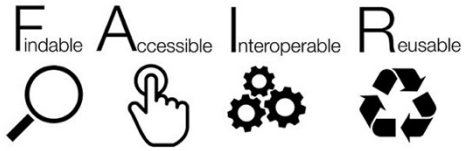
Based on: Poveda-Villalón M., Espinoza-Arias P., Garijo D., Corcho O. (2020) Coming to Terms with FAIR Ontologies. In: Keet C.M., Dumontier M. (eds) Knowledge Engineering and Knowledge Management. EKAW 2020. Lecture Notes in Computer Science, vol 12387. Springer, Cham.
https://doi.org/10.1007/978-3-030-61244-3_18



		FAIR Principles															
Guidelines ↓		F1	F2	F3	F4	A1	A1.1	A1.2	A2	I1	I2	I3	R1	R1.1	R1.2	R1.3	
FAIRSFAR	P-Rec1	x															
	P-Rec2	x		x													
	P-Rec3		x										x	x	x	x	
	P-Rec4				x												
	P-Rec5				x	x	x										
	P-Rec6				x												
	P-Rec7							x									
	P-Rec8								x								
	P-Rec9									x							
	P-Rec10									x	x	x					
	P-Rec11									x							
	P-Rec12									x		x					x?
	P-Rec13												?		x		x?
	P-Rec14										x						?
	P-Rec15												x			x	
	P-Rec16													x			
	P-Rec17															x	

17 recommendations, related to one or more FAIR principles related to:

- GUPRIs** (Global Unique Persistent and Resolvable Identifier)
- (minimum) **metadata** including provenance, license, etc.
- Semantic repositories**
 - API
 - Cross access
 - Secure protocols
- Use standards (languages, vocabularies)
- Mappings (between artefacts, to foundational ontologies)



		FAIR Principles														
Guidelines ↓	F1	F2	F3	F4	A1	A1.1	A1.2	A2	I1	I2	I3	R1	R1.1	R1.2	R1.3	
P-Rec1	x															
P-Rec2	x		x													
P-Rec3		x										x	x	x	x	
P-Rec4				x												
P-Rec5				x	x	x										
P-Rec6				x												



10 guidelines for publishing FAIR **ontologies** and **vocabularies** related to:

- Accessible** and **permanent** ontology URIs
- Generation of reusable **documentation** (metadata and human oriented)
- Publication** of ontologies on the Web (formats, findable)



Garijo, Daniel, and María Poveda-Villalón. "Best Practices for Implementing FAIR Vocabularies and Ontologies on the Web." *arXiv preprint arXiv:2003.13084* (2020)

FAIR ontologies	1
	2
	3
	4
	5
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	10

"Best Practices for Implementing FAIR Vocabularies and Ontologies on the Web"

Publish your vocabulary **on the Web** at a **stable URI** with a **open** license

Provide **human-readable documentation** and basic **metadata** such as creator, publisher, date of creation, last modification, version number

Provide **labels** and **descriptions**, if possible in several languages, to make your vocabulary usable in multiple linguistic scopes

Make your vocabulary **available** via its namespace **URI**, both as a **formal file** and **human-readable** documentation, using content negotiation

Link to other **vocabularies** by re-using elements rather than re-inventing



Vatant, Bernard. "5-stars for vocabularies." https://bvatant.blogspot.com/2012/02/is-your-linked-data-vocabulary-5-star_9588.html (2012)

There is **dereferenceable human-readable** information about the used vocabulary

The information is **available** as **machine-readable** explicit **axiomatization** of the vocabulary

The vocabulary is **linked to** other **vocabularies**

Metadata about the vocabulary is **available** (in a dereferenceable and **machine-readable** form)

The vocabulary is **linked to by** other **vocabularies**



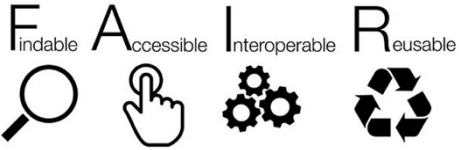
Janowicz, K., Hitzler, P., Adams, B., Kolas, D., & Vardeman, I. (2014). C. Five Stars of Linked Data Vocabulary Use. Semantic Web, 5-3.

Semantic V
Ontology Eng

5-star vocabularies
Vatant, Bernard 2012

5-star vocabularies
SWJ 2014

9
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Guidelines ↓		F1	F2	F3	F4	A1	A1.1	A1.2	A2	I1	I2	I3	R1	R1.1	R1.2	R1.3	
FAIRsFAIR	P-Rec1	x															
	P-Rec2	x		x													
	P-Rec3		x										x	x	x	x	
	P-Rec4				x												
	P-Rec5				x	x	x										
	P-Rec6				x												
	P-Rec7							x									
	P-Rec8								x								
	P-Rec9									x							
	P-Rec10									x	x	x					
	P-Rec11									x							
	P-Rec12									x		x					x?
	P-Rec13											?			x		x?
	P-Rec14										x						?
	P-Rec15											x			x		
	P-Rec16													x			
	P-Rec17														x		
FAIR ontologies	1	x															
	2	x															
	3	x															
	4												x				
	5	x															
	6		x							x			x	x	x	x	
	7					x						x	x				
	8												x				
	9					x				x							
	10				x											x	
5-stars 2012	1	<														>	
	2												x				
	3		x										x				
	4	<				x	x			x							
	5											x					
5-stars 2014	1					x											
	2					x				x							
	3											x					
	4					x							x				
	5																

Semantic Web &
 Ontology Engineering

“Best Practices for Implementing FAIR Vocabularies and Ontologies on the Web”

5-star vocabularies
 Vatant, Bernard 2012

5-star vocabularies
 SWJ 2014

Towards FAIR Ontologies – To be Findable

	Keep from SW	Needs	Discussion
F1	URIs		Persistence
F2		Minimum metadata, technical guidelines	
F3	Metadata included in the ontology		Metadata as a separate object, third-party certifier
F4	DCAT2	Federation model, SAODs	

- 🔍 F1: (meta)data are assigned a globally unique and persistent identifier
- 🔍 F2: data are described with rich metadata (defined by R1 below)
- 🔍 F3: metadata clearly and explicitly include the identifier of the data it describes
- 🔍 F4: (meta)data are registered or indexed in a searchable resource

Towards FAIR Ontologies – To be Accessible

	Keep from SW	Needs	Discussion
F1	URIs		Persistence
F2		Minimum metadata, technical guidelines	
F3	Metadata included in the ontology		Metadata as a separate object, third-party certifier
F4	DCAT2	Federation model, SAODs	
A1, A1.1, A1.2	HTTP and HTTPS		
A2		Preservation policies	

- 👉 A1: (meta)data are retrievable by their identifier using a standardized communications protocol
- 👉 A1.1: the protocol is open, free, and universally implementable
- 👉 A1.2: the protocol allows for an authentication and authorization procedure, where necessary
- 👉 A2: metadata are accessible, even when the data are no longer available

Towards FAIR Ontologies – To be Interoperable

	Keep from SW	Needs	Discussion
F1	URIs		Persistence
F2		Minimum metadata, technical guidelines	
F3	Metadata included in the ontology		Metadata as a separate object, third-party certifier
F4	DCAT2	Federation model, SAODs	
A1, A1.1, A1.2	HTTP and HTTPS		
A2		Preservation policies	
I1	KR languages		
I2	Methods to reuse ontologies	Indicators	Not force to reuse FAIR vocabularies
I3	Mechanisms to reference ontologies		



I1: (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.






I2: (meta)data use vocabularies that follow FAIR principles



I3: (meta)data include qualified references to other (meta)data

Towards FAIR Ontologies – To be Reusable

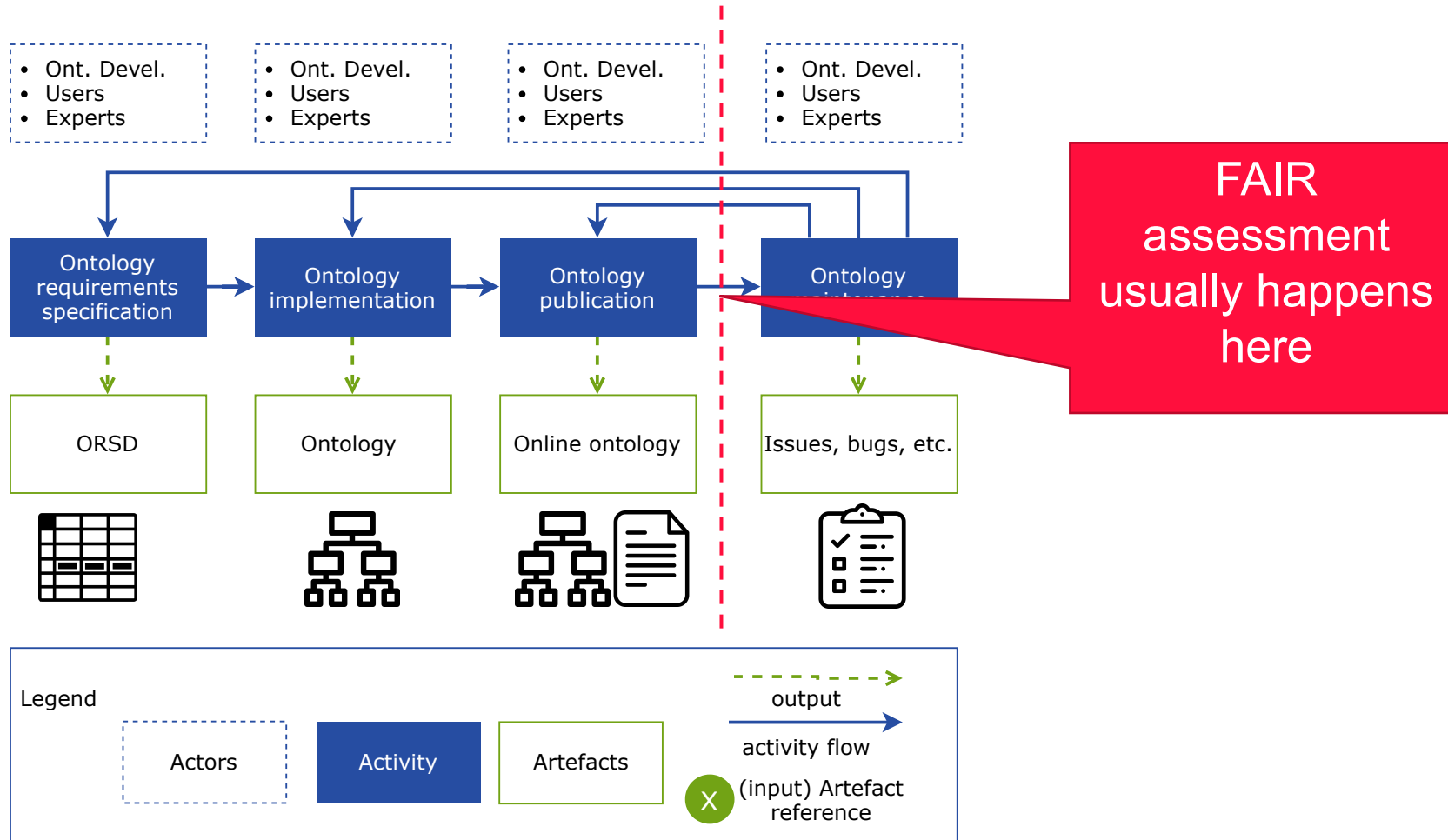
	Keep from SW	Needs	Discussion
F1	URIs		Persistence
F2		Minimum metadata, technical guidelines	
F3	Metadata included in the ontology		Metadata as a separate object, third-party certifier
F4	DCAT2	Federation model, SAODs	
A1, A1.1, A1.2	HTTP and HTTPS		
A2			
I1		<p>R1: (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation</p> <p>R1.1: (meta)data are released with a clear and accessible data usage license</p> <p>R1.2: (meta)data are associated with detailed provenance</p>	
I2			
I3			
R1		Best practices for document and communicate ontologies	
R1.1	Link to the license URI or RDF description of it		
R1.2	PROV-O		
R1.3		Community standards	

Towards FAIR Ontologies

	Keep from SW	Needs	Discussion
F1	URIs		Persistence
F2		Minimum metadata, technical guidelines	
F3	Metadata included in the ontology		Metadata as a separate object, third-party certifier
F4	DCAT2	Federation model, SAODs	
A1, A1.1, A1.2	HTTP and HTTPS		
A2		Preservation	
I1	KR languages		
I2	Methods to reuse ontologies	Indicators	Not force to reuse FAIR vocabularies
I3	Mechanisms to reference ontologies		
R1		Best practices for document and communicate ontologies	
R1.1	Link to the license URI or RDF description of it		
R1.2	PROV-O		
R1.3		Community standards	

Good news here!

Classical/Core Workflow for building ontologies

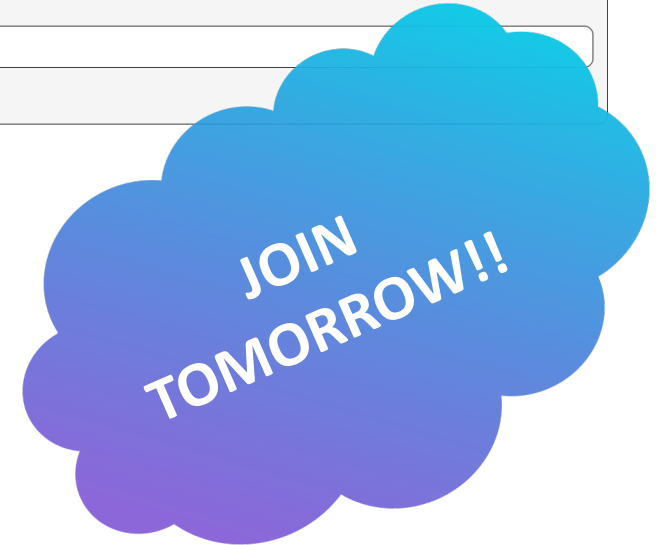
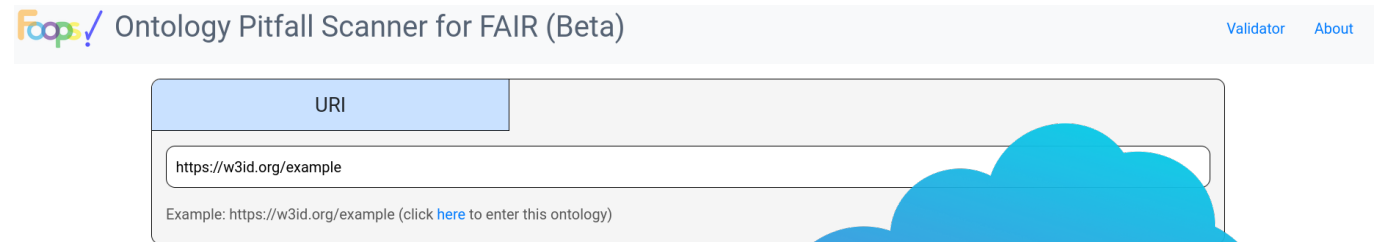


<http://lot.linkeddata.es/>

First steps to support the validation



- **Validation service** inspired by OOPS! (Ontology Pitfall Scanner)
- Designed to **guide users**
 - Tests have an explanation
 - Tests indicate potential errors
- **Practical**
 - Based on years of ontology engineering practices at UPM
- Aligned to **FAIR**

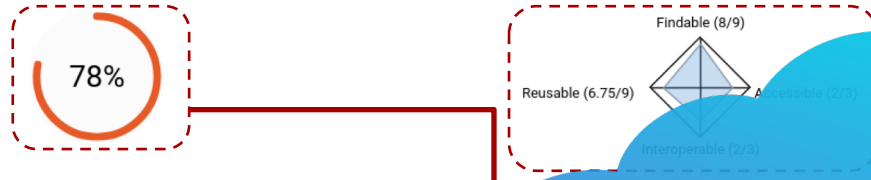


<https://w3id.org/foops/>

FOOPS!: Getting the full report

Title:
 URI:
 License:

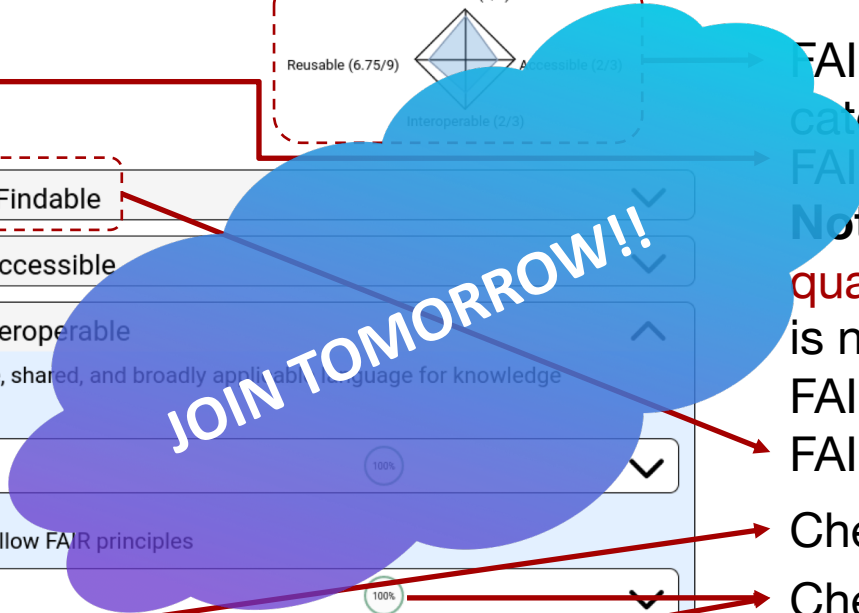
} Ontology metadata summary



FAIRness coverage by category
FAIRness overall score.

Note: this may be a quality indicator, but there is no defined threshold for FAIRness.

Findable	100%	✓
Accessible	100%	✓
Interoperable	100%	✓
I1: (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation		
RDF1: RDF Availability	100%	✓
I2: (meta)data use vocabularies that follow FAIR principles		
VOC1: Vocabulary reuse (metadata)	100%	✓
VOC2: Vocabulary reuse	0%	⬆
Description: This check verifies if the ontology imports/extends other vocabularies (besides RDF, OWL and RDFS)		
Explanation: Could not find any imported/reused vocabularies		



FAIR Category

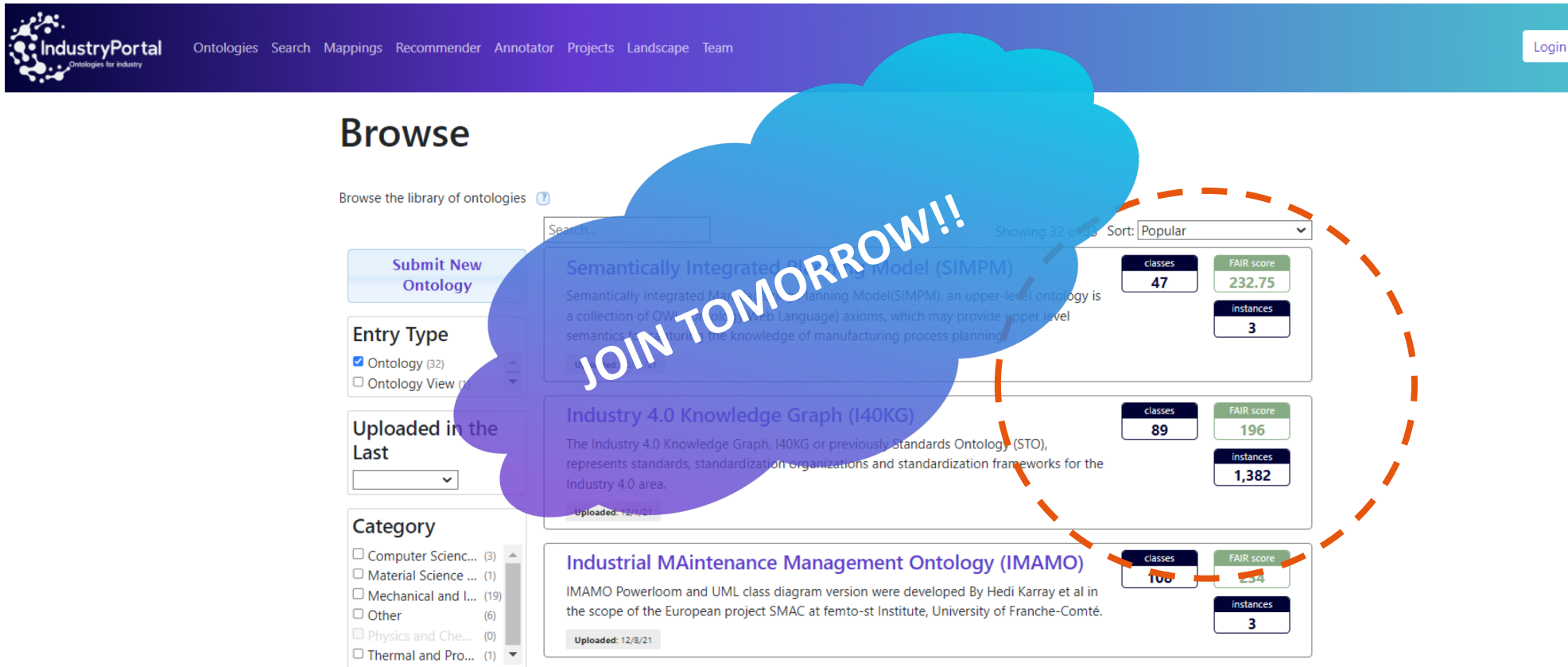
Check

Check coverage

Check description

Check explanation

Slide taken from "FOOPS! An Ontology Pitfall Scanner for the FAIR principles. Dbpedia day" by Daniel Garijo



IndustryPortal Ontologies Search Mappings Recommender Annotator Projects Landscape Team Login

Browse

Browse the library of ontologies ⓘ

Search...

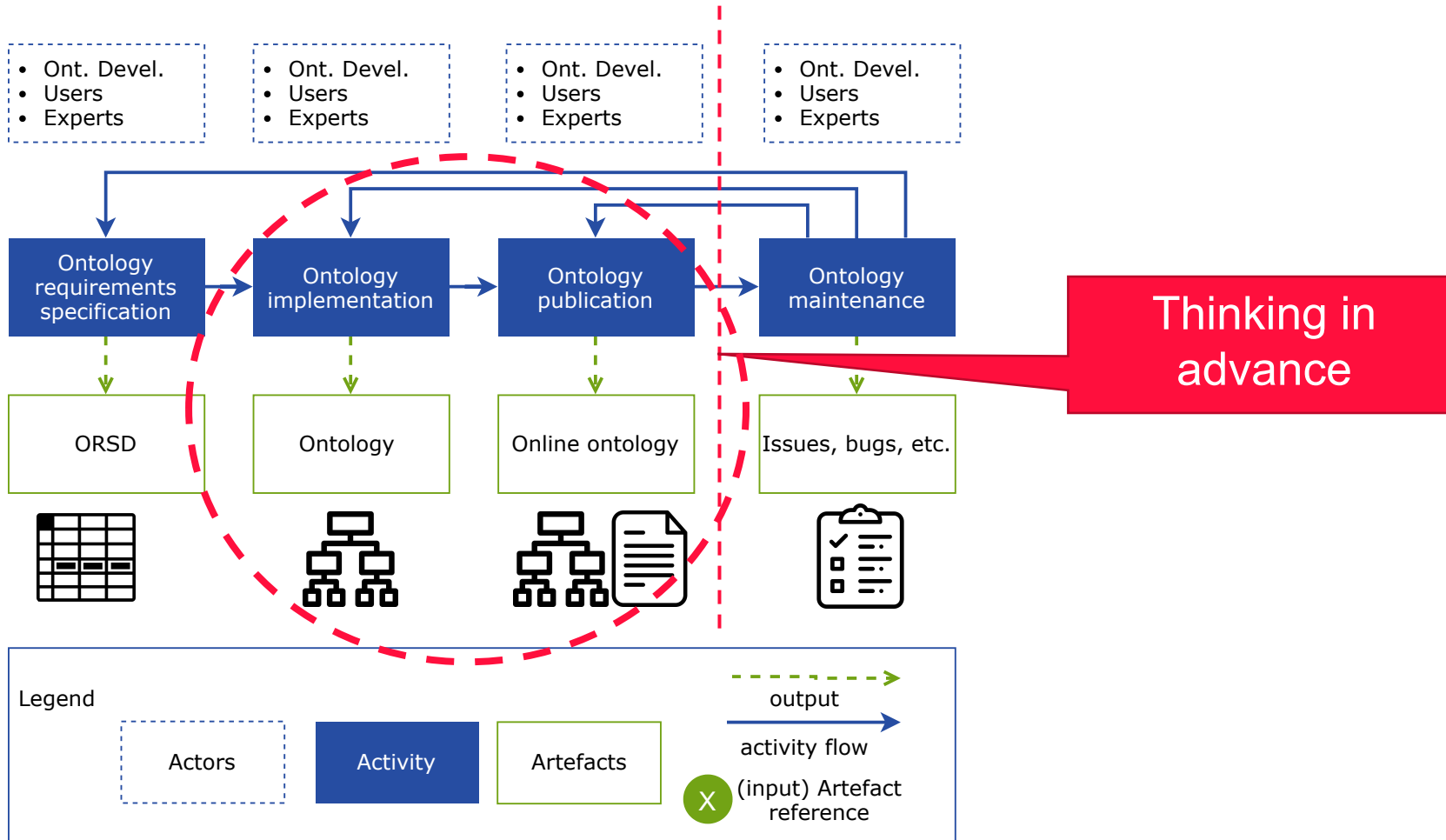
Showing 32 ontologies Sort: Popular

Ontology Name	classes	FAIR score	instances
Semantically Integrated Manufacturing Planning Model (SIMPM)	47	232.75	3
Industry 4.0 Knowledge Graph (I40KG)	89	196	1,382
Industrial MAintenance Management Ontology (IMAMO)	100	234	3

JOIN TOMORROW!!

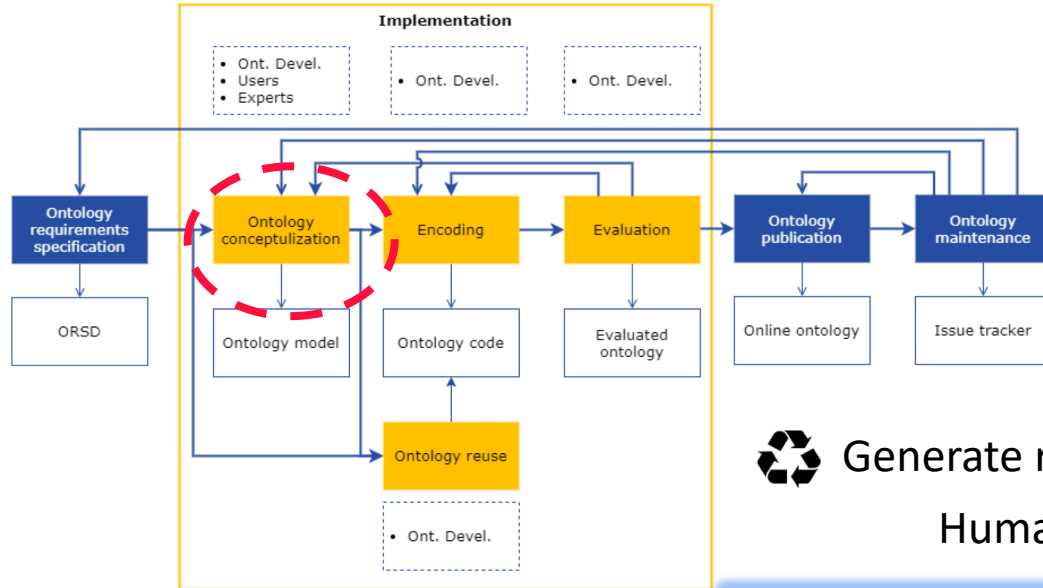
Amdouni, Emna, Syphax Bouazzouni, and Clement Jonquet. "O'FAIRe: Ontology FAIRness Evaluator in the AgroPortal semantic resource repository." *The Semantic Web: ESWC 2022 Satellite Events: Hersonissos, Crete, Greece, May 29–June 2, 2022, Proceedings*. Cham: Springer International Publishing, 2022. 89-94.

Classical/Core Workflow for building ontologies



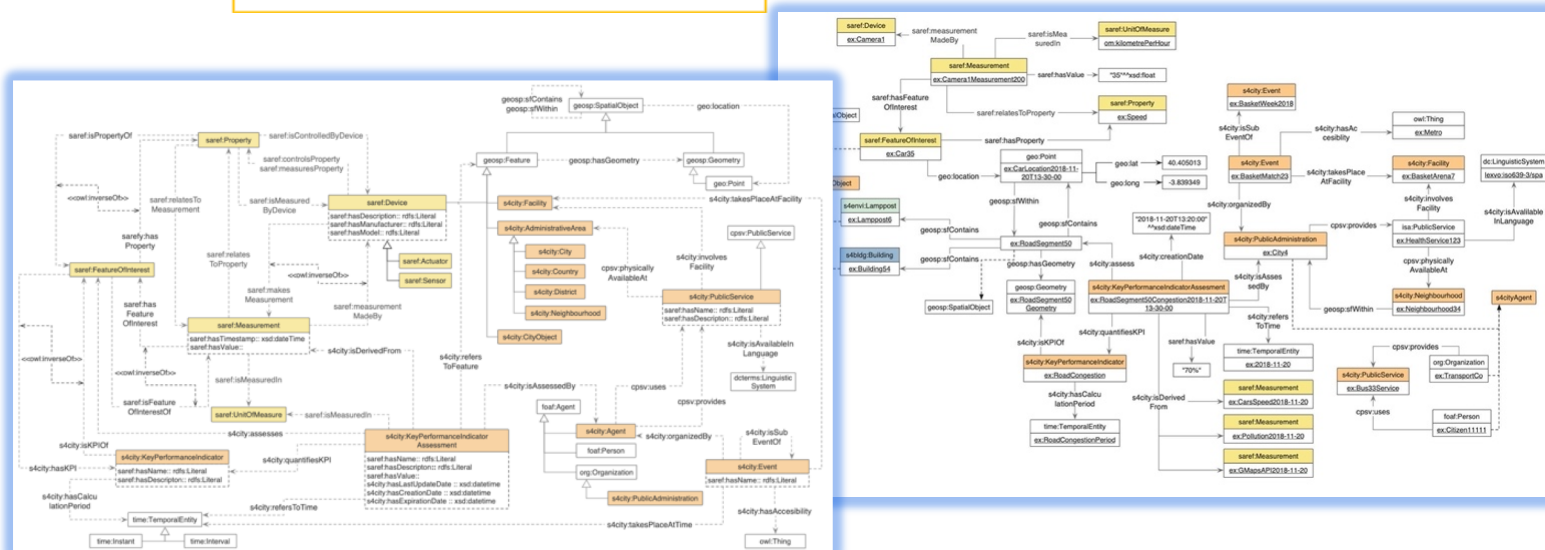
<http://lot.linkeddata.es/>

Ontology Implementation



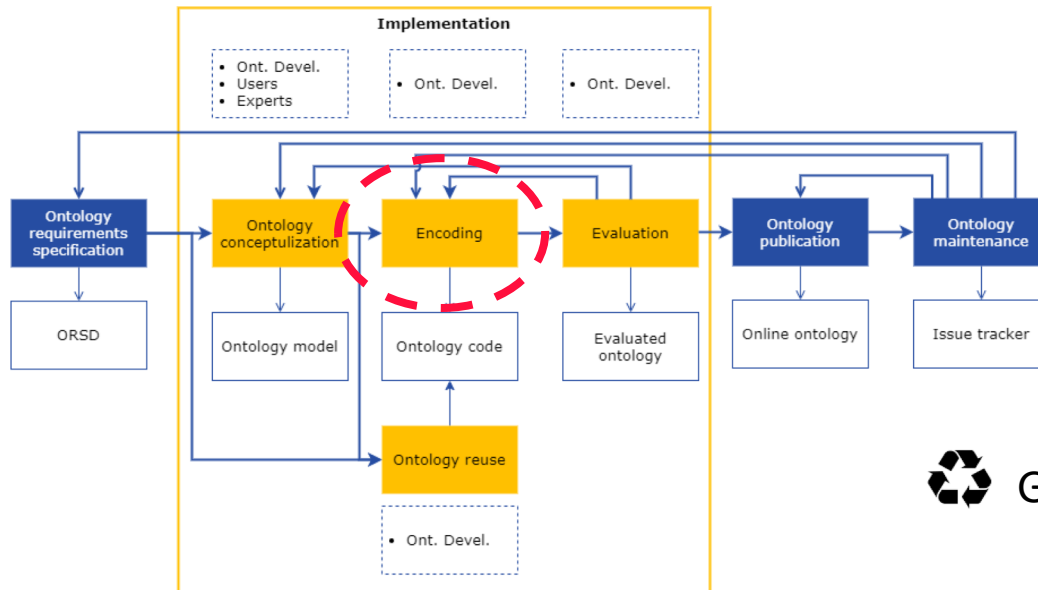
Generate reusable documentation

Human-readable documentation, including good **ontology visualization**



<https://chowlk.linkeddata.es/>

Adapted from Paola Espinoza Arias



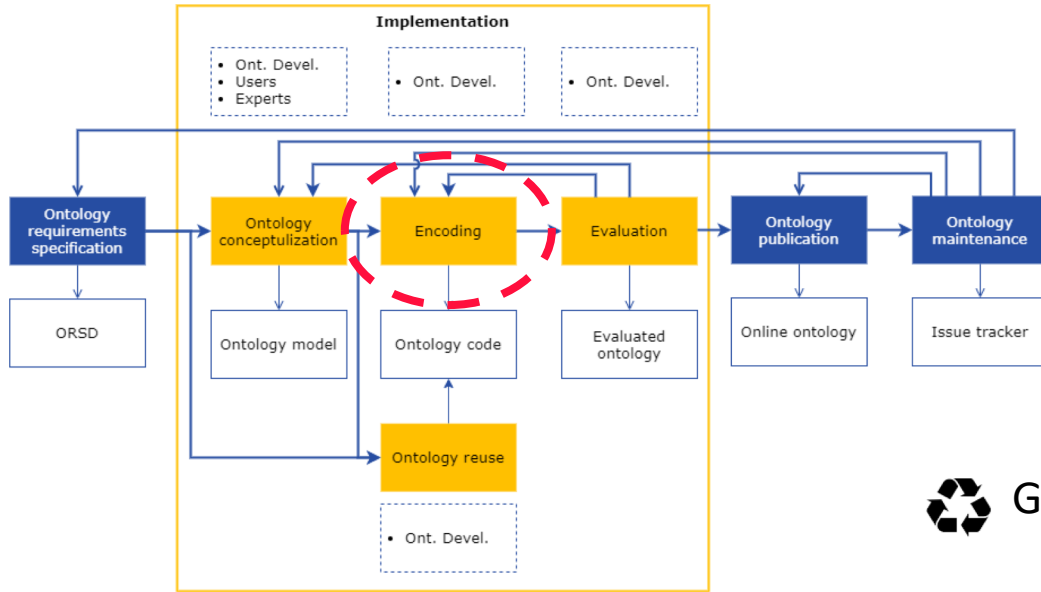
Generate reusable documentation

Ontology metadata to describe **ontologies**

Property name	Annotation Property	Rationale
License	dcterms:license	Usage conditions
Creator	dcterms:creator	Provenance and attribution
Contributor	dcterms:contributor	Provenance and attribution
Creation date	dcterms:created	Provenance
Previous version	owl:priorVersion	Provenance and comparison
Namespace URI	vann:preferredNamespaceUri	Identifying the ontology
Version IRI	owl:versionIRI	Versioning
Prefix	vann:preferredNamespacePrefix	Identifying the ontology
Title	dcterms:title	Understanding
Description	dcterms:description	Understanding
Citation	dcterms:bibliographicCitation	Credit

Property name	Annotation Property	Rationale
Abstract	dcterms:abstract	Additional information
Also	rdfs:seeAlso	Additional information
Status	sw:status	Maturity information
Forward compatibility	owl:backwardCompatibility	Version compatibility
Incompatibility	owl:incompatibleWith	Version compatibility
Modification Date	dcterms:modified	Provenance and timeliness
Issued date	dcterms:issued	Provenance and timeliness
Source	dcterms:source	Provenance
Publisher	dcterms:published	Provenance
DOI	bibo:doi	Bibliographic information
Logo	foaf:logo	Identifying the ontology
Diagram	foaf:depiction	Visual documentation

Ontology Implementation



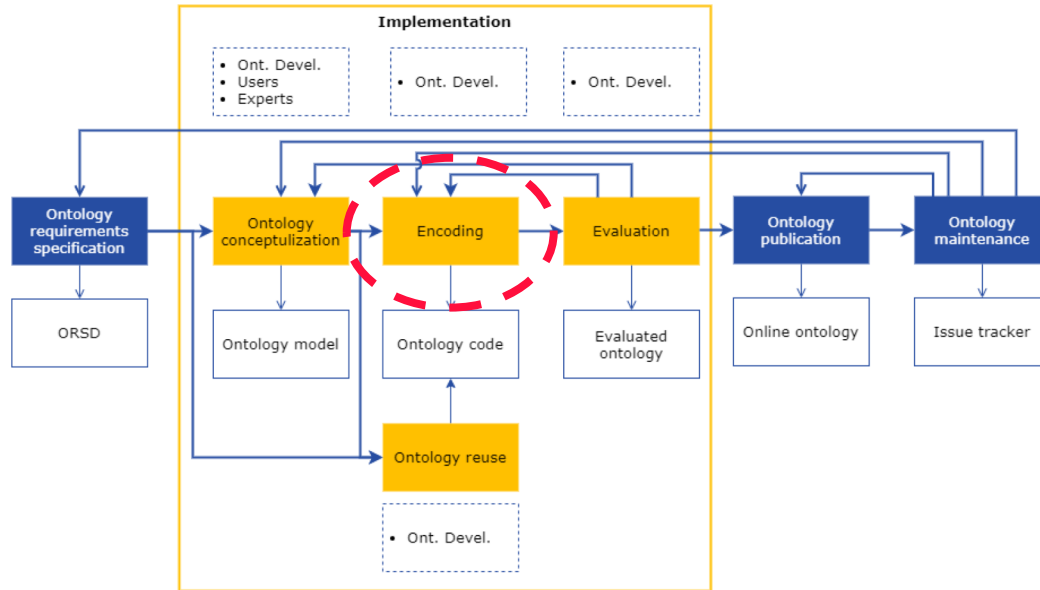
Generate reusable documentation

Ontology metadata to describe **terms**

Property name	Annotation Property	Rationale
Label	rdfs:label	Readability
Definition	rdfs:comment	Understanding

Property name	Annotation Property	Rationale
Example	vann:example	Understanding
Status	sw:term_status	Understanding
Rationale	vaem:rationale	Understanding
Source	dcterms:source	Provenance

Adapted from Paola Espinoza Arias



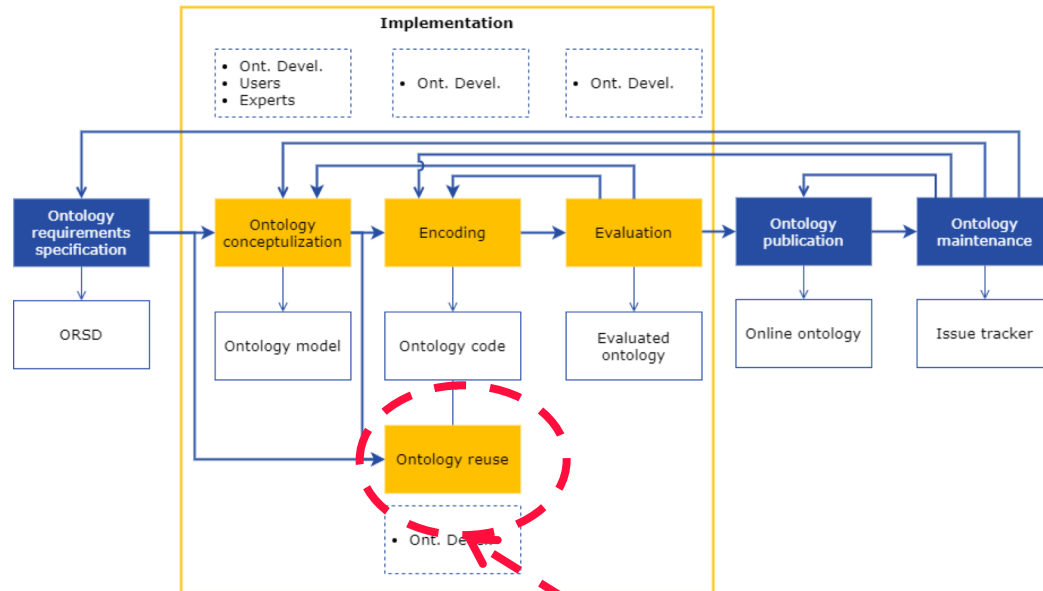
Design accessible ontology URIs:

1. Ontology name and prefix
2. Hash or slash
3. Meaningful or opaque
4. Ontology versioning
5. Permanent URIs

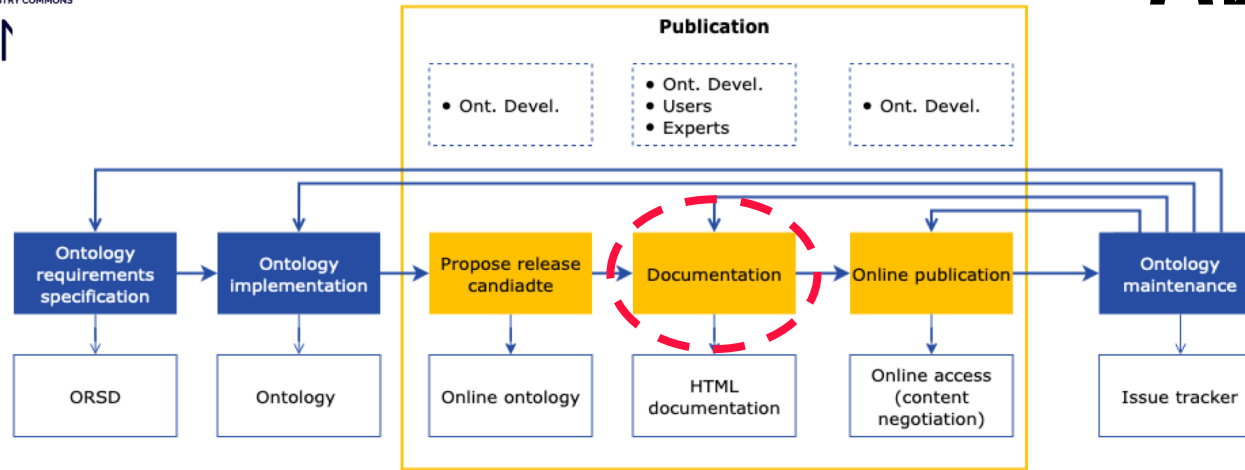
Example

1. name: SAREF extension for Smart Cities, prefix: saref4city
2. `https://w3id.org/def/saref4city#`
3. `https://w3id.org/def/saref4city#AdministrativeArea`
4. `<owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#decimal"> 1.0.0</owl:versionInfo>`
5. `https://w3id.org`

Ontology implementation



Reuse (FAIR) ontologies
Maximize interoperability



Generate reusable documentation

Human-readable documentation, including good ontology visualization, examples of use, queries, etc.



Ontology Specification Draft

SAREF extension for Smart Cities

language [en](#)

Ontology URI:
<https://w3id.org/def/saref4city>

Revision:
 1.0

Authors:
[María Poveda-Villalón](#) (Ontology Engineering Group, Universidad Politécnica de Madrid)
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[Paola Espinoza-Arias](#) (Ontology Engineering Group, Universidad Politécnica de Madrid)

Publishers:
[Ontology Engineering Group](#)
[ETSI](#)

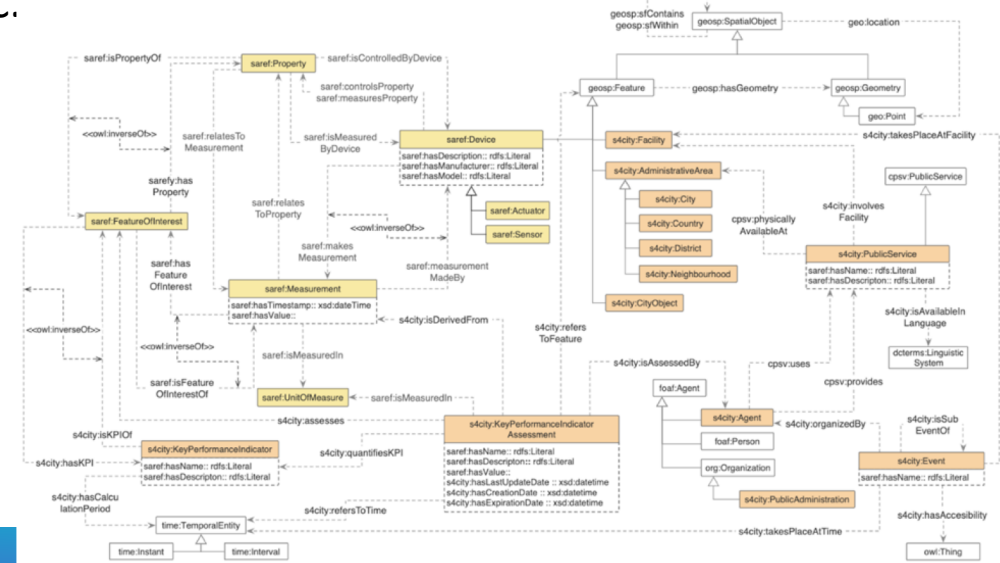
Download serialization:
[Format JSON LD](#) [Format RDF/XML](#) [Format N-Triples](#) [Format TTL](#)

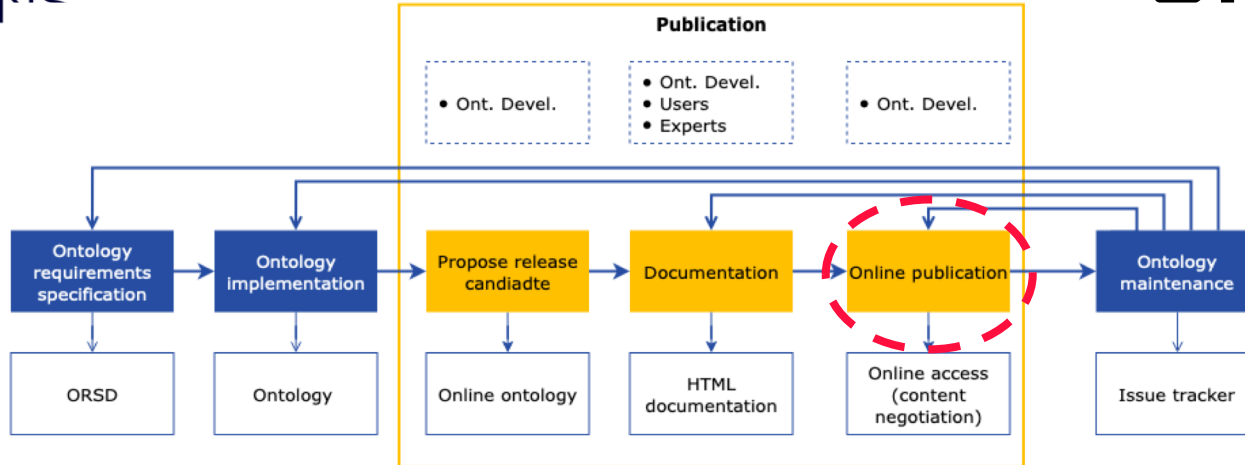
License:
<http://purl.org/NET/rdflicense/cc-by4.0>

[Provenance of this page](#)

Abstract

This ontology extends the SAREF ontology for the Smart Cities domain. This work has been developed in the context of the STF 534 (<https://portal.etsi.org/STF/STFs/STFHomePages/STF534.aspx>), which was established with the goal to create three SAREF extensions, one of them for the Smart Cities domain.





Publish the ontology on the Web



Provide several interoperable **formats**

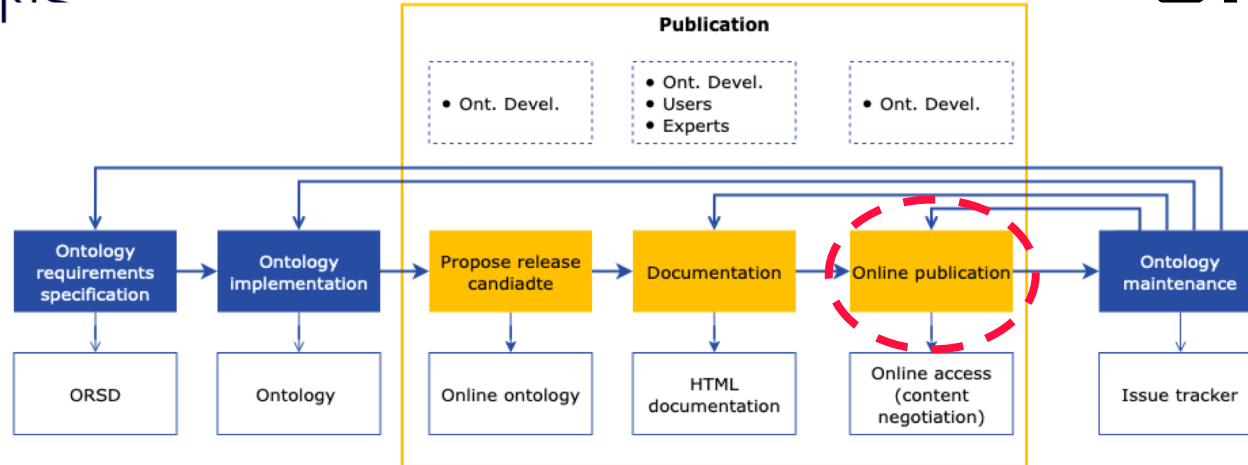
URI



- Own URI
- purl, w3id, etc.
- Content negotiation



<https://www.w3.org/TR/swbp-vocab-pub/>



Publish the ontology on the Web

🔍 Make the ontology **findable**



Linked Open Vocabularies (LOV)

Ontologies Ontology report Ontology listing



Here you can find the list of ontologies developed in VICINITY GitHub repository for VICINITY project
 If you want to contribute developing ontologies please follow the guidelines we provide

Ontology	Description	Repository	Issue tracker	Requirements	Releases
Ontology model for Web of Things	This ontology aims to model the Web of Things domain according to the w3c Interest Group (http://w3c.github.io/wot/)	wot-ontology	ontology issues	ontology requirements	ontology releases
Vicinity core model	This ontology represent the core terms to allow interoperability in an IoT context based on VICINITY technological solutions.	vicinity-ontology-core	core issues	core requirements	core releases
Vicinity WoT mappings model	This ontology represent the mapping definitions between WoT to allow interoperability in an IoT context based on VICINITY ... See more	vicinity-ontology-wot-mappings	mappings issues	mappings requirements	mappings releases



BioPortal

FAIRsharing

Ontobee

AgroPortal LIRMM



prefix.cc
 namespace lookup for RDF developers

foaf look up

examples: foaf foaf.names foaf rdflib foaf.names rdflib http://xmlns.com/foaf/0.1/name

<https://prefix.cc/>

```
<!-- Annotations for the example ontology -->
<script type="application/ld+json">{
  "@context": "http://schema.org",
  "@type": "WebPage",
  "url": "https://w3id.org/example",
  "name": "The example ontology",
  "datePublished": "4-2-2020",
  "version": "1.0.1",
  "license": "http://creativecommons.org/licenses/by/2.0/",
  "author": [{"@type": "Person", "name": "Daniel Garijo"},
             {"@type": "Person", "name": "Maria Poveda"}],
}</script>
```

- **Metadata** is one of requirements to produce FAIR ontologies.
 - But **not** the **only** one
- Adopt **existing practices** and **technologies**
- Think about FAIR principles at all stages of the development
 - But note that FAIR **doesn't** look at the resource **quality!**



Thank you very much
for your attention!

Contact: mpoveda@fi.upm.es

Questions?



OntoCommons “Ontology-driven data documentation for Industry Commons” has received funding from the European Union’s Horizon Programme call H2020 -NMBP-TO-IND-2020-singlestage, Grant Agreement number 862136