OntoCommons and DOME 4.0 Ontology Alignment

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Main Contributing Partners: UNIBO, CNR, SINTEF, UCL, ENIT, GCL, UKRI, ATB, UiO

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DOME 4.0 Ontologies

DOME 4.0 relies on an **ontology based architecture** with a

- **Semantic Data Exchange Ontology** (called the dataset ontology, based on EMMO and DCAT) (Lead: UNIBO, UCL, SINTEF)
- **Ecosystem Ontology** (extending existing ontologies and vocabularies, such as European Virtual Marketplace Ontology and European Science Vocabulary) (Lead: UKRI)

DOME 4.0 Data Set Ontology

Objectives of the Data Set Ontology:

1) To **develop an ontology for semantic exchange of data** between data providers and consumers. The semantic data exchange ontology will be lightweight in terms of logical complexity and number of entities and should be **based on existing established standards and ontologies (e.g., EMMO).**
2) Interactions with the **project funded from the NMBP-39-2020-CSA (OntoCommons)** call will provide guidelines for such development to provide a high level of generality and applicability, shared by a larger community.
3) Develop an **ontological syntactic representation** of data with an extensible, light-weight data structure ontology capable of mapping between syntactic representations and thereby supporting the exchange of data.

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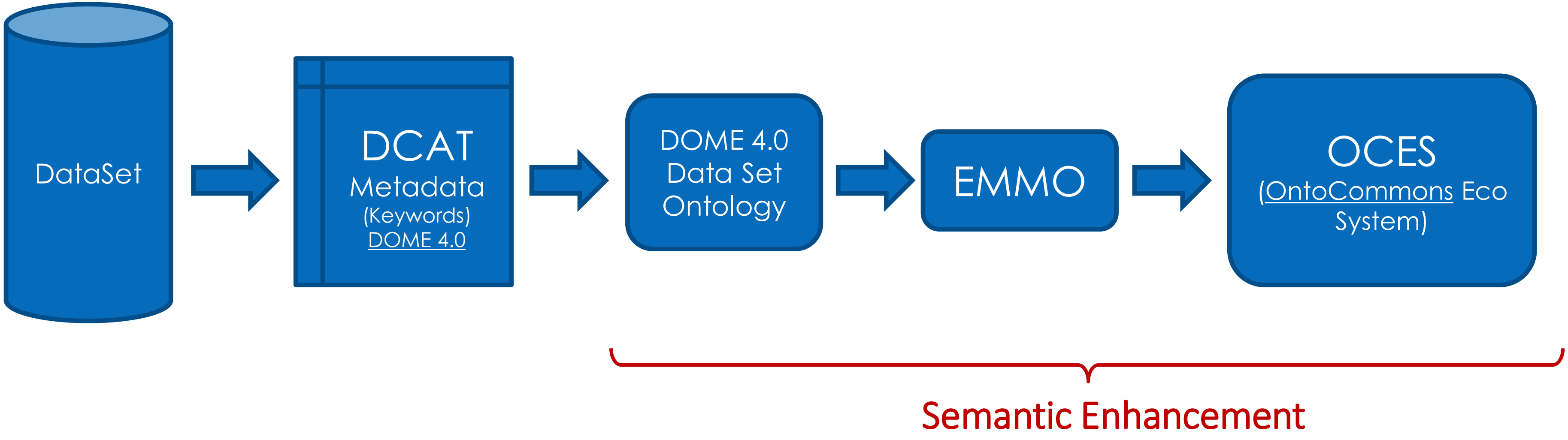
DOME 4.0 and OntoCommons

Bare Data

RDFS Documented Data
(keywords as semantic meaning providers)

OWL-DL Documented Data
(data are part of an ontology framework that provides a richer semantic framework)

Data Interoperability
(data are sematically placed into a large ontology framework, enabling interoperability)



From RDF to OWL 2 DL

- There exist **several RDF vocabularies** and schemas aimed to document data and their use in different scenarios, that are already **widely used and understood by several communities**. These RDF schemas includes the Dublin Core Metadata Initiative collection of terms (**DCMI** Metadata Terms), the Data Catalog Vocabulary (**DCAT**), the Friend of a Friend Vocabulary Specification (**FOAF**) and the PROV Data Model ontology (**PROV-O**).
- These schemas rely on RDF concepts, and in some cases on OWL 2 concepts and provide a **very flexible way** to document data and their usage. **However, the permissivity of the RDF language prevents the introduction of more sophisticated axiomatisations to impose constraints that are commonly used in the definition of a highly expressive ontology**.
- While such permissivity facilitates a fast deployment of metadata schemas developed ad hoc for the documentation of specific domain cases, it **prevents the building a more semantically rich environment**, that requires a **language** (e.g., OWL 2 DL) and **some syntactic constraints** to **grant computability (i.e., reasoning)**.
- Moreover, it would be beneficial to embed such RDF vocabularies into a larger ontological environment, to **use the information conveyed by such terms in an environment that connects the existing terms towards other knowledge domains.**

from DOME 4.0 D3.1 - “Semantic data exchange ontology”, UNIBO, UCL, SINTEF

Basic Metadata

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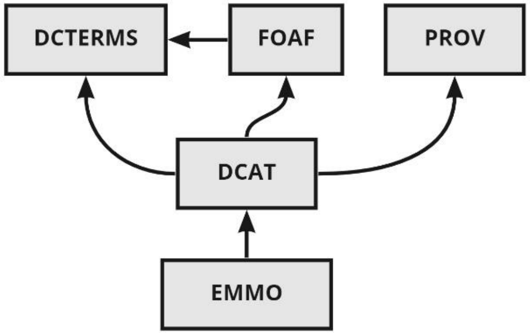
- Defined a list of data documentation concepts.
- Mapped the EMMO 1.0.0-beta4 to DCAT and other relevant RDFS vocabularies, to build a **semantically enhanced data documentation environment**, compatible with other H2020 initiatives (OntoCommons, OntoTrans, OpenModel, SimDOME)



Label	Definition	RDFS Schema References
DataSet	DCAT: A collection of data, published or curated by a single agent, and available for access or download in one or more representations.	dcat:Dataset (rdfs:Class) subclass of dcat:Resource (rdfs:Class)
Title	DCTERMS/DCAT: A name given to the resource.	dcterms:title (rdf:Property) with range rdfs:literal
Keyword	DCAT: A keyword or tag describing the resource.	dcat:keyword (rdf:Property) with range rdfs:literal
Creator	DCTERMS/DCAT: An entity responsible for making the resource.	dcterms:creator (rdf:Property) with range dcterms:Agent (rdfs:Class)
Publisher	DCTERMS/DCAT: An entity responsible for making the resource available.	dcterms:publisher (rdf:Property) with range dcterms:Agent (rdfs:Class)
Issued	DCTERMS/DCAT: Date of formal issuance of the resource.	dcterms:issued (rdf:Property) with range rdfs:literal
License	DCTERMS/DCAT: A legal document giving official permission to do something with the resource.	dcterms:license (rdf:Property) with range dcterms:LicenseDocument (rdfs:Class)
Source	DCTERMS/DCAT: A related resource from which the described resource is derived.	dcterms:source (rdf:Property)
URI	RDF-XSD: xsd:anyURI represents an Internationalized Resource Identifier Reference (IRI). DCTERMS/DCAT: An unambiguous reference to the resource within a given context.	xsd:anyURI (rdfs:Datatype) dcterms:identifier (rdfs:Datatype)
Homepage	FOAF/DCAT: The homepage property relates something to a homepage about it. (a public Web document usually available in HTML).	foaf:homepage (owl:ObjectProperty) with range foaf:Document (rdfs:Class)
Description	DCTERMS/DCAT: An account of the resource.	dcterms:description (rdf:Property)

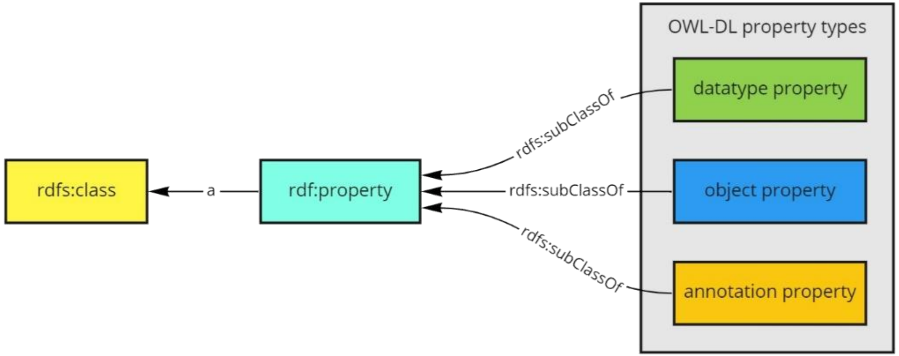
Properties OWL 2 DL Restrictions

Several terms in the DCAT/DCTERMS/FOAF schemas are associated with the *rdf:Property* type, giving the user the freedom to choose the OWL 2 resource type (data, object or annotation) to which the property points.

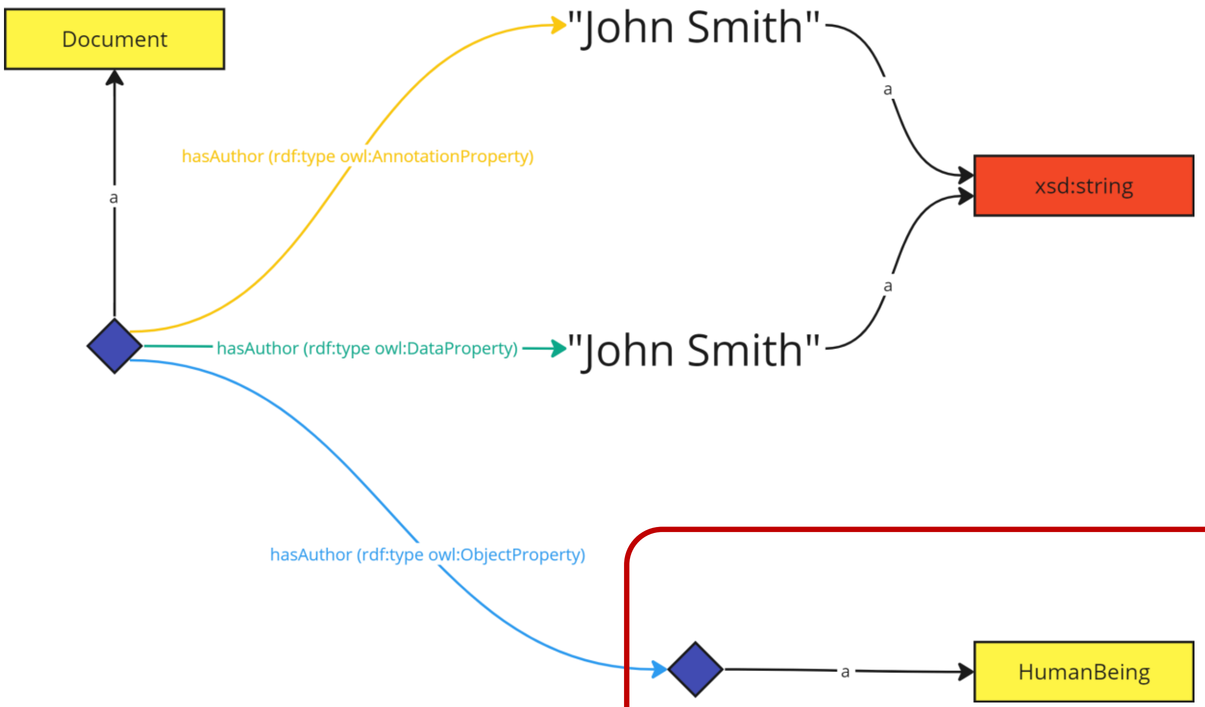
For example, a *dcterms:creator* can refer to a textual annotation (e.g. “John Smith”) or to an individual of type *dcterms:Agent*.

However, to build an **OWL 2 DL compliant mapping enabling reasoning**, there is the need **to specify one specific type of property between datatype, object, or annotation property**. The mapping will then distinguish between the different types of properties according to the expected range and domain.

In OWL 2 Full, object properties and datatype properties are not disjoint. In OWL 2 DL the set of object properties and datatype properties are disjoint, to enable decidable reasoning. See https://www.w3.org/TR/2012/REC-owl2-syntax-20121211/#Typing_Constraints_of_OWL_2_DL.



Semantic Enhancement



Non-Logical Statement.

Reasoner does not make use of this information

Non-Logical Statement.

Reasoner can make use of this information through data properties, but with limited expressivity.

Logical Statement.

Reasoner make use of this information. Possible to connect this knowledge to other concepts and make inferences.

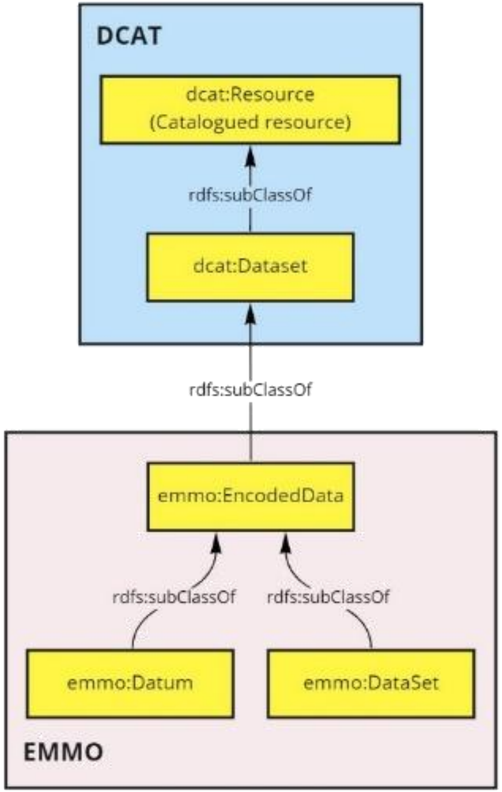
Semantic Enhancement metadata are ontological entities fully exploiting OWL 2 DL capabilities

Dataset Mapping

This mapping enables a direct relationship between an EMMO and DCAT data concepts, whereby the **emmo:DataSet** is a restriction of the **dcat:Dataset** since it requires that at least two **emmo:Datum** are present in the dataset, while the **dcat:Dataset** is not clear about the definition of the term "collection".

Within the EMMO, the distinction between data and datum terms, enables the use of the expressivity power of mereotopology for the representation of the content of a dataset.

The EMMO nominalistic approach requires that individuals of the **emmo:EncodedData** are actual material expressions of data, thus restricting the mapping to **dcat:Dataset** entities that refers to actual data material basis.



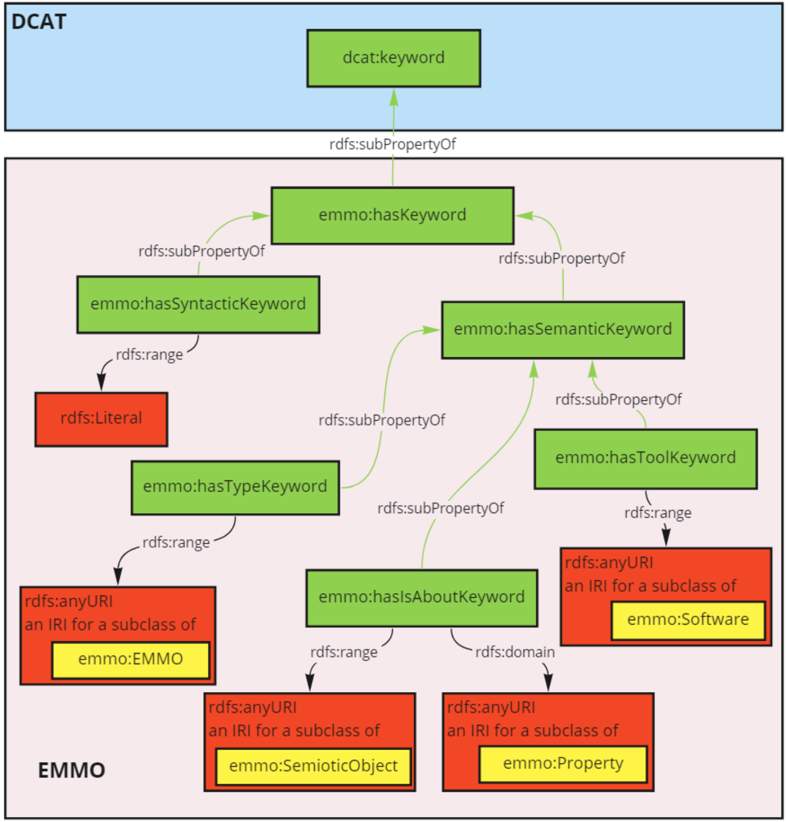
Keyword Mapping

This design choice recognises that it is possible to provide data with **syntactic keywords**, giving complete descriptive freedom to the user, and **semantic keywords**, that are restricted to IRIs pointing to valid OWL 2 DL entities.

The **emmo:hasTypeKeyword** data property is aimed to define the type of the data, i.e. what the data physically is (e.g. a book, a csv file, a picture). This suggests that a dataset can take any physical form.

The **emmo:hasIsAboutKeyword** reflects something about the data via a semiotic process stating that the data "is about" something else. Here we make use of the EMMO semiotic approach with a domain **emmo:SemioticObject**

The **emmo:hasToolKeyword** is the missing link between the seemingly thin metadata layer imposed both by DCAT dataset and the deep content of a dataset (i.e. the actual raw data stored in the dataset) referring to specific computational tools (e.g. a spreadsheet, or a simulation package, or a user provided script) that are able to decipher the syntactic information

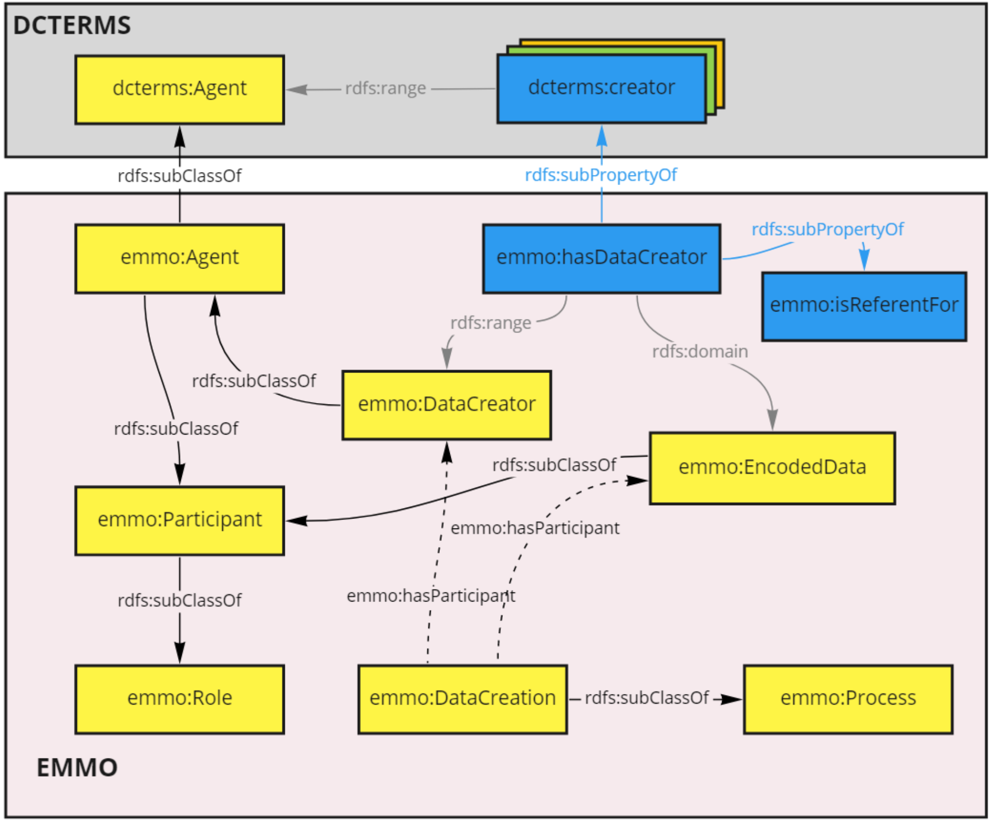


Creator Mapping

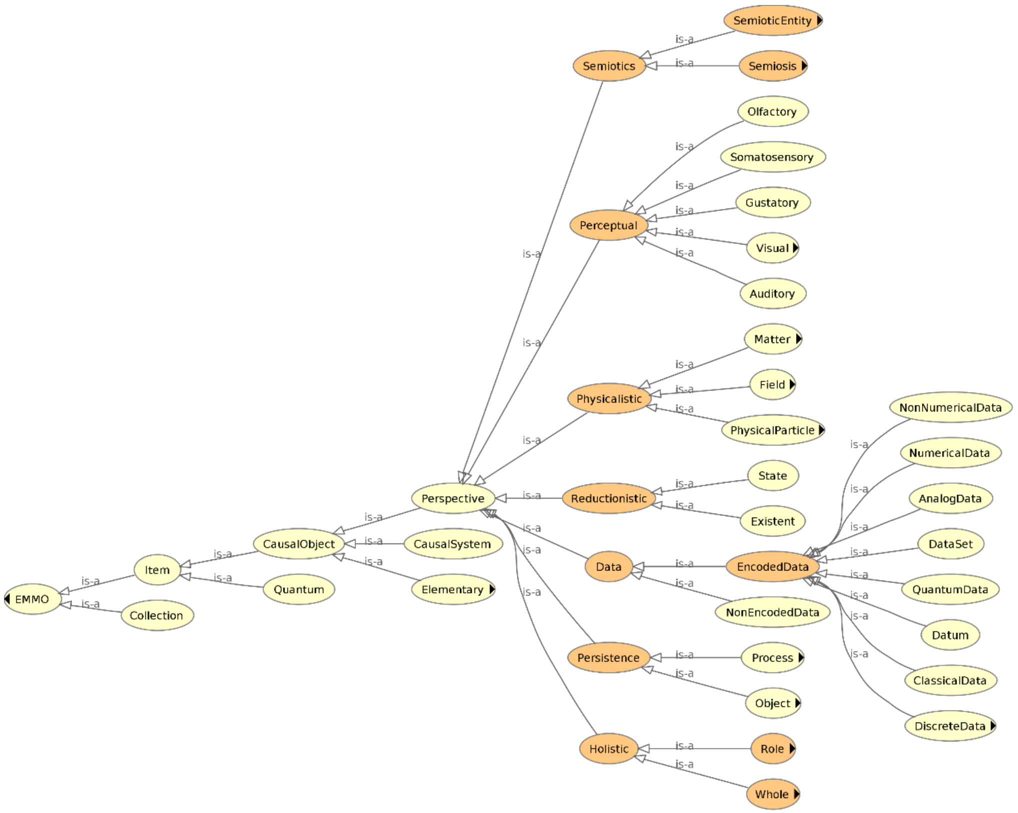
The EMMO mapping of **dcterms:creator** restricts the scope of the relation within the data field, restricting the domain to **emmo:Data**, and defining **emmo:Agent** as sub class of **dcterms:Agent**. We also introduce the **emmo:DataCreator** class to specify the type of agent involved in the data creation process, and the data creation process itself by the **emmo:Creation** class.

The semantic enhancement provided by the EMMO is related to the use of the Holistic and Persistence perspectives, that provide mereotopological relations to deal with the concepts of e.g. process, role, and participant.

These concepts are peculiar to most of the Top Level Ontologies that are not expressed in the existent RDF schemas for data documentation.



Benefit of an Ontology (in short)



Reasoning:

- possibility to apply constraints to data documentation improving the quality of your databased documentation (consistency)
- inferring new knowledge (e.g., types, relations) from existing one

Interoperability:

- between disciplines, providing a network of relations between entities, and placing them under different perspectives

Expressivity:

- taxonomy, annotations, and relations provides a way to express meaning for a dataset, much powerful than a simple keyword

An ontology bubbles up knowledge towards the user, reducing the need for data analysis and complex queries.

Benefit of an Ontology (EMMO)

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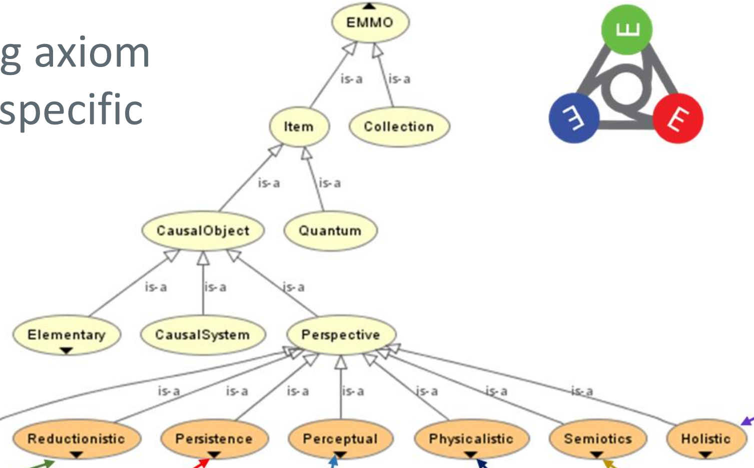
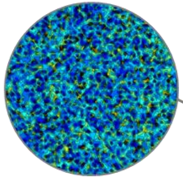
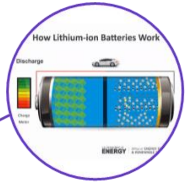
ONTOLOGY-DRIVEN DATA DOCUMENTATION FOR INDUSTRY COMMONS

Each perspective provides a covering axiom for all causal objects according to a specific categorisation.

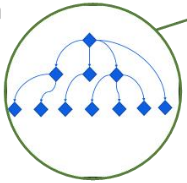


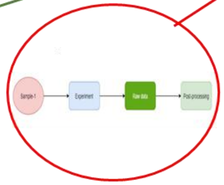


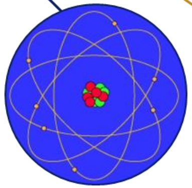
Data
- Contrasts
- Encoded data
- Information

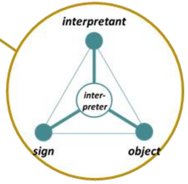


Holistic
- Whole
- Parts (roles)









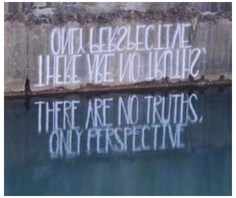
Reductionistic
- Direct parthood
- Countability
- Ordering

Persistence
- Process
- Objects

Perceptual
- Audio
- Visual
- Olfactory etc

Physicalistic
- Matter
- Field
- Material

Semiotics
- Signs
- Models
- Properties



Syntax and Semantics in the EMMO

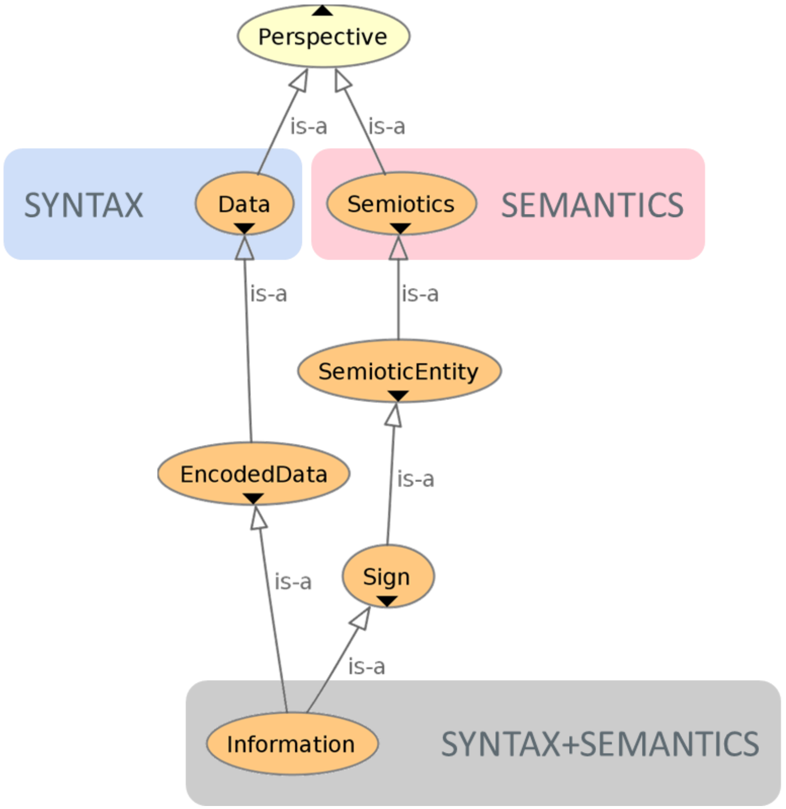
EMMO perspectives draw a **clear separation between data and their meaning**.

Information, usually defined as "*data with meaning*" is an important concept for EMMO.

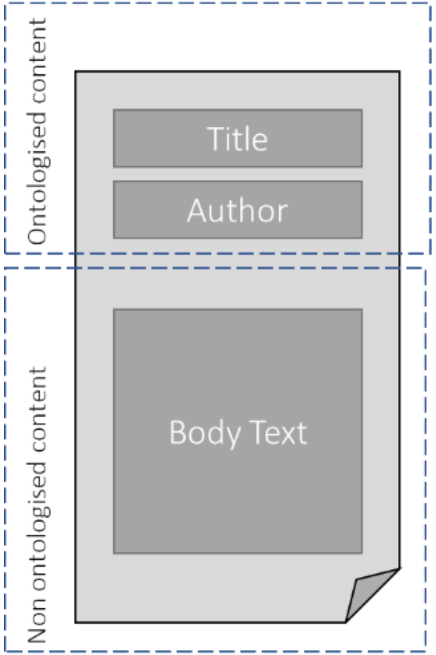
Mereotopology (not present in RDFS vocabularies, but in several TLOs) enables description of the syntax of a dataset.

EMMO forces the users to consider information only the data that has been semiotically connected to another entity.

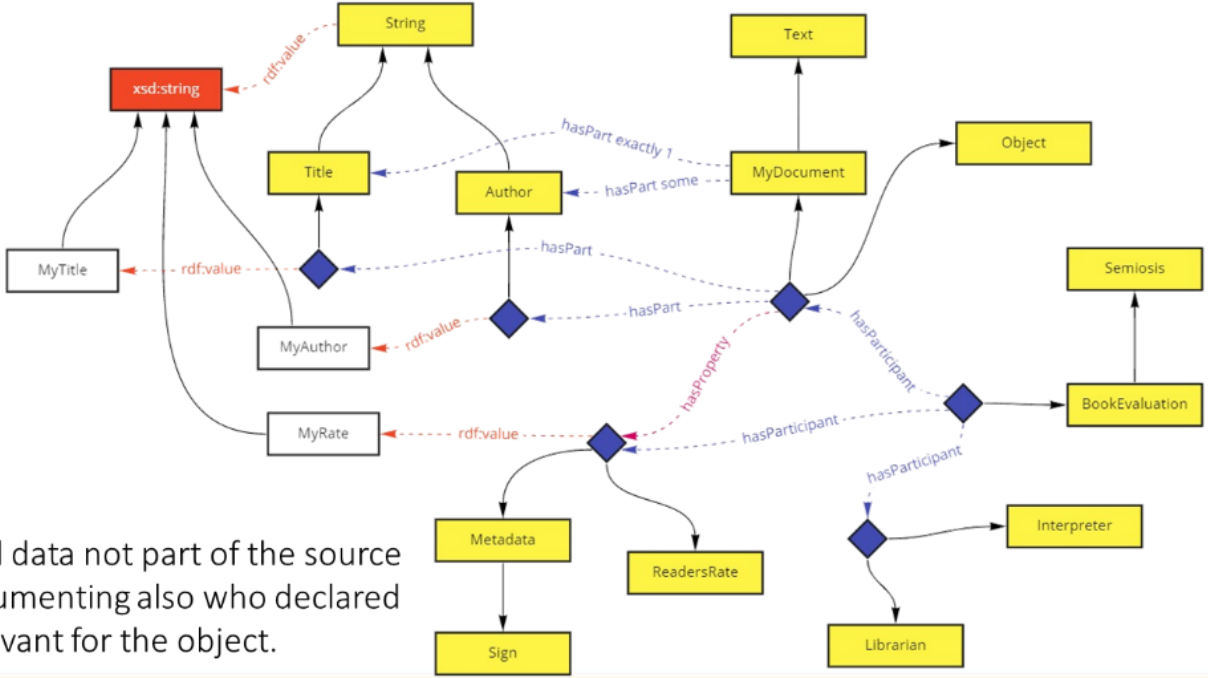
e.g. to connect physical properties to the relevant physical entity, extremely relevant for material characterization or modelling



Example of Metadata Origin Documentation



Using parthood we can extract some relevant data from the source (e.g. title), while leaving the bulk of the data outside the ontology.

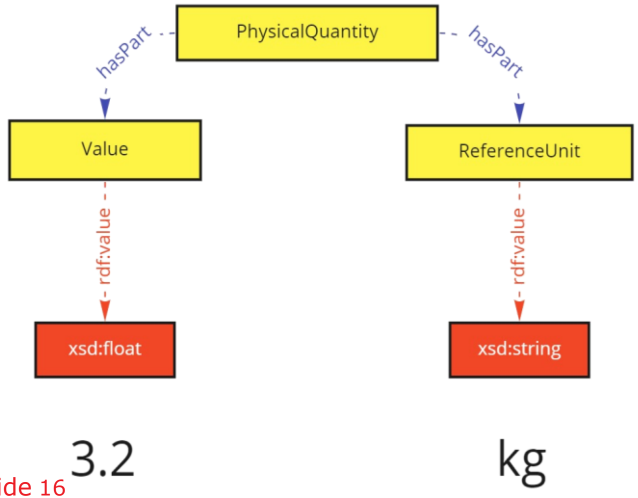


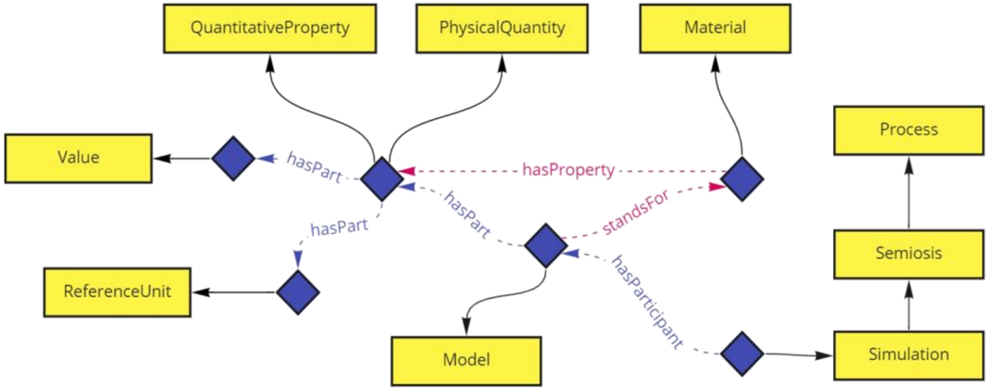
Using semiosis we can add data not part of the source (e.g. book rating) and documenting also who declared that particular data as relevant for the object.

Example of Metadata Origin Documentation

Physical Quantities are represented as **syntactical structures** of numbers and strings, and **stored in RDFS format**.

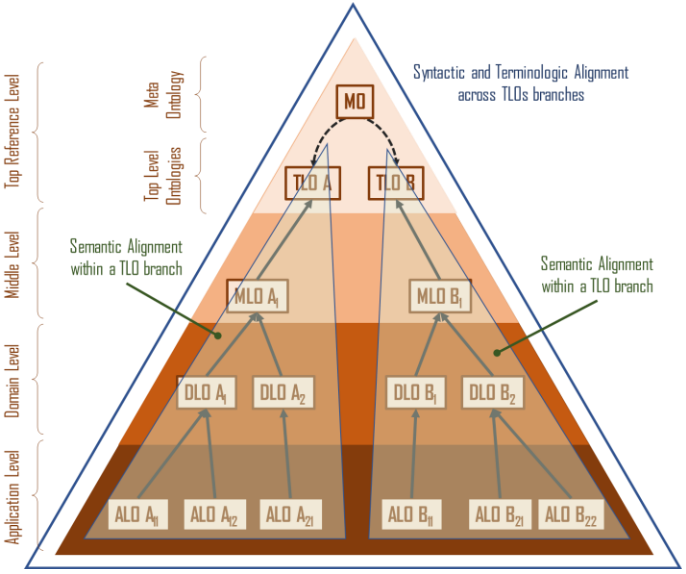
QuantitativeProperties are physical quantities that are connected to a material through a **semiotic process** of **simulation**.

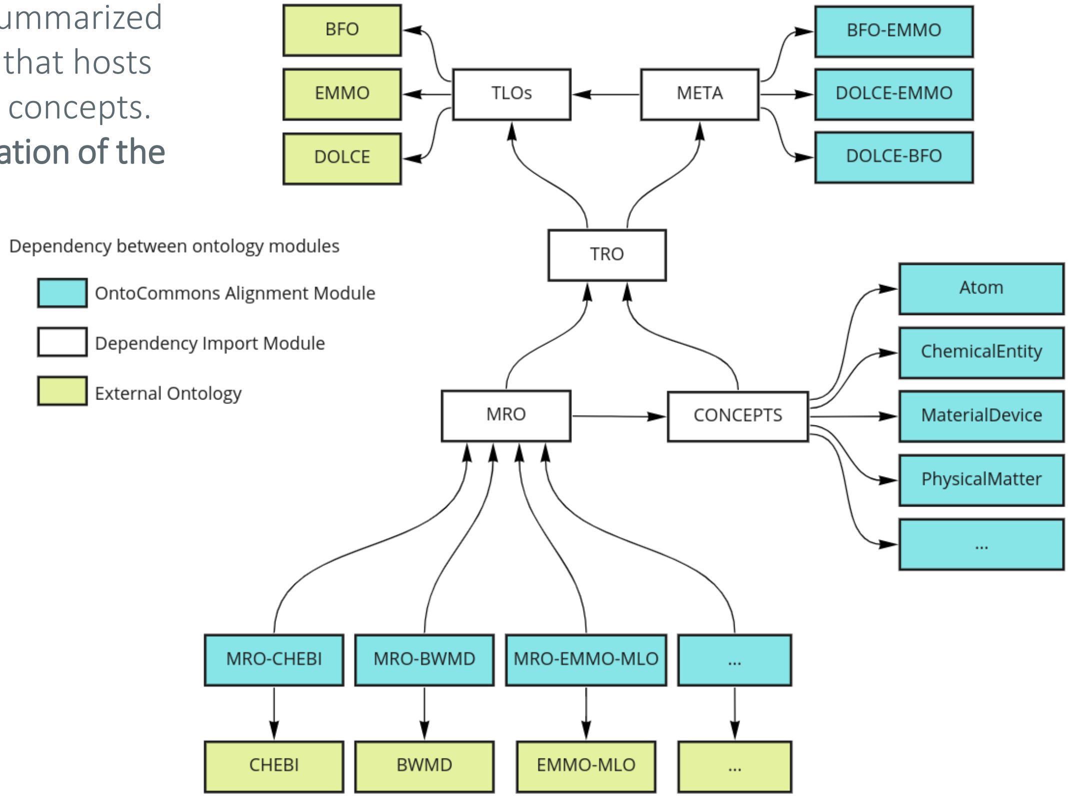




Beyond the EMMO

The **structure of the TRO-OWL ontology modules** is summarized here, also including the Middle Reference Ontology, that hosts the alignments of a selected set of MLOs and bridge concepts. The **Meta ontology** is clearly depicted as the **combination of the mappings between the three selected TLOs**.



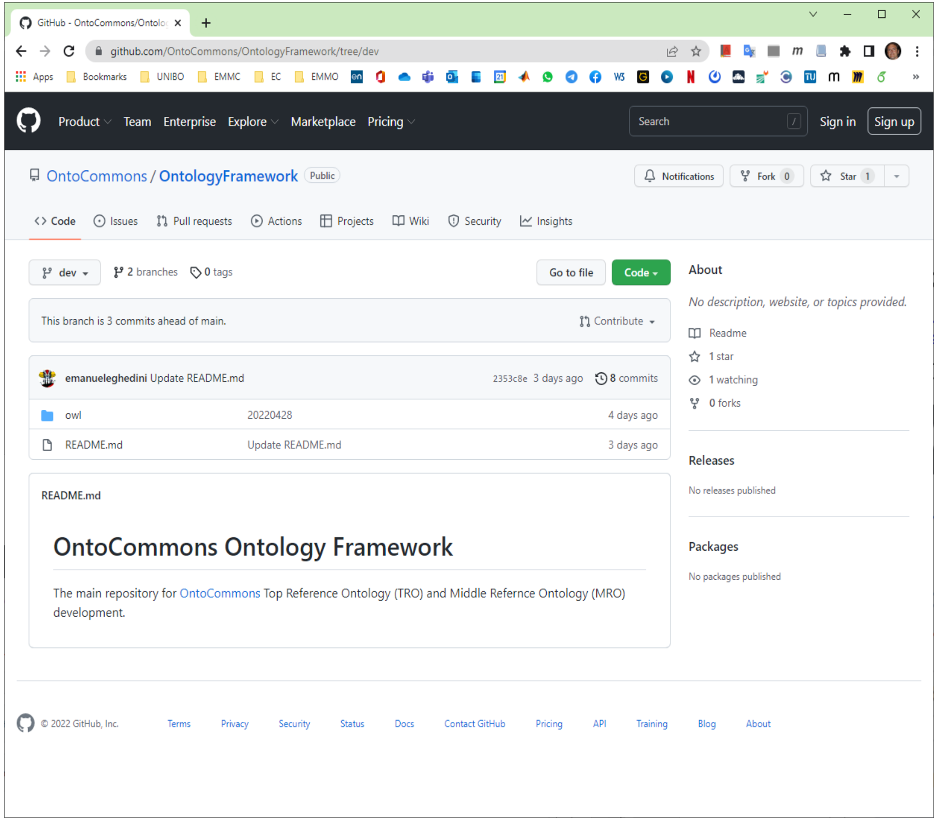


Protégé Environment

The TRO-OWL framework has been published publicly in the GitHub repository at:
https://github.com/OntoCommons/OntologyFramework

It will be continuously updated in the course of the OntoCommons Project:

- Accessible
- Easy to maintain

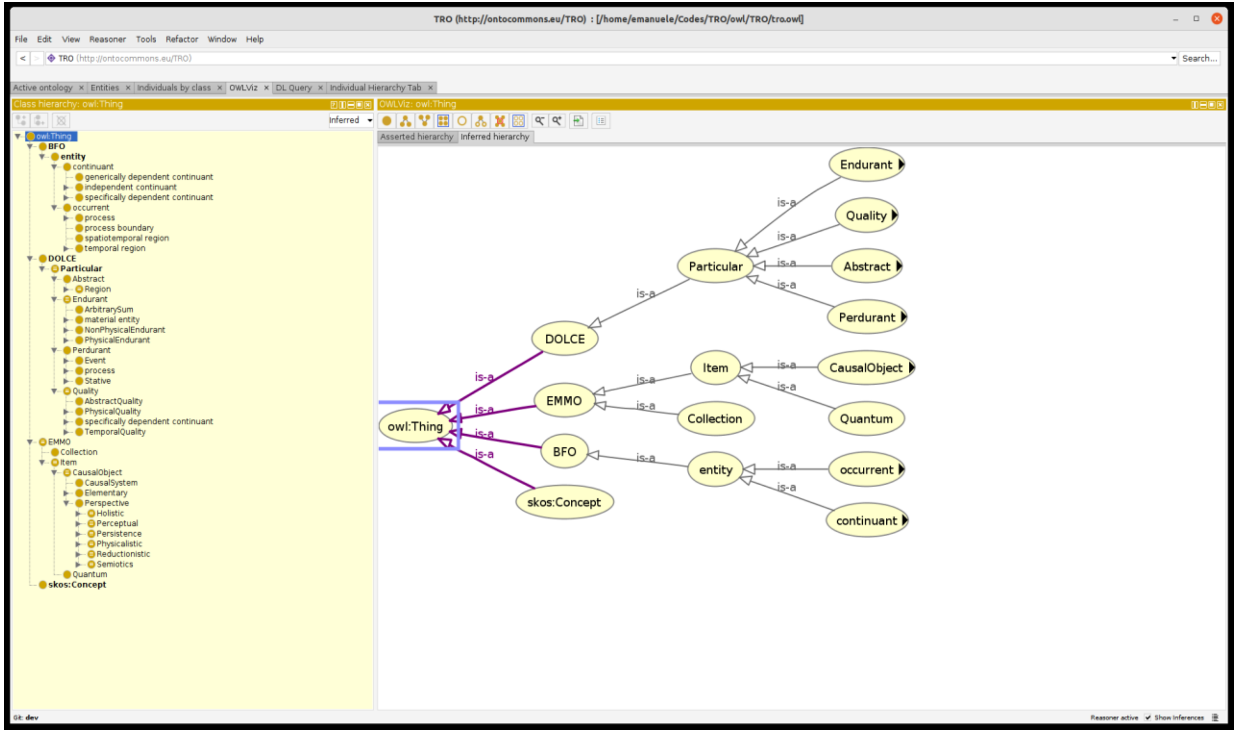


Protégé Environment

The framework is Protégé-compatible and will offer the end user the possibility to navigate through the TLOs, their mappings and the lower-level ontologies that depends on them.

The OWL mappings, derived from the more rigorous FOL alignment, connect TLOs' taxonomic trees… and not just that.

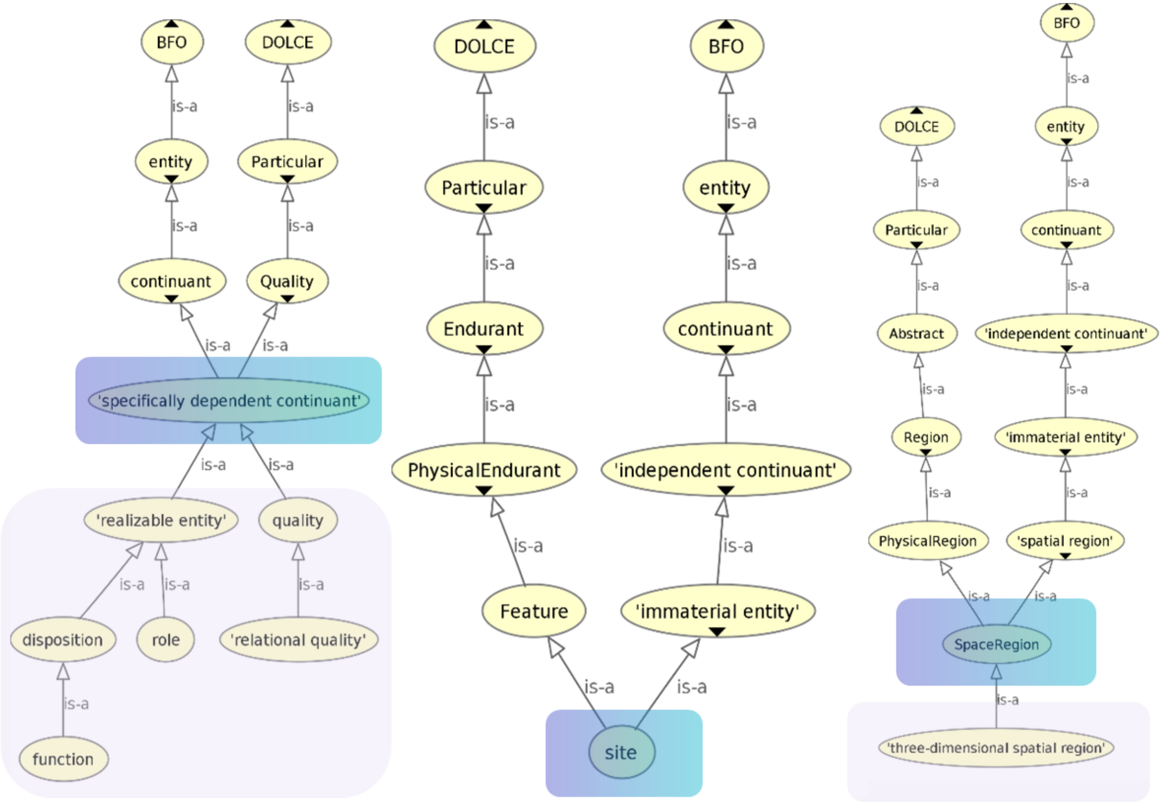
The TRO-OWL will constitute a **development framework for semantic web ontologists** to build and test OntoCommons compliant ontologies.



The connected roots of the three TLOs

TLO Alignment

DOLCE/BFO mapping expressed in the OWL 2 DL language and visualised through the **Protégé OWLViz Plugin.**



Solid FOL foundations

T 2.4
Currently working on
DOLCE/EMMO
EMMO/DOLCE
Partial FOL Mappings

Bridge Concepts Template

DOME 4.0

ONTO COMMONS – Ontology-driven data documentation for industry commons

Domain Experts (non-ontology educated)
Ontology Experts (ontology educated) → Concept elucidation

Domain Experts (non-ontology educated) → Knowledge domain resources

Ontology Experts (ontology educated) → Definition by an existing formal ontology

NEW CONCEPT NAME[1]

(use the preferred label, or IRI name, provided in the first table as title)

General Concept Info:

IRI:	*Suggested entity new IRI.*
OWL Type:	*Class / ObjectProperty / Individual.*
Concept Elucidation:	*Natural language definition of the concept (elucidation).* *Here the concept that we want to introduce is expressed as precisely as possible, making references to knowledge domain resources, including instance and usage examples when relevant.*
Labels:	*Labels used to address the concept, ordered as:* *i) preferred (one) (the label to primarily used to shortly refer to the concept)* *ii) alternative (multiple) (labels that are commonly used to address the concept in practice, even if they are used with narrower of wider sense)* *iii) deprecated (multiple) (labels that are misleading with respect to the concept, because of misuse, ambiguity or too wide meaning).*

Knowledge Domain Resources:

Related Domain Resources:	*Existing domain resources (e.g. standards, books, articles, dictionaries) that defines or are related to the concept (provide reference to the resource and quote the relevant informational content).* *More than one resource can be reported.* *These resources are aimed to support the choice of the above concept choice and elucidation.*
Comments:	*Explain the motivations behind the concept definition with reference to the domain resources, underlying similarities and differences.*

Alignments To Existing Ontologies:

Target Ontology:	*Existing IRI of the ontology that will express the concept according to its logical framework (concept alignment).*
Related Ontology Entities:	*List of terms and IRIs of the Target Ontology entities that are relevant for the concept (documentation is supposed to be accessible through the target ontology).*
Mapping Elucidation:	*Natural language description of the mapping choice and motivations.*
Semantic Relation Level:	*The level of semantic relationship between the Concept and the Target Ontology entities:* - *Equivalence (strong mapping) (e.g. owl:equivalentClass, owl:equivalentProperty)* - *Strong Hierarchical (e.g. rdfs:subClassOf, rdfs:subPropertyOf)* - *Weak Hierarchical (e.g. skos:narrower, skos:broader)* - *Similarity (e.g. skos:related).*
Mapping Axioms:	*Proposed mapping axiom (or axioms) between the Concept entity and the Target Ontology entities in a OWL2 compliant syntax (e.g. Turtle, Manchester, RDF/XML, Functional-Style, OWL/XML).*

Protégé Environment

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KNOWLEDGE DOMAIN RESOURCES:

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Comments:	*Explain the m… reference to the domain resourc…*

ALIGNMENTS…

Target…	*…ill express the concept according to its logical …ent).*
Related O… E…	*… of the Target Ontology entities that are relevant for the …mentation is supposed to be accessible through the target ontology).*
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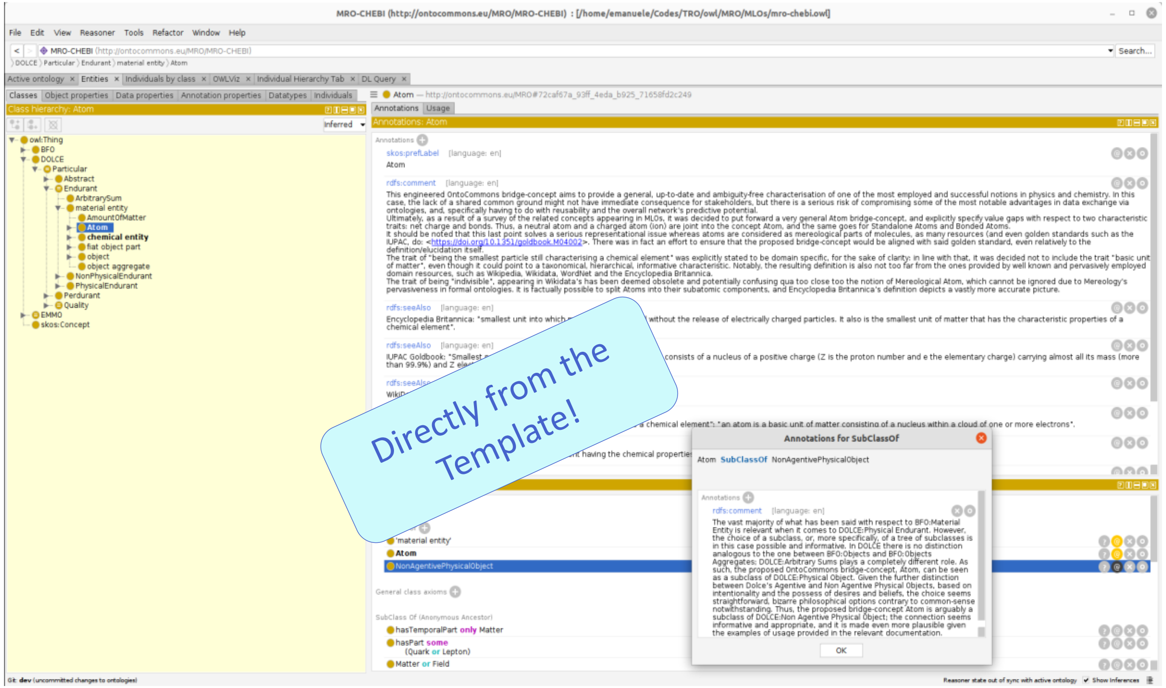
Mapping Axioms:	*Proposed mapping axiom (or axioms) between the Concept entity and the Target Ontology entities in a OWL2 compliant syntax (e.g. Turtle, Manchester, RDF/XML, Functional-Style, OWL/XML).*

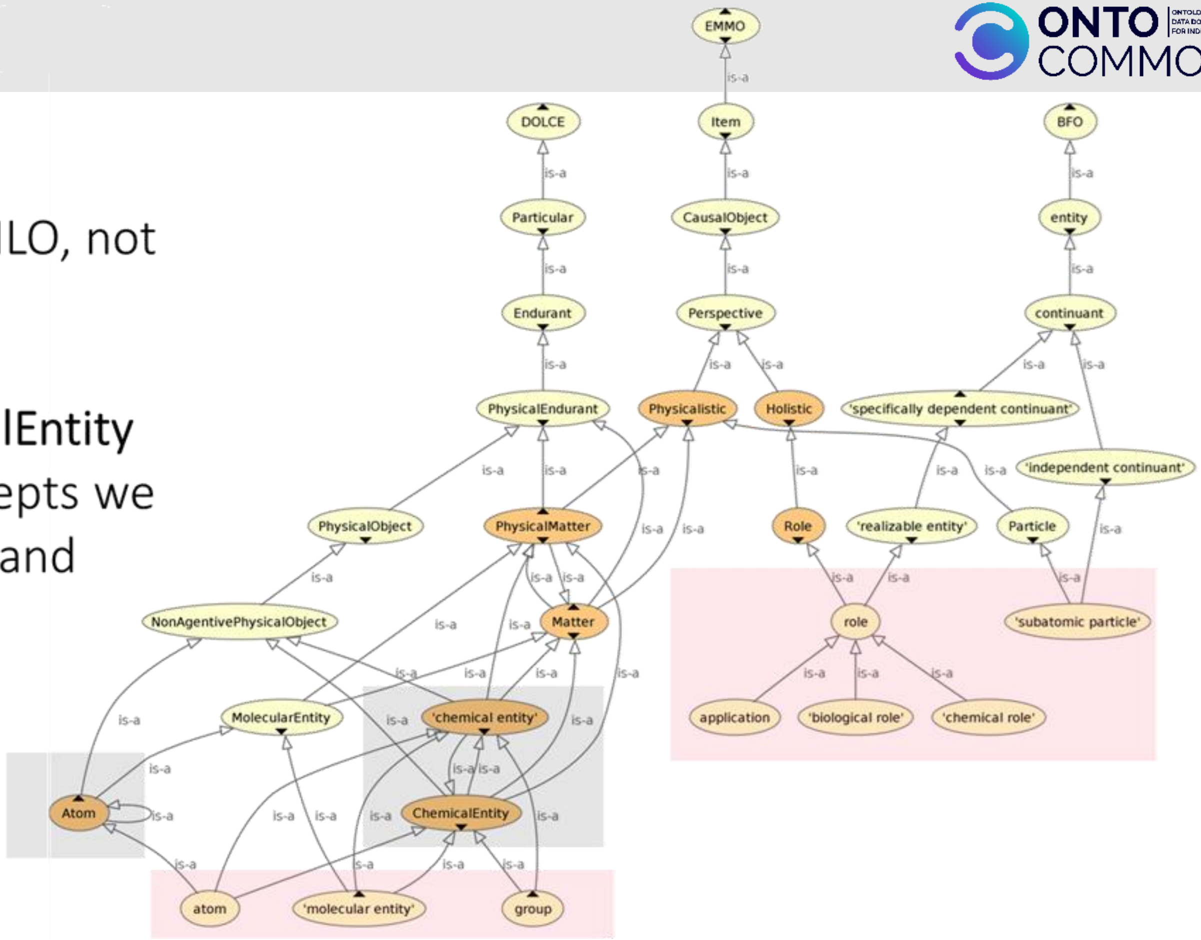
The content of the template (now a table), can be expressed using more flexible formats (e.g. XML, JSON) and documented within the RDFS version of the ontology.



CHEBI to TLOs

CHEBI is a chemistry MLO, not aligned with a TLO.

Thanks to the **ChemicalEntity** and **Atom** Bridge Concepts we can align it to the TRO and hence **to all TLOs.**



Conclusions

- The DOME 4.0 Data Set Ontology can **open the gate towards ontology frameworks** that provides **well documented ontology concepts to semantically enrich your data** (OCES specifications).
- An ontologized data set can **answer complex questions** such as: “Which software may provide such data so that I can build a workflow?”, “Which real world object type this data stands for?”, “What do you mean with viscosity in this dataset?”, “Are there workflows that make use of this dataset type?”
- The Data Set Ontology is **respectful** of DCAT and people that does not like ontologies! You **may or may not use it** to enhance your dataset and live with simple syntactic keywords (with all their pros and cons).

The OCES comprises also **Technical Specifications** and **Tools** for optimal ontology development and documentation.

DOME 4.0

@DOME40_H2020 DOME40 www.dome40.eu

ONTO COMMONS

ONTOLOGY-DRIVEN
DATA DOCUMENTATION
FOR INDUSTRY COMMONS

This projects has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements No. 953163 and No. 958371