OCES: Material Science Domain and Bridge concepts as alignment tools

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Abstract

The necessity of OCES (Ontology Commons Ecosystem), to reduce heterogeneity and to avoid ambiguities, has not to be confused with a proposal of a monolithic approach concerning the development of an all-encompassing theory of foundational ontologies.
The creation of a single gigantic ontology containing all available knowledge, would be difficult to be sustainable from both a theoretical and application perspective given the incompatibilities already present in the most basic levels.
It is therefore plausible to have a modular approach in which the individual ontological can be integrated with each other as far as possible through formal relations.
This poster presents the work that has been done focusing on ontologies related to the **Material science** domain. It provides a practical evidence of result, using a tool for matching ontologies at low level.
The goal is to propose a practical and flexible tool for strong semantic alignment between a plurality of ontologies through a standalone entity: **"the Bridge Concept"**, greatly reducing the connection to be established. The Bridge Concept Engineering an holistic process, focused on the target Ontology applications to deal with lack of documentation. This process properly identifies the place that the bridge-concepts would occupy in an ontology, on the base of **Flexibility**, **Findability** and **Pragmatism** principles.
The tool includes the guide to be used, it is therefore ready to use by any expert in the sector, who wants to connect what he wants to represent to the Ontologies of the domain of interest.

Ontologies matching tools

Matching refers to the process used to find relations or correspondences between entities of different ontologies, and the **alignement** is the result of Matching Process.

Research gaps

The goal of matching ontologies is to reduce heterogeneity between them. *Syntactic heterogeneity* occurs when two ontologies are not expressed in the same ontology language. *Terminological heterogeneity* occurs due to variations in names when referring to the same entities in different ontologies. *Conceptual heterogeneity*, also called semantic heterogeneity, occurs when there are differences in modelling the same domain of interest. Hence, a methodology for ontology matching is required and needs to be supported for helping engineers to develop applications. Yet, at present, almost no support exists for such an activity at the methodological or at the tool level. Even in the database field, where similar problems have been considered for years, there is no consensus methodology on how database schema matching may be conducted.

Research objectives

- **Objective 1:** Propose an alternative to the existing tecniques to aligne the concept that it is need to be presented, in a standard knowledge framework.data FAIR (Findable, Accessible, Interoperable and Reusable)
- **Objective 2:** Propose an alternative tool ready to use by demonstrators for represent any concept related to their domain of interest and of expertise.

Bridge Concept Template: Ready to use

NEW CONCEPT NAME

(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: *(1: vertical, MLOs/TLOs; 2: horizontal, DLOs)*

1: Vertical Alignments

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).*

2: Horizontal Alignments

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).*
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Bridge Concepts and Material Science Domain

Material Science Domain Ontologies hierarchies

Domain or particular ontologies, are ontologies that can give different views of the same slices of reality or deal with different realities but containing similar elements. In this case, Material domain ontologies give different views of applied sciences sectors.
Total of close to 50 ontologies were gathered from MatPortal, OntoCommons, IndustryPortal, github and OntoCommons surveys. These ontologies are at different levels, depending on the concepts they host, so they are distinguished from Mid level, Domain level, Application level. Most of them are connected to TOP-level Ontologies such as EMMO, BFO, SUMO, SIO.

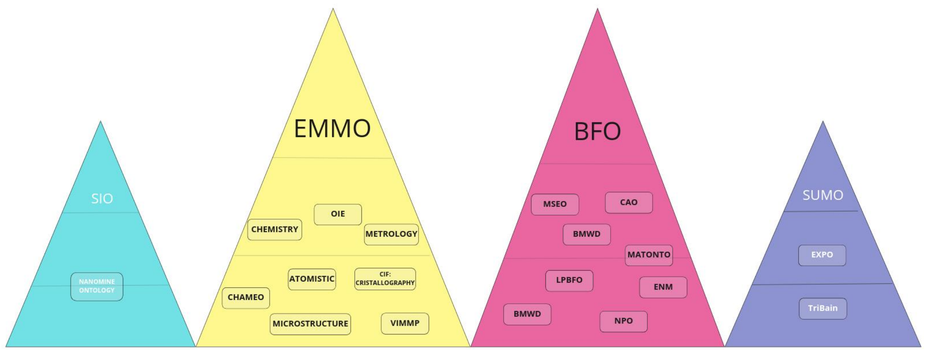

Figure 1. Material Science Domain Ontologies and their TOP Reference Ontologies

Material Component: First Bridge Concept Candidate

Completing the template with all the required and easily available documentation. The result found a strong hierarchical connection through an **equivalence** or **subclass** relations between three ontologies belonging to three different pyramids.

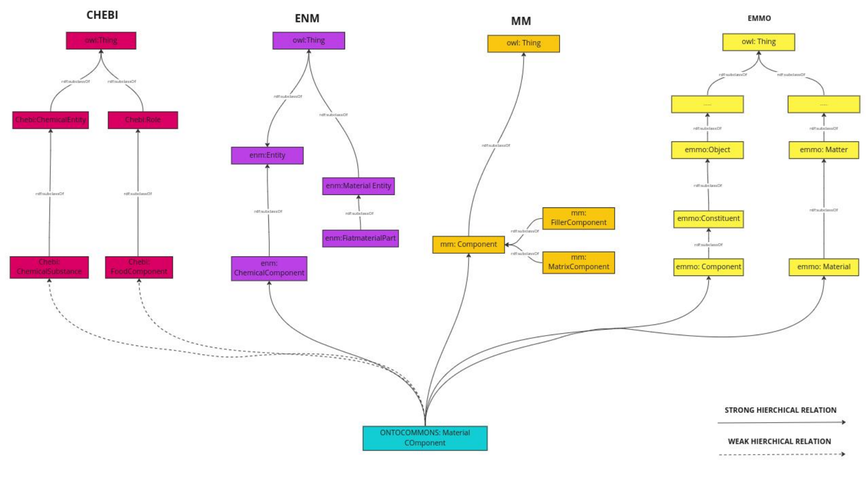

Figure 2. Fist Material Science Bridge concept candidate

Conclusions

- Bridge Concept as a **tool ready to use**;
- **Material Component** as Bridge Concept implemented for Material Science Domain, as a strong hierachical semantic relation between entities in MaterialsMine, EMMO and NPO Ontologies.
- **Material Processing**, **Molecule** Bridge concepts are in working progress, as a connection of a plurality of ontologies.
- Other Candidates Bridge Concepts selected to be implemented.

What does this study add?

- It adds a **Core Tool**, creating a **Standalone Entities**, explicitly connected to **Domain Resources and Standards** through **simple data pipelines**.
- It adds a **Strong Semantic Relations**, creating a **mediated connection**, taking advantage of **Reasoning** proper of the Ontologies aligned that spreads downwards and facilitated **Data sharing** in only **one point**.

Practical implications

- It is a tool **ready to be used**. The template that has to be filled acts as a **guide in Bridge Concept Engineering**;
- It has parts dedicated both **User** or **Ontologist**;

References

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