What is Ontology?

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https://christophe-roche.fr/

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Funded by the European Union

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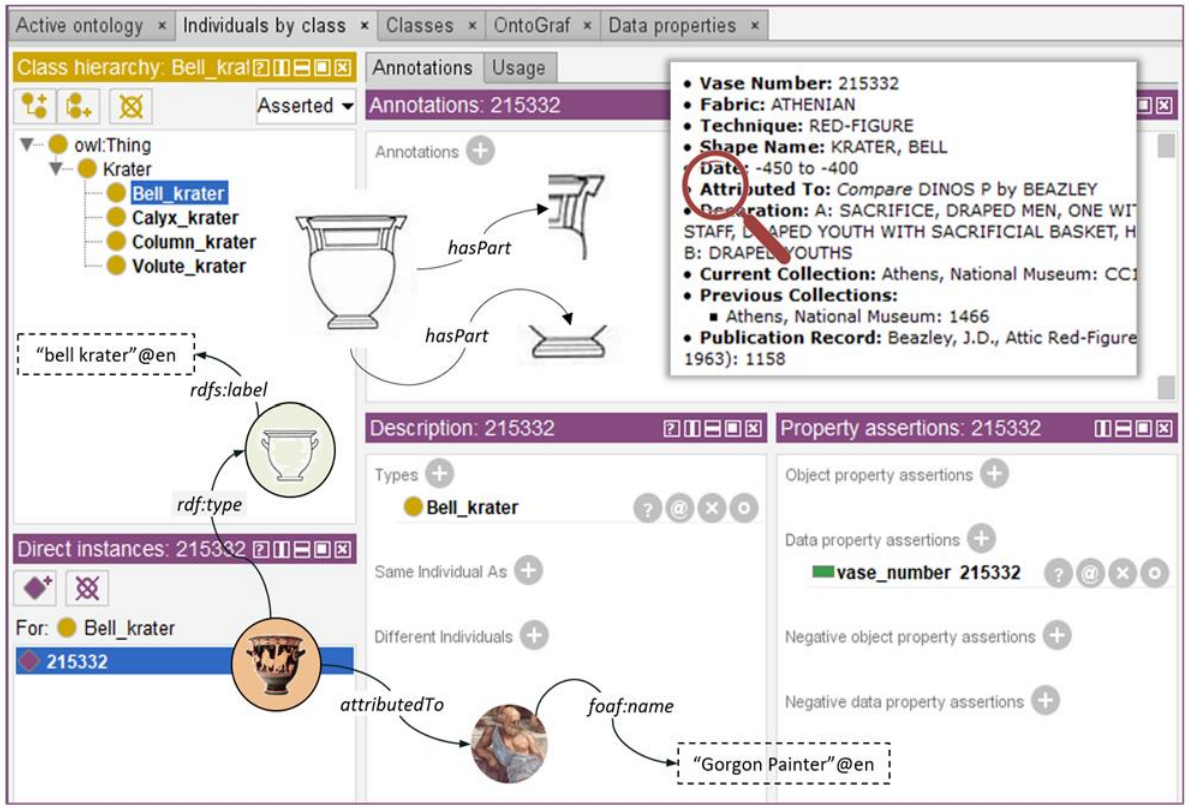
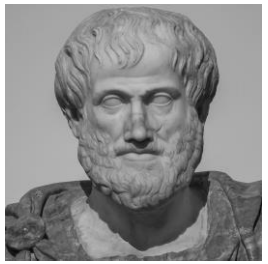


1. Introduction

1

“The branch of metaphysics dealing with the nature of being” OXFORD UNIVERSITY PRESS

“The science of being as being… independently of its particular determinations”



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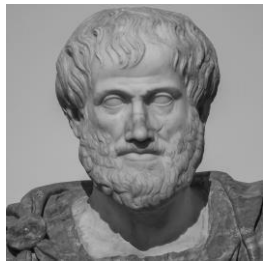

2

“The branch of Knowledge Engineering dealing with conceptualization in a computer-readable form”

“The science of what exists”

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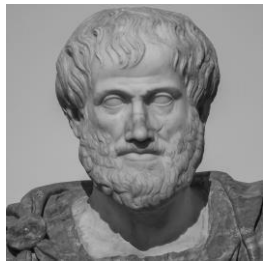
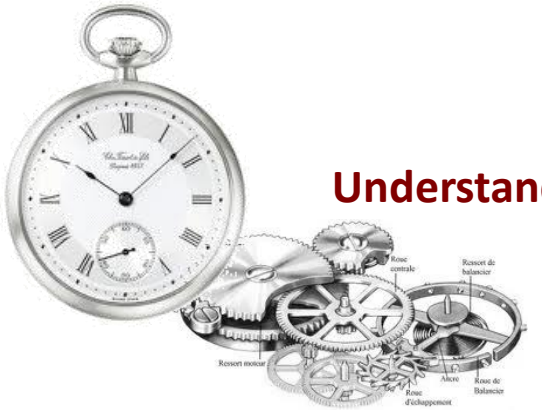


“The science of being as being… independently of its particular determinations”

➥ ***Epistemological Principles***



Understanding the “world”

2

“The branch of Knowledge Engineering dealing with conceptualization in a computer-readable form”

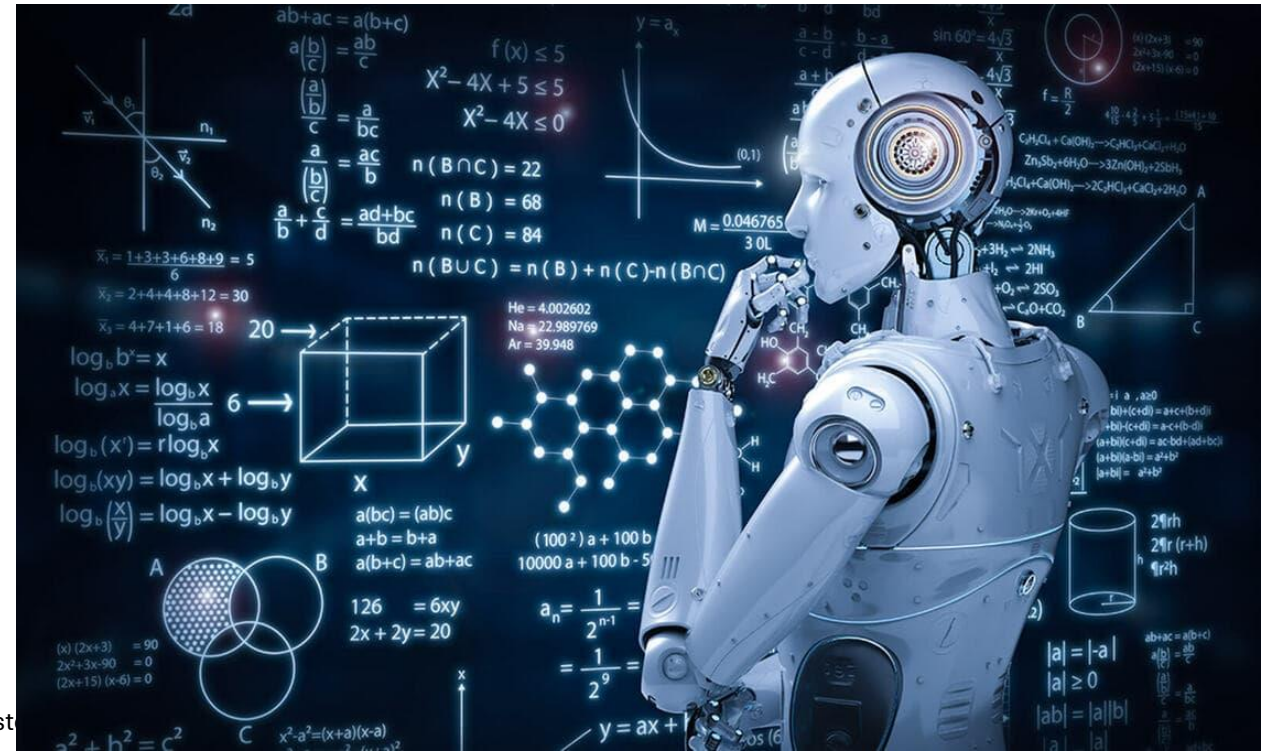
“The science of what exists”

➥ ***Formalization & Representation***

1. Introduction

Knowledge Engineering

- ✓ How to represent & organise the objects which populate the world in a computer-readable form?
- ✓ Everything that can be represented exists



2. Definition

- **Set of Concept and Relationship Definitions**

What is an Ontology ? Short answer: **An ontology is a specification of a conceptualization**.

In the context of knowledge sharing, I use the term ontology to mean a *specification of a conceptualization*. That is, an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents. This definition is consistent with the usage of ontology as set-of-concept-definitions, but more general.

Tom Gruber

2. Definition

Set of Concept and Relationship Definitions

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Vocabulary of Terms

"An [explicit] ontology may take a variety of forms, but necessarily it will include **a vocabulary of terms and some specification of their meaning** (i.e., definitions)"

M.Ushold & M.Gruninger. Knowledge Engineering Review, Vol.11, n°2, June1996

"There is no clear division between what is referred to as "vocabularies" and "ontologies"."

OWL 2 Web Ontology Language Document Overview (Second Edition)

W3C Recommendation 11 December 2012

"Ontologies are formalized vocabularies of terms, often covering a specific domain and shared by a community of users. They specify the definitions of terms by describing their relationships with other terms in the ontology. "

2. Definition

“Ontologies are used to capture knowledge about some domain of interest. An ontology describes the concepts in the domain and also the relationships that hold between those concepts. Different ontology languages provide different facilities”

“*A Practical Guide to Building OWL Ontologies Using Protégé 4 and CO-ODE Tools* Edition 1.3 ” Matthew Horridge

An ontology is a shared definition of a network of concepts and relationships of a domain, expressed in a formal and computer-readable language

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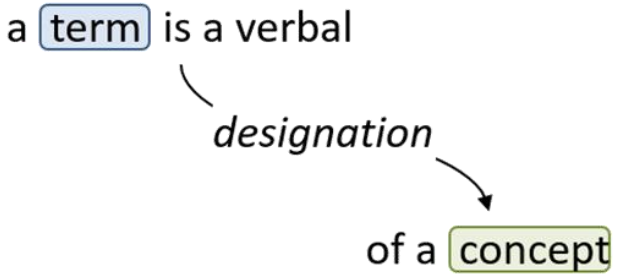
An ontology is a shared definition of a network of concepts and relationships of a domain, expressed in a formal and computer-readable language

Ontoterminology: Terminology whose conceptual system is a formal ontology

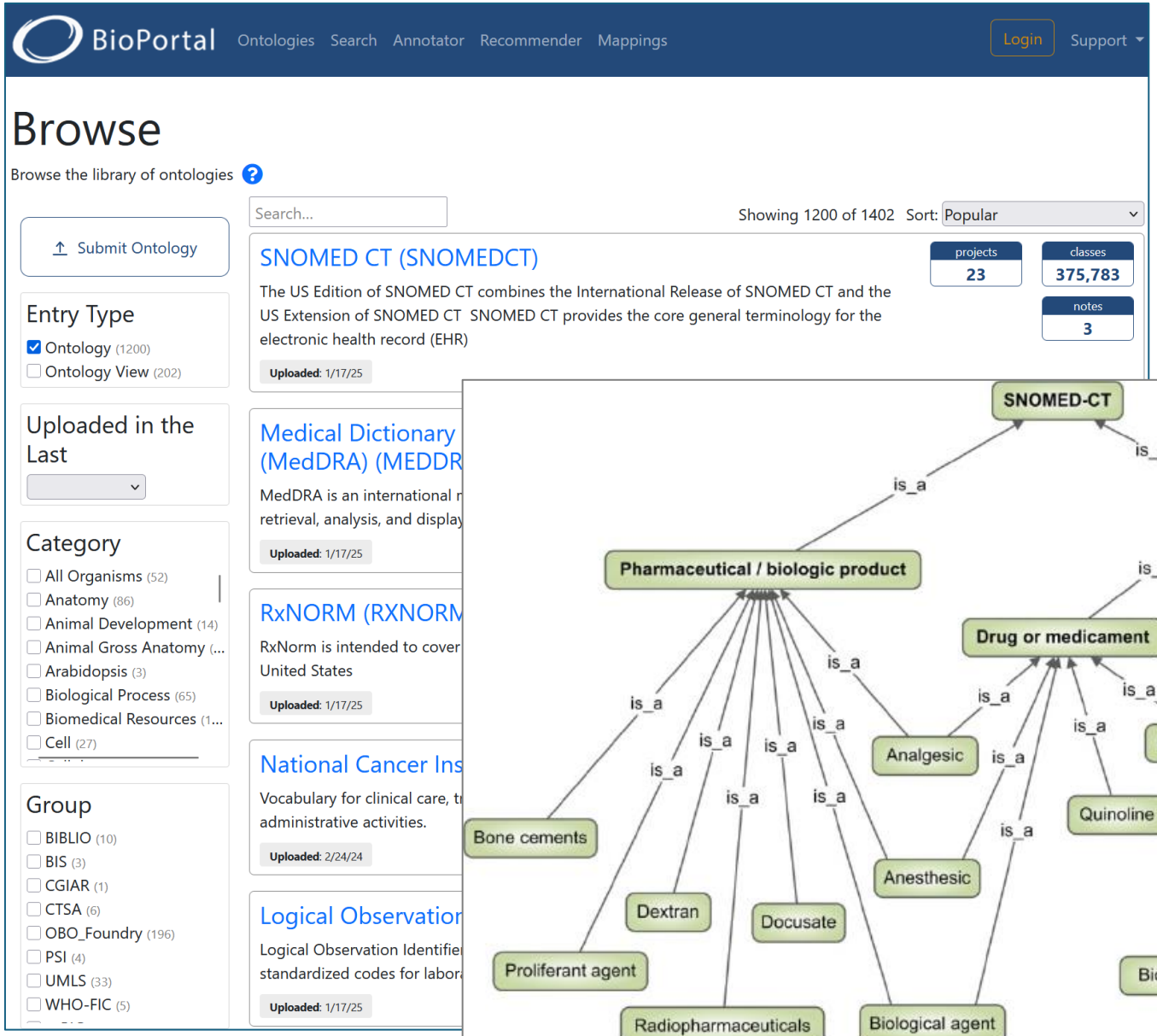


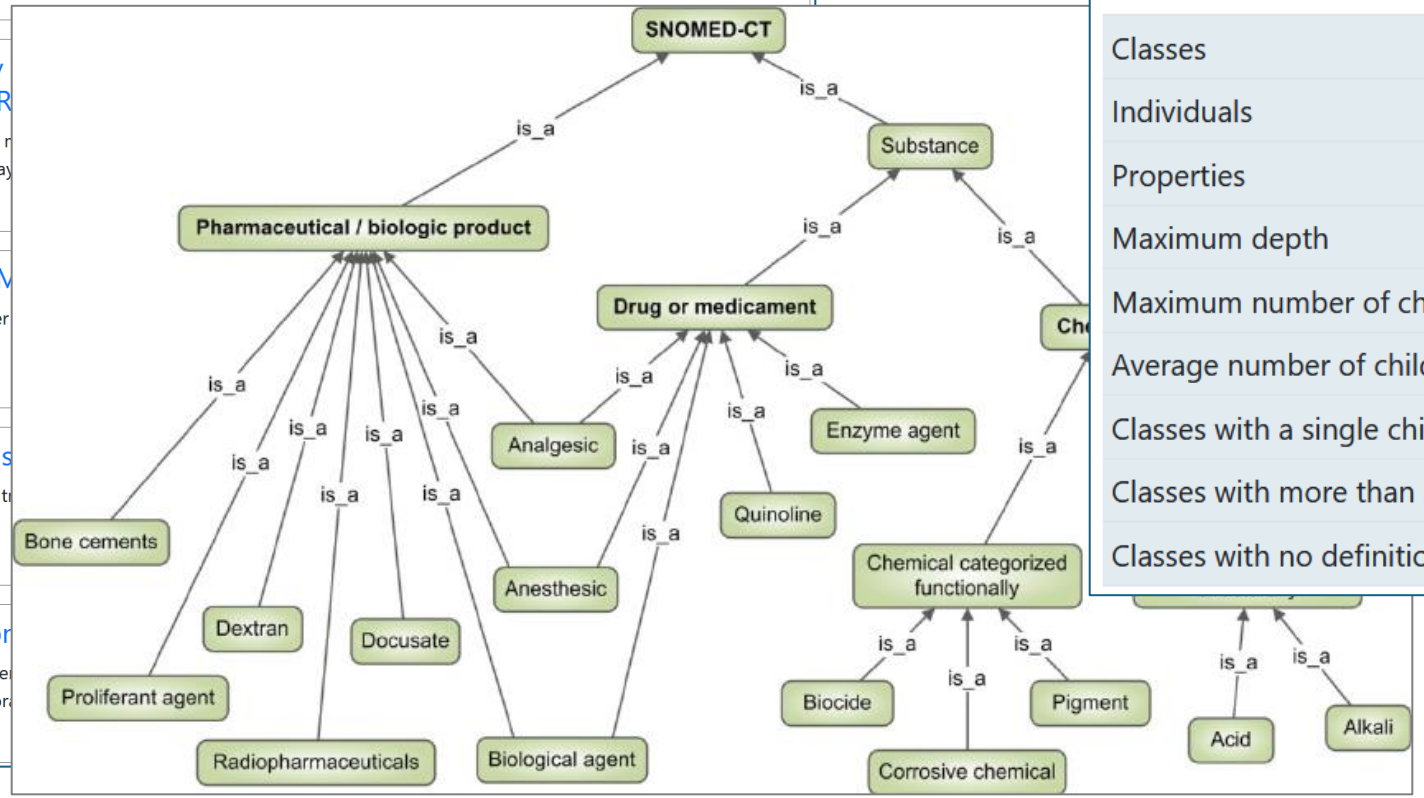
ISO 1087:2019

3.4.2
term
designation (3.4.1) that represents a *general concept* (3.2.9) by linguistic means

3.2.7
concept
unit of knowledge created by a unique combination of *characteristics*

3. Examples: Medicine





SNOMED CT provides the core general terminology for the electronic health record (EHR). The concepts have unique meanings and formal logic-based definitions organized into hierarchies.

https://bioportal.bioontology.org/ontologies/SNOMEDCT

Metrics

Classes	375,783
Individuals	0
Properties	246
Maximum depth	30
Maximum number of children	3,027
Average number of children	4
Classes with a single child	48,683
Classes with more than 25 children	3,114
Classes with no definition	367,146

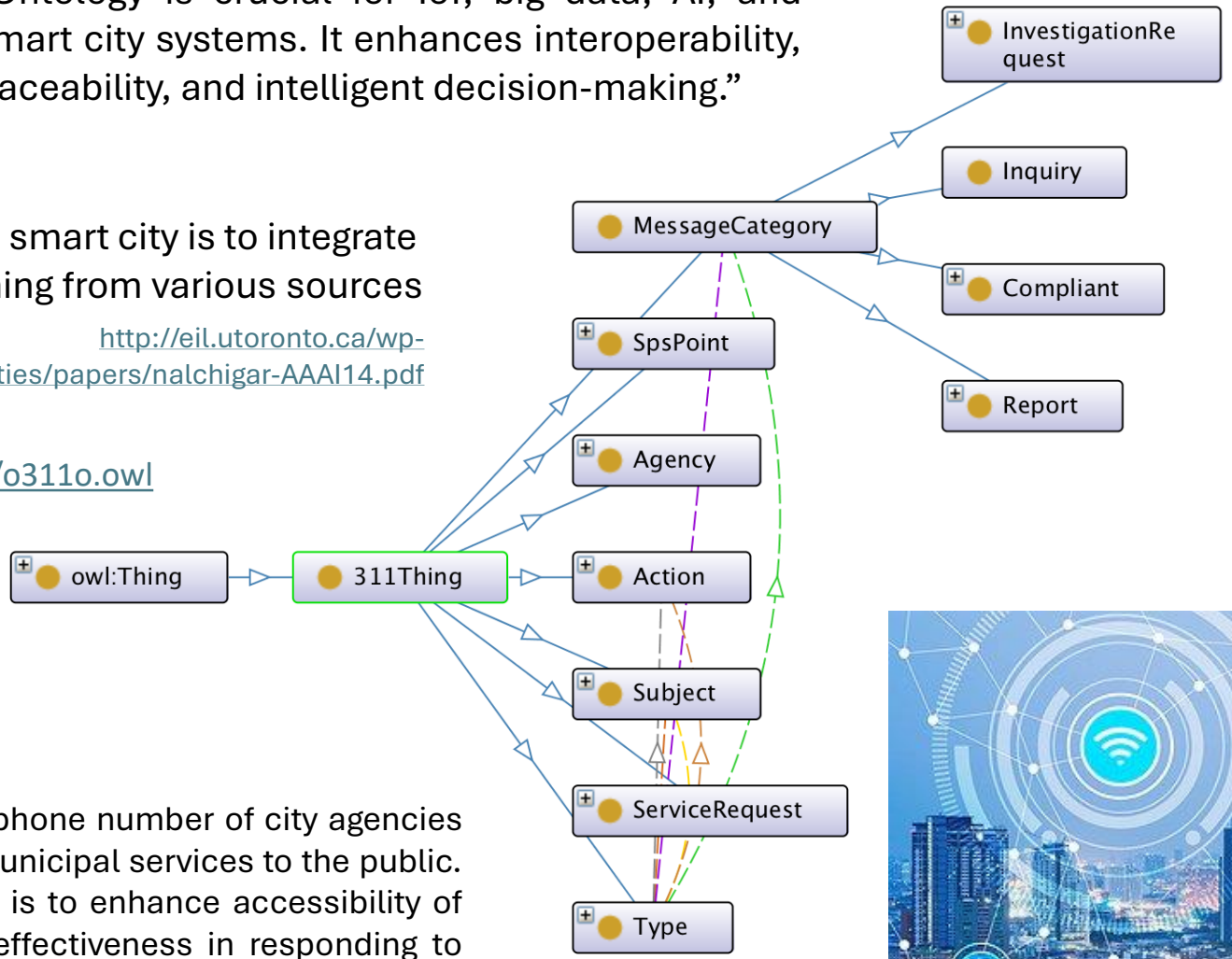
3. Examples: Smart City

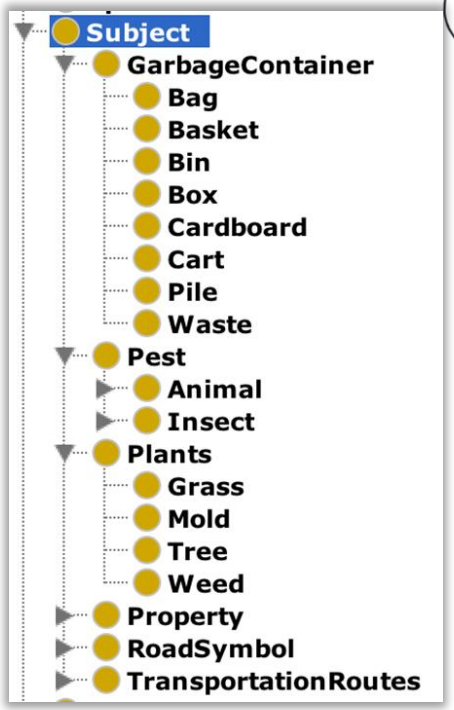
International Electrotechnical Commission

"Ontology is crucial for IoT, big data, AI, and smart city systems. It enhances interoperability, traceability, and intelligent decision-making."

"A fundamental aspect of a smart city is to integrate and combine the data coming from various sources and places" http://eil.utoronto.ca/wp-content/uploads/smartcities/papers/nalchigar-AAAI14.pdf

http://ontology.eil.utoronto.ca/o311o.owl





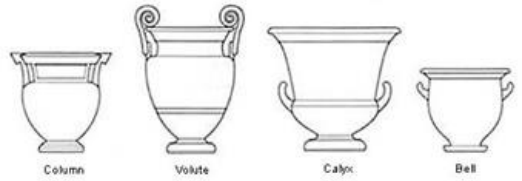
"311 is the name and the telephone number of city agencies that provide non-emergency municipal services to the public. The main goal of 311 systems is to enhance accessibility of city services, increase cities effectiveness in responding to public inquiries, and hence to improve city life."

3. Examples: Digital Humanities

http://o4dh.com/

Ontoterminologie

Ontology



<Vessel for mixing wine with water with open mouth with foot with handles>

"krater"@en
"cratère"@fr
designates

/with neck/
/without neck/

<Vessel for mixing wine with water with open mouth with foot with handles with neck>

<Vessel for mixing wine with water with open mouth with foot with handles without neck>

Definition in natural language

Large open container with a foot, used in ancient Greece for mixing wine with water.

Definition in formal language

<Vessel> +
/for mixing wine with water/ + /with open mouth/ + /with foot/ + /with hadnles/

Terminology

"column krater"@en
"cratère à colonnettes"@fr
designates

/with column-like handles/
/with volute-like handles/

"volute krater"@en
"cratère à vilutes"@fr
designates

<Vessel for mixing wine with water with open mouth with foot with hand with neck with column-like handles>

<Vessel for mixing wine with water with open mouth with foot with handles with neck with volute-like handles>

Definition in natural language

Krater with neck and with column-like handles.

Krater with neck and with volute-like handles.

"bell krater"@en
"cratère en cloche"@fr
designates

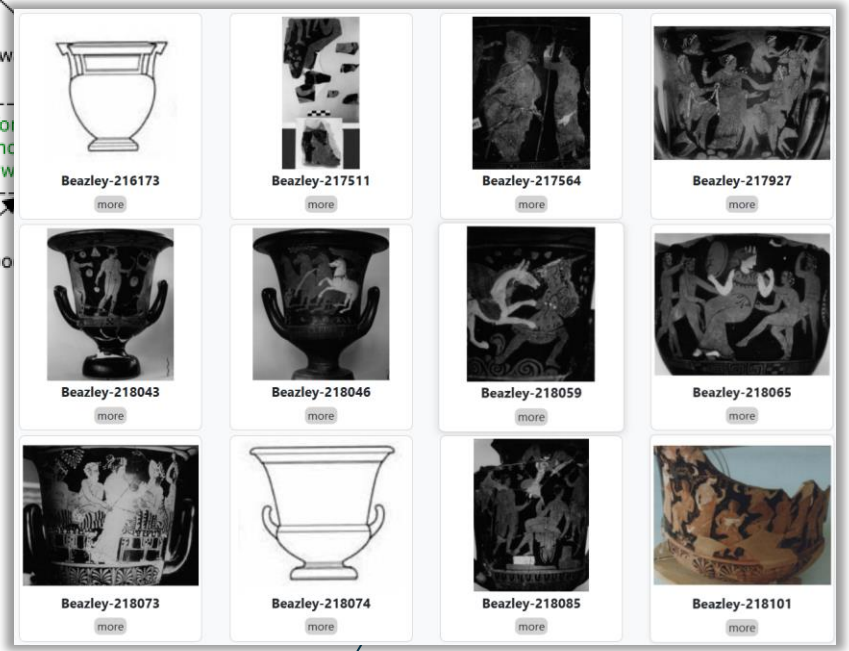
<Vessel for mixing wine with water with open mouth with foot with handles without neck with upward curling handles placed high on body>

Definition in natural language

Krater without neck, with upward curling handles placed high on the body.

Krater without neck, with upward curling handles placed low on the body.

Object Collection

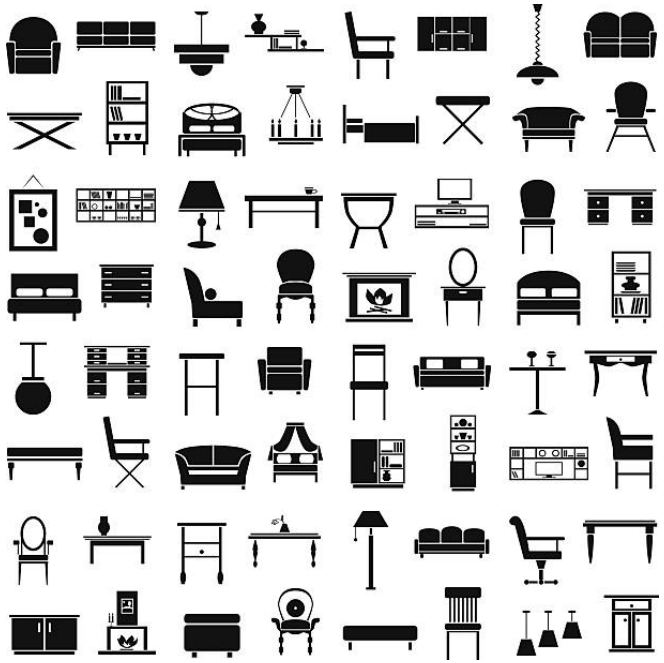


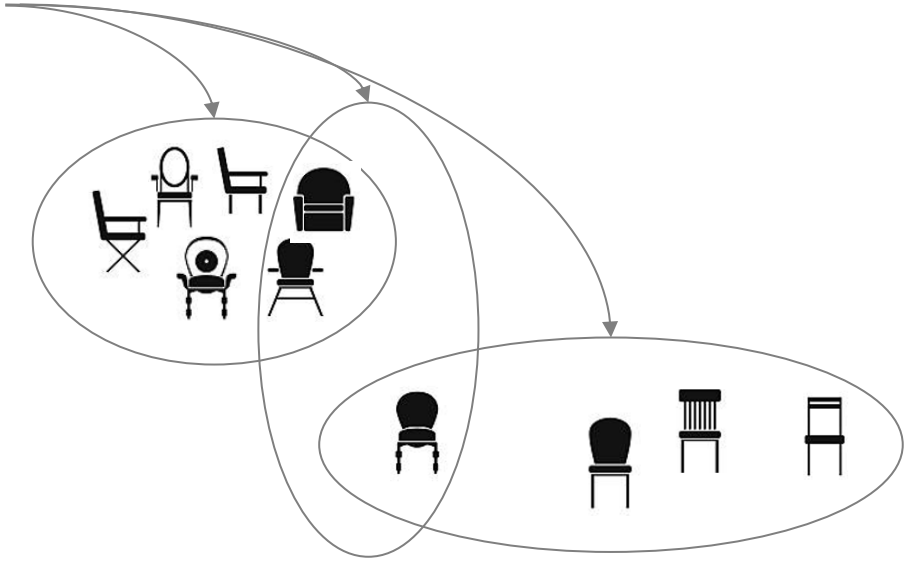
4. Theories of Concept

<u>Concept</u>: Unit of knowledge about…. a plurality of things

✓ **Understanding the "World"**

✓ **Organizing the objects**





….verifying a same property

4. Theories of Concept

■ Epistemological Principles

■ **« Nature » (essence) of thing**: as I *conceive* things

- **essential characteristic**

■ **« Description» of thing**: as I *perceive* things

- **descriptive characteristic (attribute)**
- **relation** between objects

4. Theories of Concept

■ **Knowledge about a plurality of things**

■ **Concept**: unique combination of essential characteristics

<Chair> ::= /for one person/ + /with feet/ + /with back/ + /without arms/

■ **Class**: set of objects verifying a same property

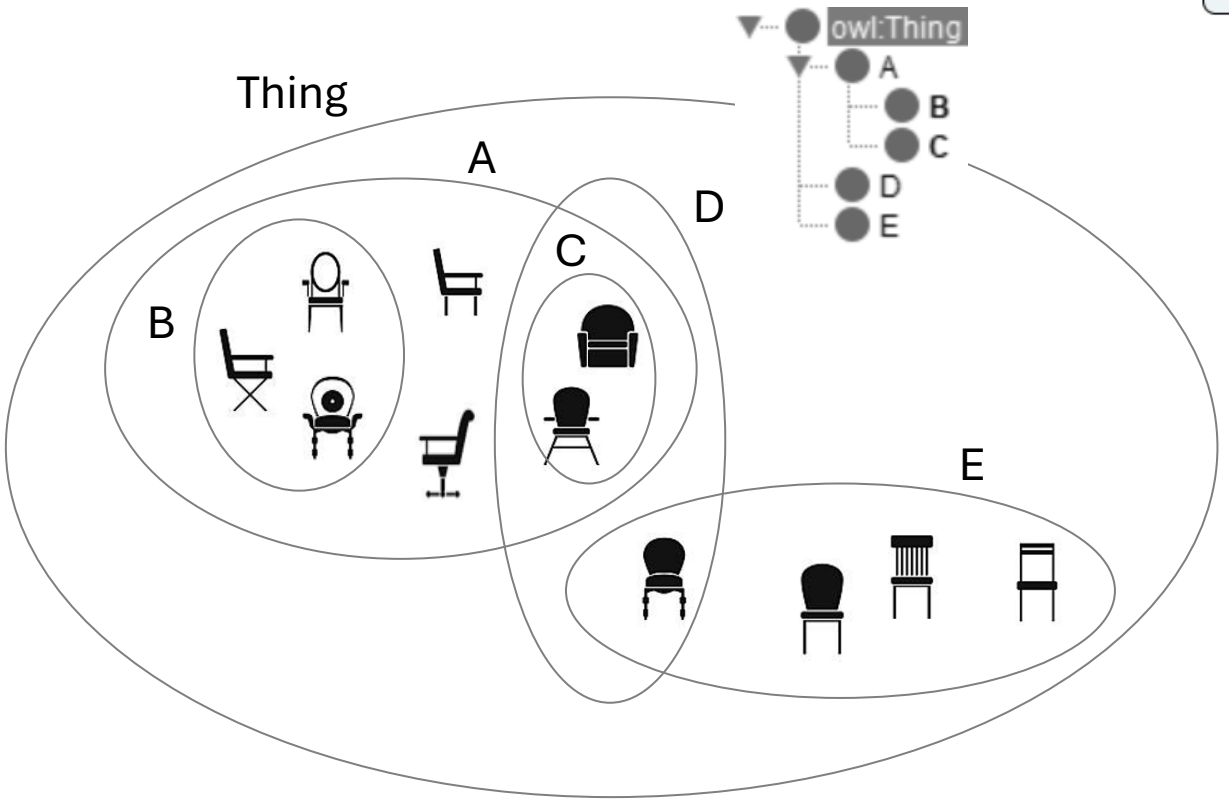
Parisian ::= { x / Person(x) Λ livesIn (x, Paris) }

Things can be defined not according to their "nature" but through their relationships

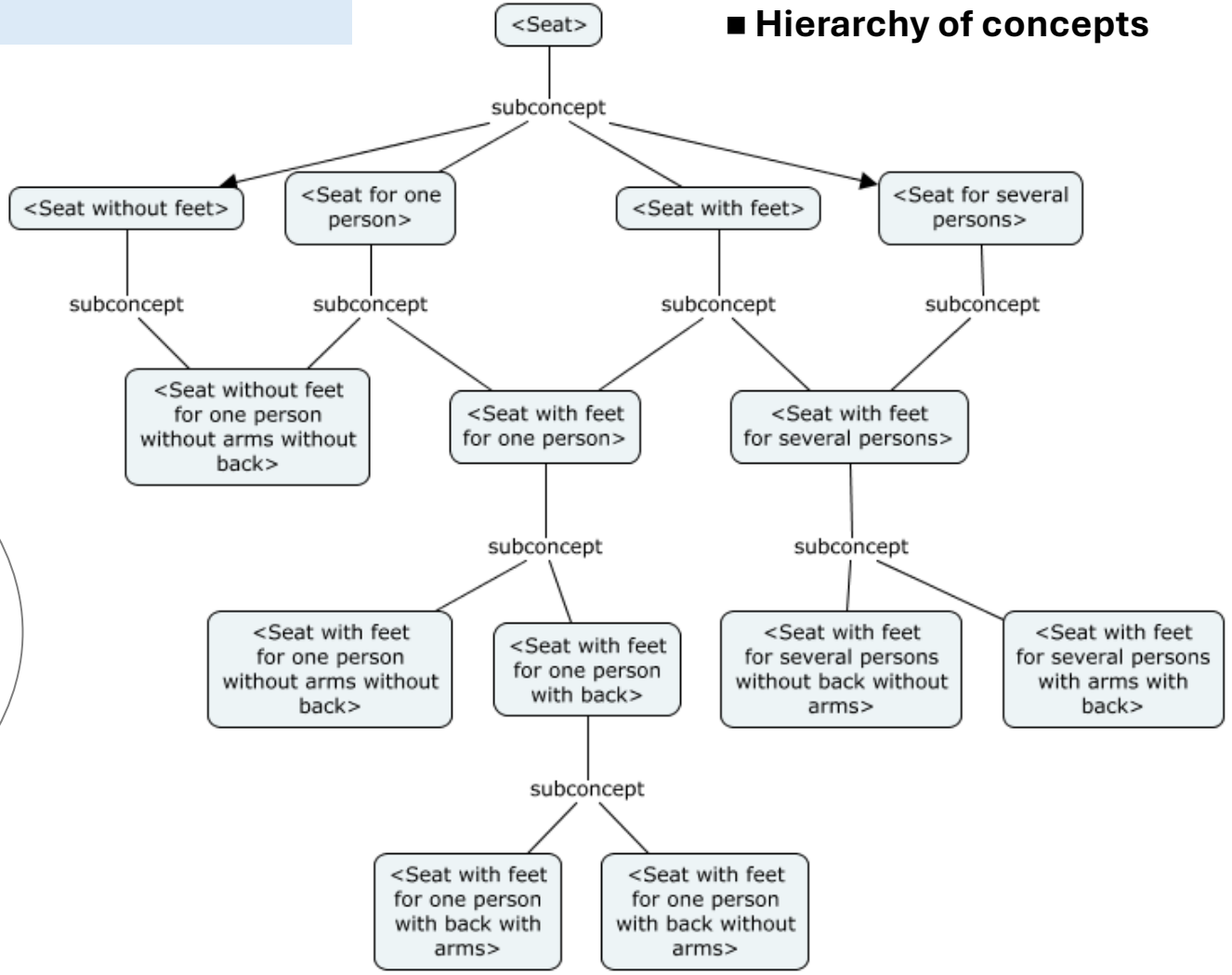
4. Theories of Concept

An ontology is a network of concepts or classes structured in a system according to their relations (hierarchical, associative)

■ **Hierarchy of classes**



■ **Hierarchy of concepts**



5. Representation Languages

- **The expression of knowledge is limited to the well-formed formulas of the formal language**

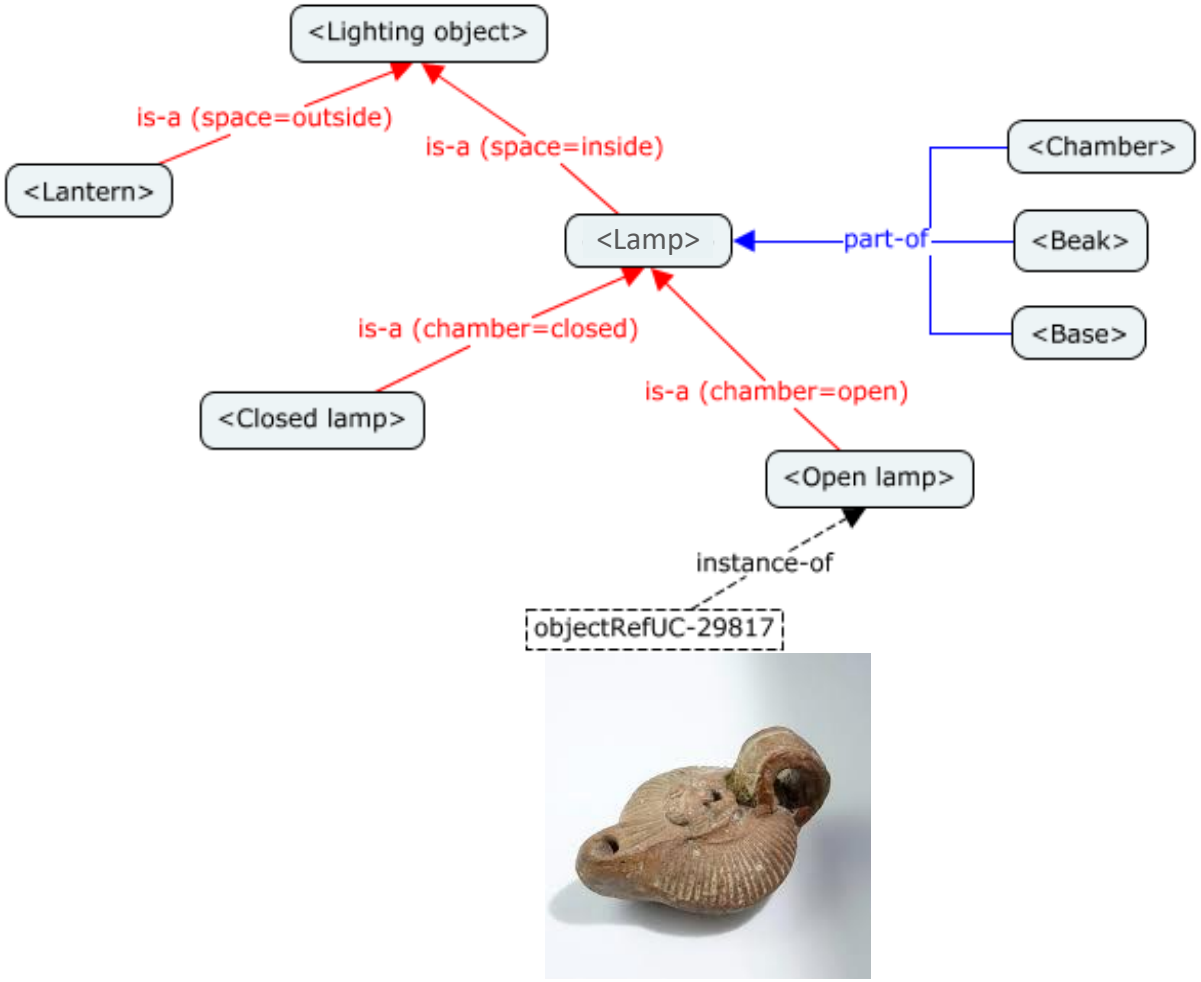
- **The formal languages are not equivalent**

The Sapir-Whorf's hypothesis is true for all languages

- ✓ Domain of application
- ✓ Power of expression (categories of thought supported by the categories of the language)
- ✓ Logical Properties
- ✓ Operationalization

5. Representation Languages: Graphical Languages

- ✓ **Easy to use**
- ✓ **Human Readable**
- ✓ **Semi-Formal**



- **Categories of language?**
- **Methodology?**
- **Consistency?**
- **Operationalization?**

5. Representation Languages: AI Languages

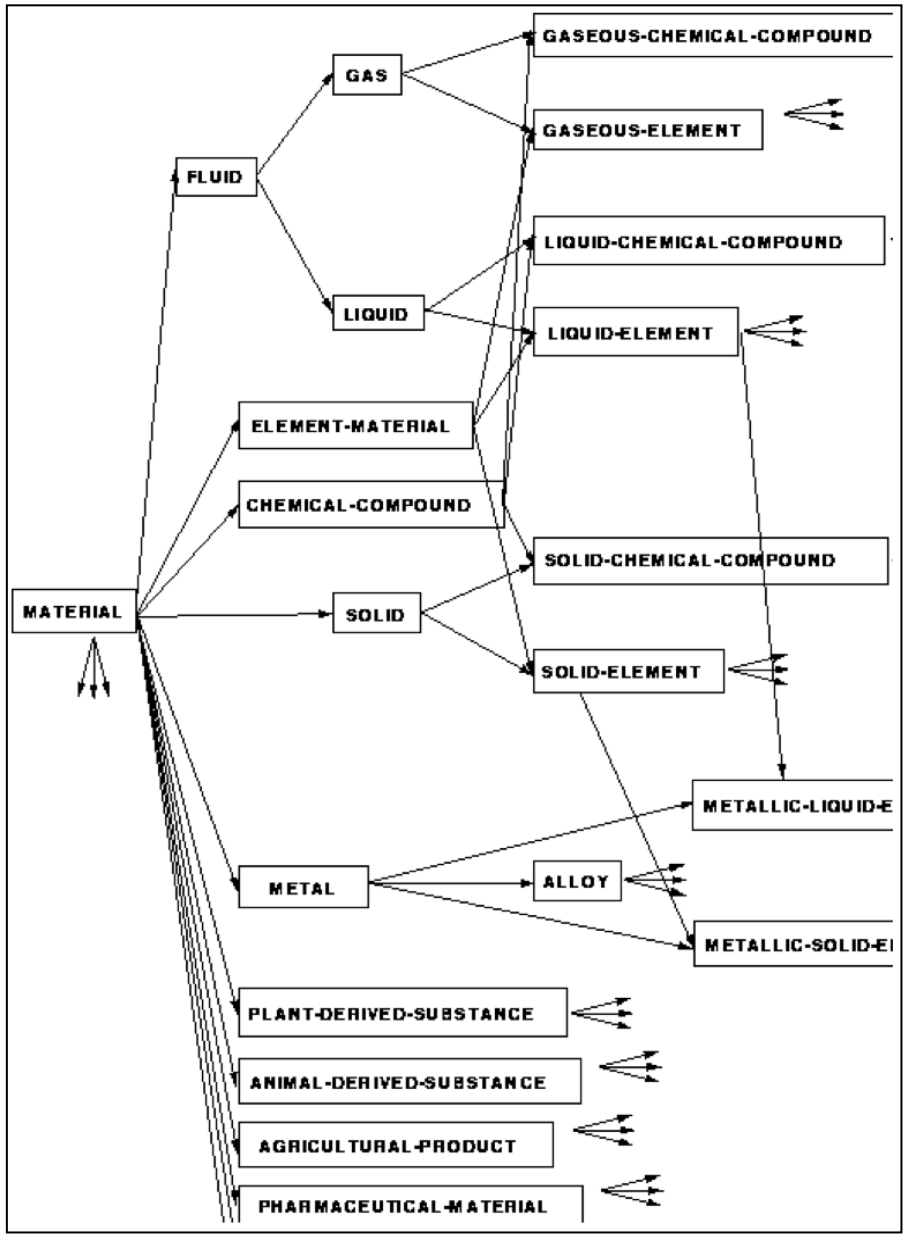
Schema (Frame) - Minsky

Define the **object structure**

A **class** is defined as a set of **slots** with **values**

```
(defun-class lamp
      (is-a ‘lighting-object)
      (space ‘inside)
      (has-part ‘chamber ‘beak ‘base))
```

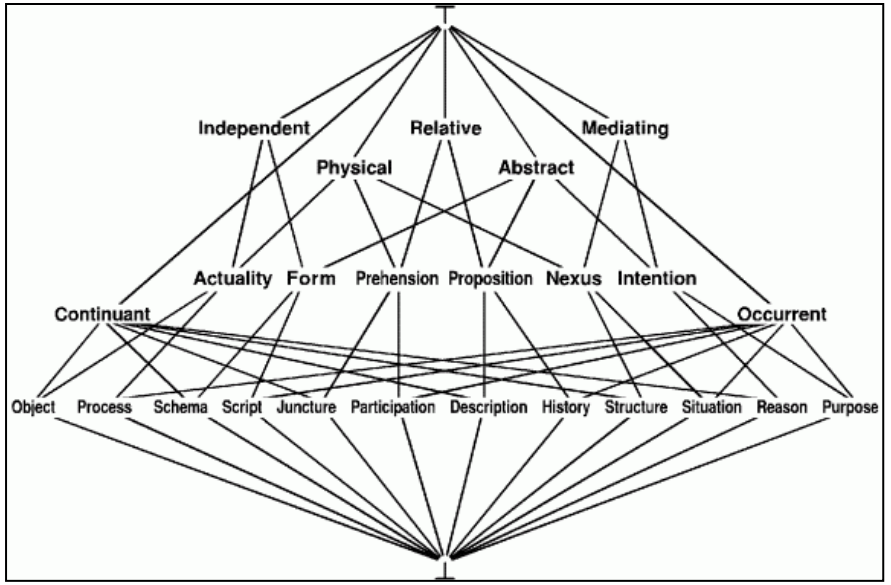
Clear, powerful, readable both by human and computer



5. Representation Languages: Logical Languages

Syntax and Semantics:

- ✓ Clear
- ✓ Precise
- ✓ Formally specified



A concept (category) is an unary predicate.

Form(x) ::= Independant(x) $\wedge$ Abstract(x)

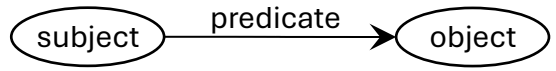
➡ **Properties of Axiomatic System**

Definitions are:

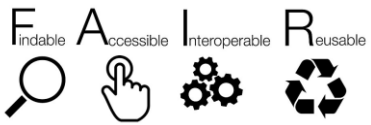
- Objective
- Coherent
- Precise
- Consensual
- Reusable
- Sharable
- Readable (for an expert)

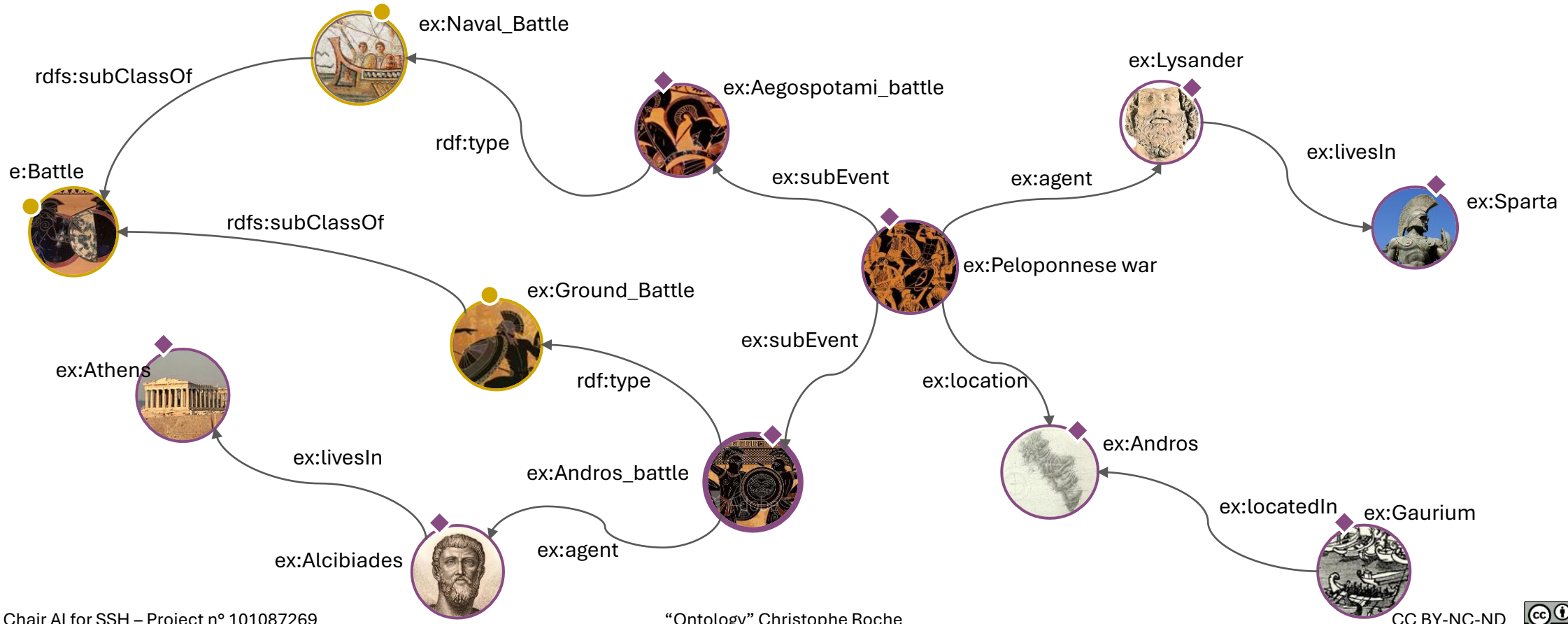
5. Representation Languages: W3C Languages

RDF is a standard for representing and exchanging data on the Web.



OWL is a Semantic Web language designed to represent rich and complex knowledge about things, groups of things, and relations between things. OWL is a computational logic-based language such that knowledge expressed in OWL can be exploited by computer programs, e.g., to verify the consistency of that knowledge or to make implicit knowledge explicit.

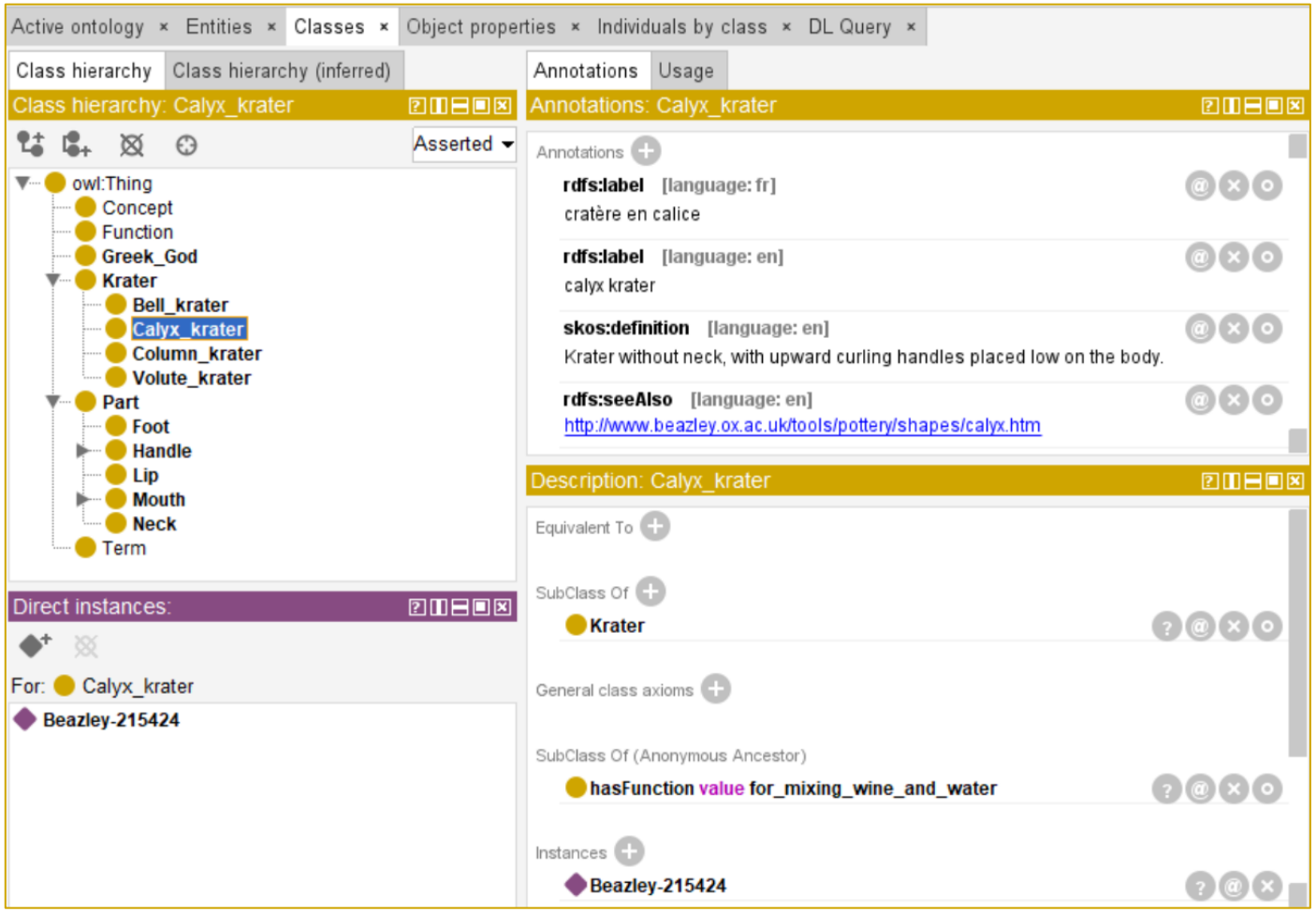




6. Environments: Protégé

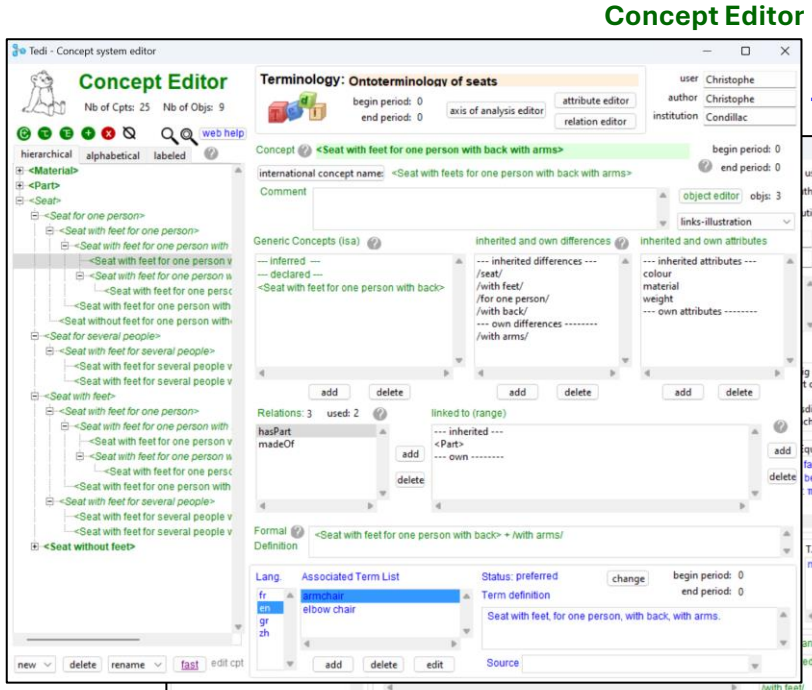
https://protege.stanford.edu/

- ✓ Free environment
- ✓ Large Community
- ✓ Definition based on relations between objects (Class)
- ✓ Description Logic Reasoners
- ✓ W3C Standards compliant



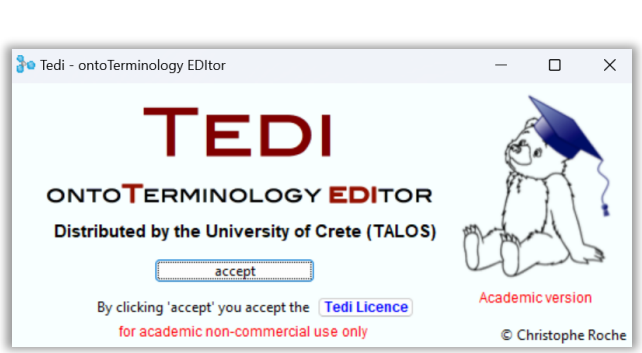
- How to represent essential characteristics (Concept)?
- How to represent the linguistic dimension?
- How to take into account the way of thinking of Experts?

6. Environments: Tedi



Term Editor

Virtual Exhibition

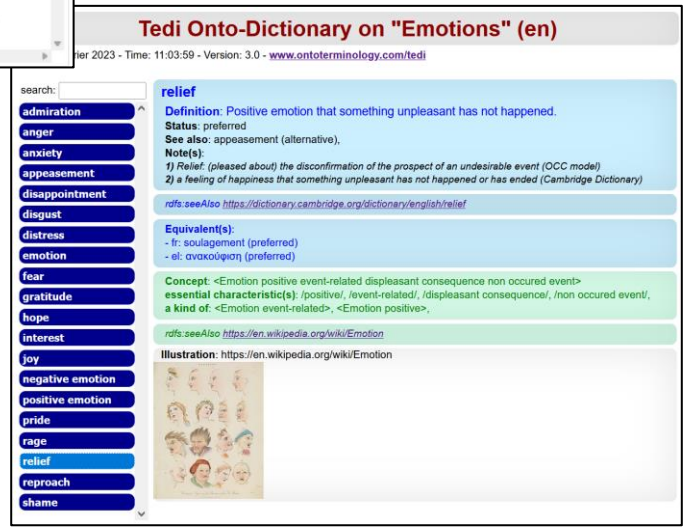


XML

TBX

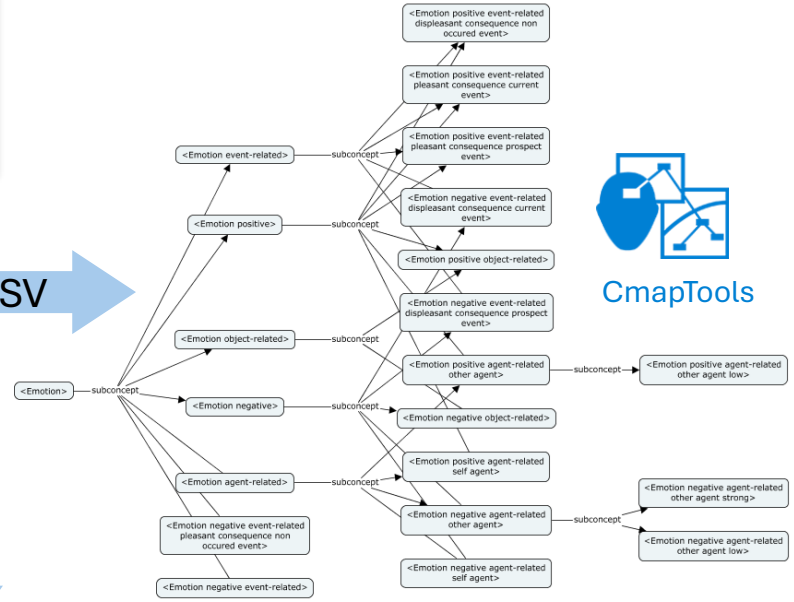
HTML

E-Multilingual Dictionary



RDF

CSV



CmapTools

RDF, OWL, SKOS, OntoLex-Lemon, OTV

```
<?xml version="1.0" encoding="utf-8"?>
<!-- Ontoterminology: Emotions -->
<!-- Author: Christophe Roche -->
<!-- Creation date: 12 février 2023 -->
<!-- Export date: 7 octobre 2024 time: 18:38:03 -->
<!-- TEDI version: 3.7 -->
<!-- http://ontoterminology.com/tedi -->
<rdf:RDF xmlns="http://www.ontologia.fr/OTB/Emotions#"
    xml:base="http://www.ontologia.fr/OTB/Emotions"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:skos="http://www.w3.org/2004/02/skos/core#"
    xmlns:foaf="http://xmlns.com/foaf/0.1/"
    xmlns:dc="http://purl.org/dc/elements/1.1/"
    xmlns:xml="http://www.w3.org/XML/1998/namespace"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
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    xmlns:ontolex="http://www.w3.org/ns/lemon/ontolex#">
```

SPARQL

Protégé