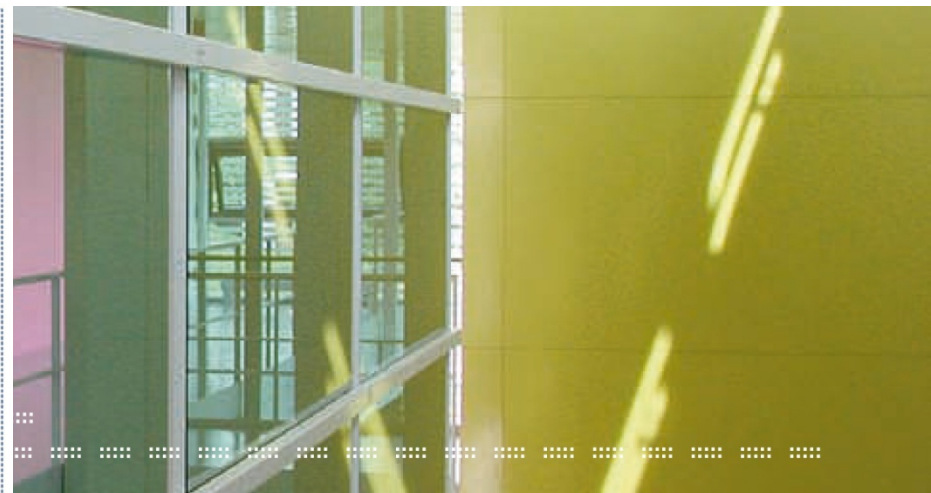
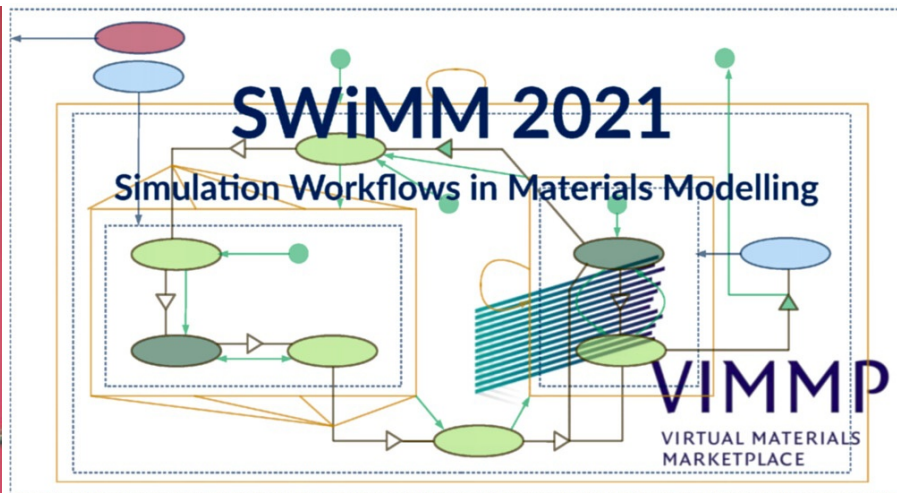


Semantic interoperability and ontology-driven technology for simulation workflows

Silvia Chiacchiera and Martin Thomas Horsch



The meaning of ... coffee

An Italian bar in Germany:

- Silvia: "Un caffè macchiato, per favore." [A *caffè macchiato*, please.]
- Barman: "Un caffè macchiato... che significa?" [A *caffè macchiato*... what does it mean?]



The meaning of ... coffee

An Italian bar in Germany:

- Silvia: “Un caffè macchiato, per favore.” [A *caffè macchiato*, please.]
- Barman: “Un caffè macchiato... che significa?” [A *caffè macchiato*... what does it mean?]

What is happening?

The barman needs a clarification, namely: which meaning do we refer to, the Italian one (as language suggests) or the German one (as the location suggests)? They differ, notably in the average size of the cup and drink.



The meaning of ... coffee

An Italian bar in Germany:

- Silvia: “Un caffè macchiato, per favore.” [A *caffè macchiato*, please.]
- Barman: “Un caffè macchiato... che significa?” [A *caffè macchiato*... what does it mean?]

Let's analyse this further:

- 1) The two subjects speak the same language (Italian)
- 2) A disambiguation is needed (to agree which convention is being followed)
- 3) They are in a bar: the first sentence implies a trading interaction between the speakers (e.g., this wouldn't be the case in a friend's place)

These correspond to: 1) [syntactics](#), 2) [semantics](#) and 3) [pragmatics](#) (see next).

The meaning of ... coffee

An Italian bar in Germany:

- Silvia: “Un caffè macchiato, per favore.” [A *caffè macchiato*, please.]
- Barman: “Un caffè macchiato... che significa?” [A *caffè macchiato*... what does it mean?]

From Merriam-Webster (following [Charles Morris](#)):

- 1) **Syntactics**: “a branch of semiotics that deals with the **formal relations between signs or expressions** in abstraction from their signification and their interpreters.”
- 2) **Semantics**: “the study of **meanings**; a branch of semiotics dealing with the **relations between signs and what they refer to (...)**.”
- 3) **Pragmatics**: “a branch of semiotics that deals with the **relation between signs** or linguistic expressions **and their users**; a branch of linguistics [the study of human speech] that is concerned with the relationship of sentences to the **environment** in which they occur.”

According to [Morris](#), these are the three branches of **semiotics**: “a general philosophical **theory of signs and symbols** that deals especially with their function **in both artificially constructed and natural languages.**”

The meaning of ... data

Now: how does this picture look in the context of **data**?

Let's imagine we receive a file "sigma.dat" (on the right).

```
# Model 1
# A      sigma      sigma_err
40.0    1.17745    0.167
60.0    3.03579    0.3592
80.0    3.62384    0.3797
100.0   4.30474    0.3719
```

```
# Model 2
# A      sigma      sigma_err
40.0    1.25022    0.1238
60.0    2.75247    0.2723
80.0    4.05209    0.2691
100.0   4.05401    0.2726
```

1) Syntax/syntactics:

formal relations between signs



The file format (ASCII text file).

2) Semantics:

meaning, relations between signs and what they refer to



Info about the content: e.g., what each column and block means, the data provenance, etc.

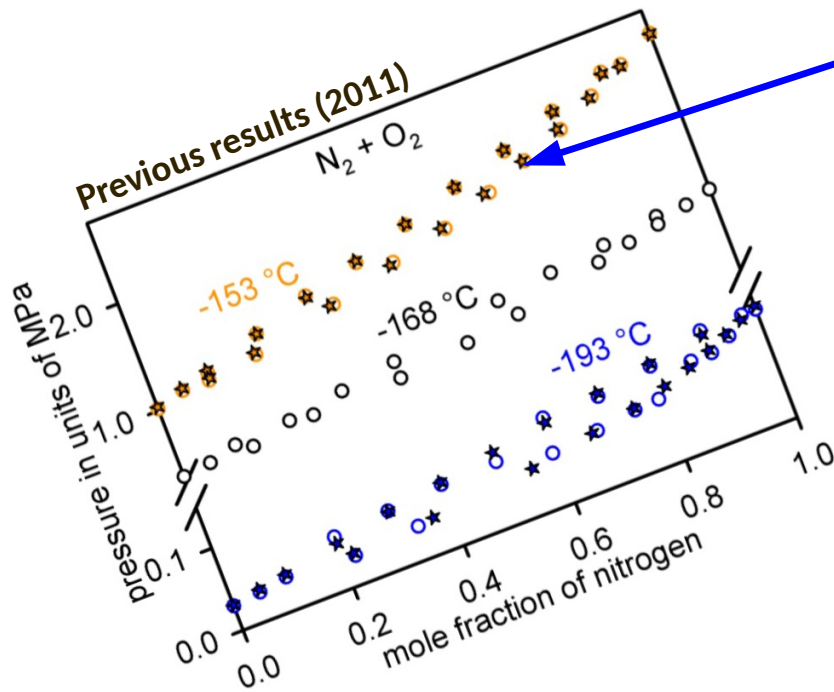
3) Pragmatics:

relation between signs and their users/environment



E.g.: we type "rm sigma.dat" in a terminal. Depending on our rights on the file, it will be removed or not.

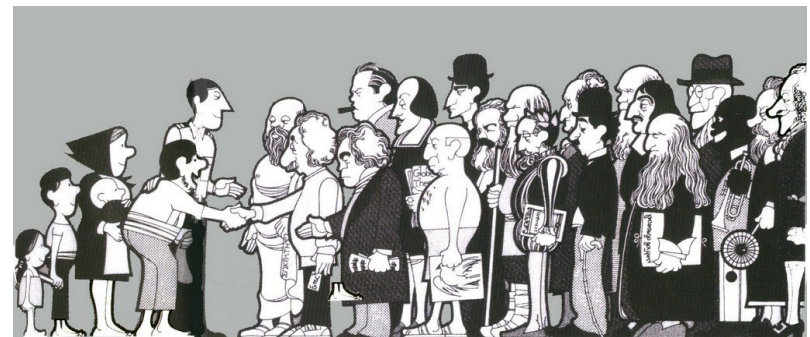
Why do we need semantic technology?



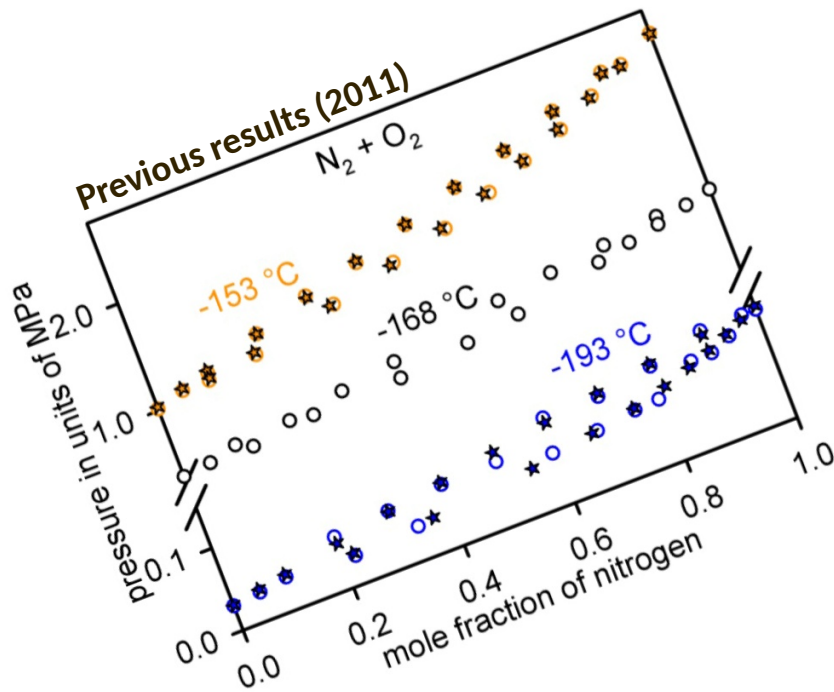
What values did x and p have?

How was the data point obtained?

What is the margin of error, how was the error defined, and what software (or experimental setup) was used?



Why do we need semantic technology?



What values did x and p have?

How was the data point obtained?

What is the margin of error, how was the error defined, and what software (or experimental setup) was used?

competency
questions



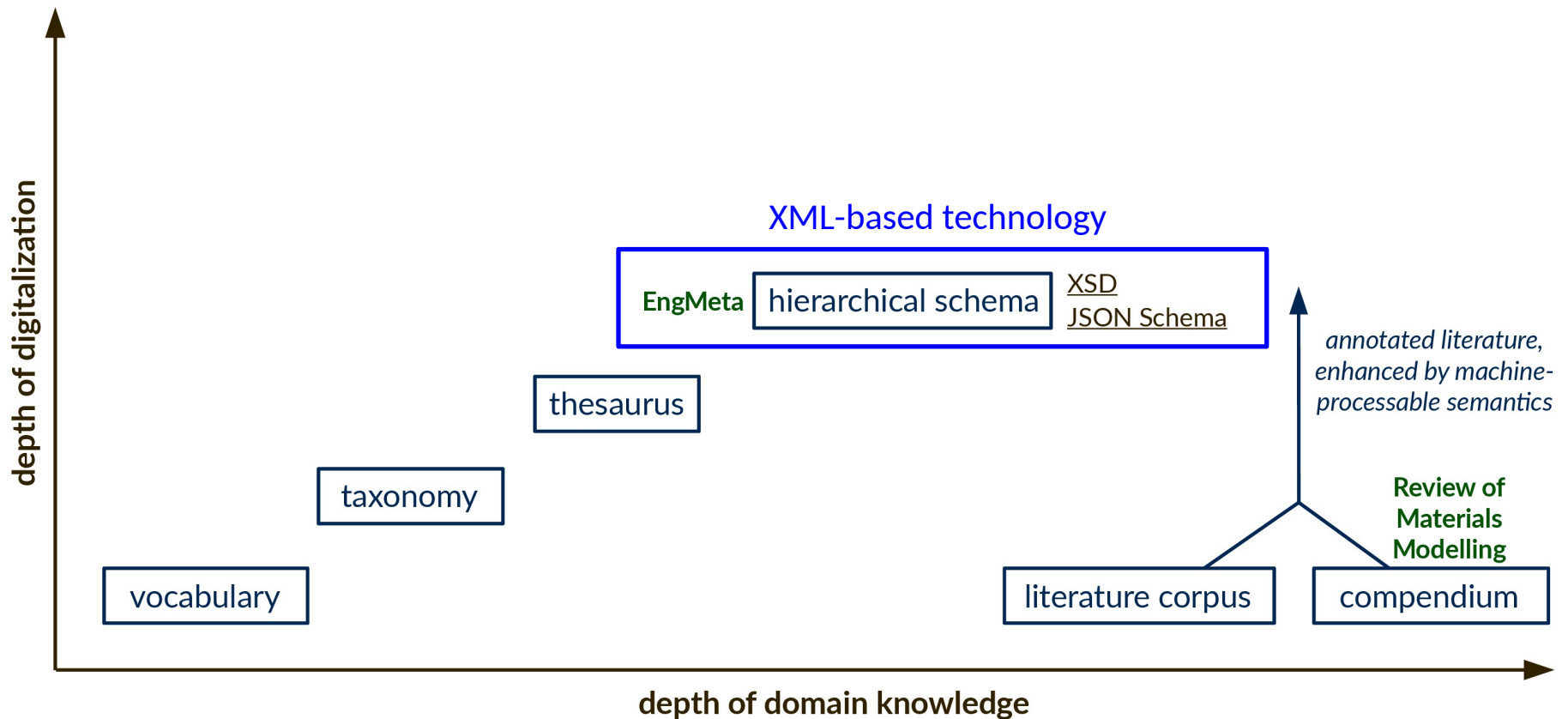
*"I remember.
Haha, joke. Of course I don't."*

Good practice in managing research data:

Make all data findable, accessible, interoperable, and reusable (FAIR).

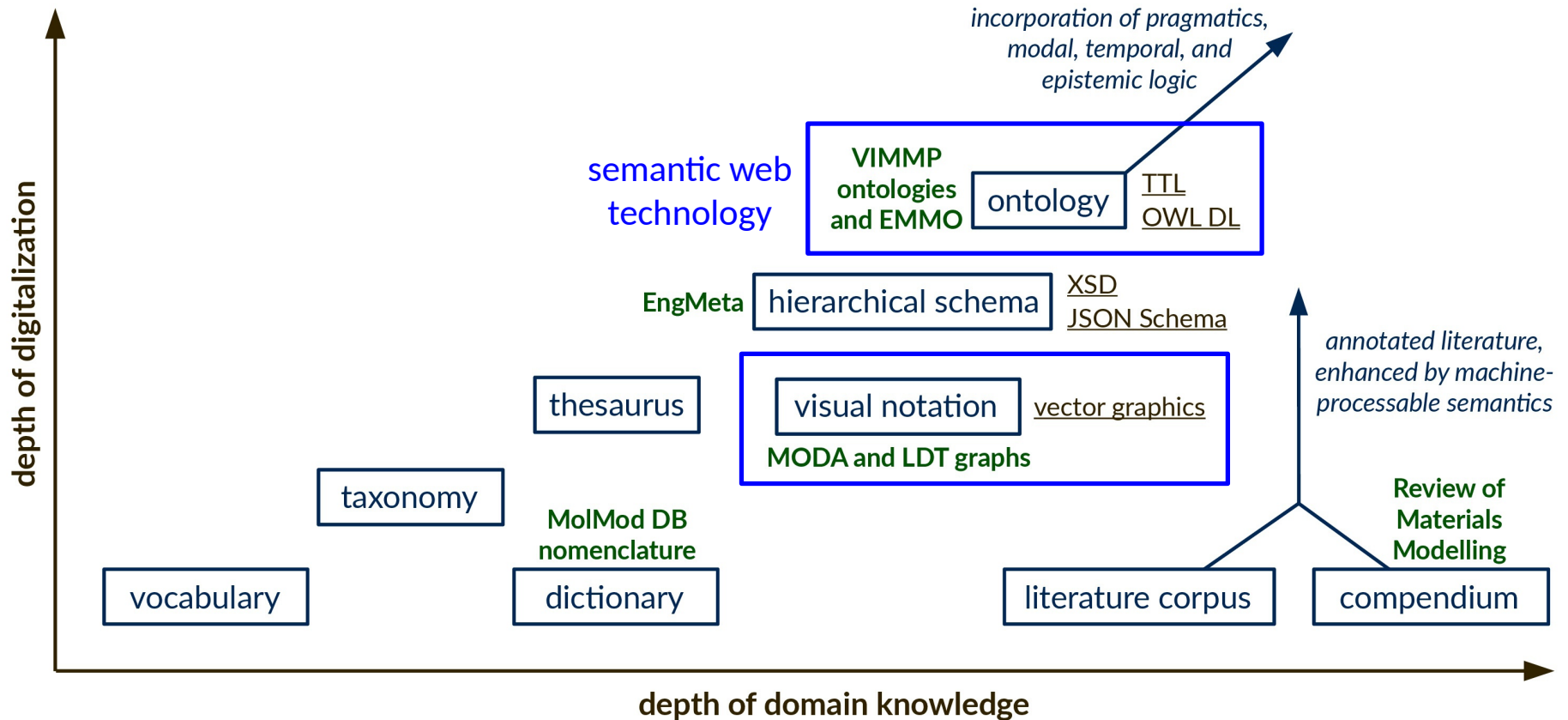
Metadata standardization

Hierarchy of semantic assets



Metadata standardization

Hierarchy of semantic assets



Ontologies (in a nutshell)

What are they?

In philosophy, Ontology is the “science of what is”.

In information science, an ontology is a **formal (machine-readable) representation of knowledge within a certain domain**. It identifies the **categories (“classes”)** that exist in the domain and the **relations between them**.

Why are they useful?

Ontologies allow 1) **automatic reasoning**, 2) **easier exchange of information** across heterogeneous sources.

What is the bigger picture?

The context is that of **semantic technologies** and **semantic interoperability**. Notably, the Semantic Web concept, an evolution of the World Wide Web that is based on semantics rather than ad-hoc links between resources (e.g., web-pages) was proposed in the 1990s.

Ontologies (in a nutshell)

| | | |
|---------|----------------|------------------------------|
| subject | a | class_of_subject; |
| | has_property | first_object, second_object; |
| | other_property | another_object. |

TTL format applied to OWL



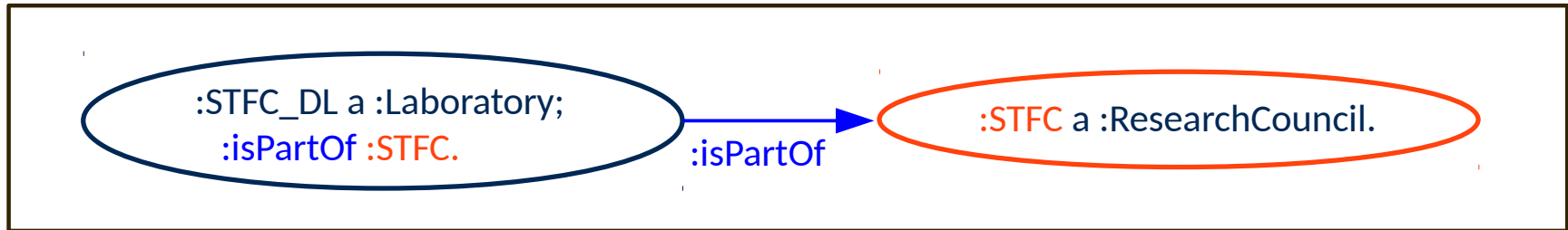
Example

```
osmo:logical_access a owl:Class;
  rdfs:subClassOf evmpo:annotation;
  owl:disjointWith osmo:section_aspect;
  owl:disjointUnionOf
    (osmo:logical_read_access osmo:logical_write_access);
  rdfs:comment "connection from a section to a logical resource".

osmo:has_access_point a owl:ObjectProperty;
  rdfs:domain osmo:logical_access;
  rdfs:range osmo:section;
  rdfs:subPropertyOf viprs:satisfies_requirement_of.

osmo:has_resource a owl:ObjectProperty;
  rdfs:domain osmo:logical_access;
  rdfs:range osmo:logical_resource.
```

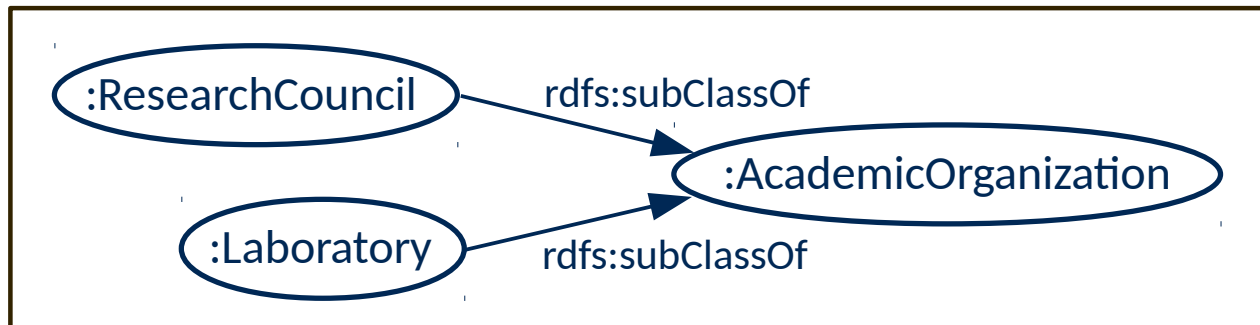
Ontologies (in a nutshell)



Knowledge graph; also: Scenario or assertional box (ABox)



RDF triple, consisting of subject, predicate, and object

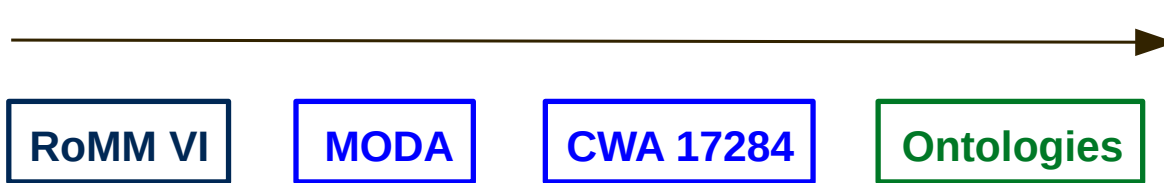


Taxonomy, part of
the ontology

also: TBox
(terminological box)

Ontology development in materials modelling

Community-governed development of metadata standards

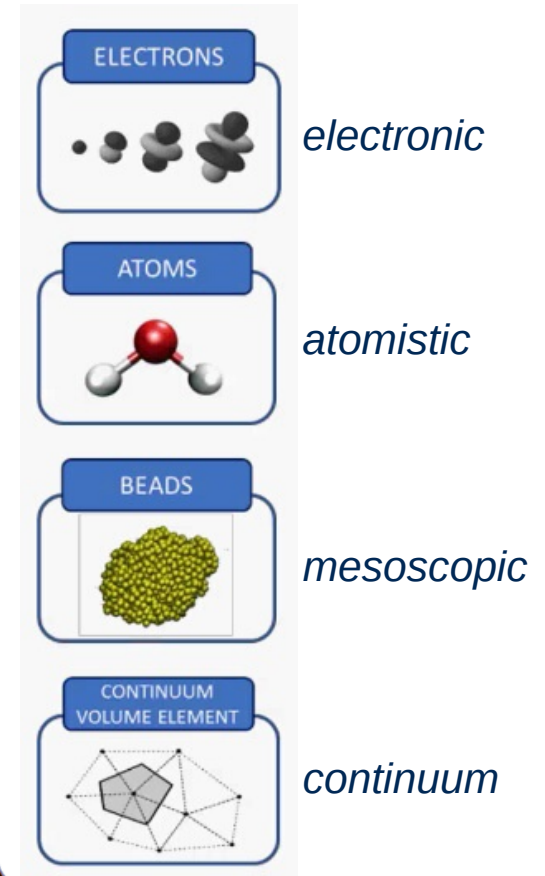
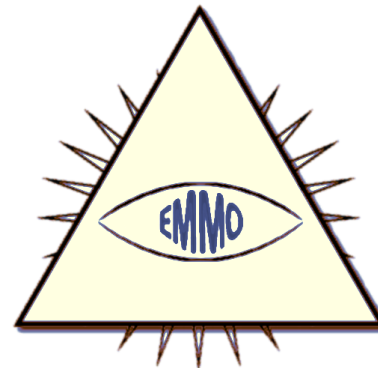
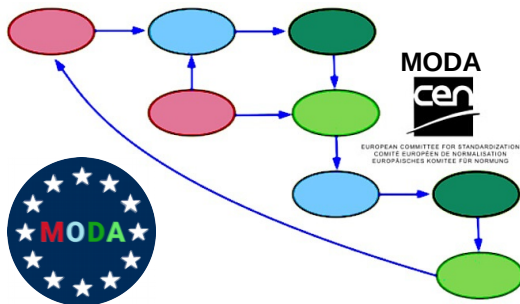


Review of Materials Modelling (compendium)

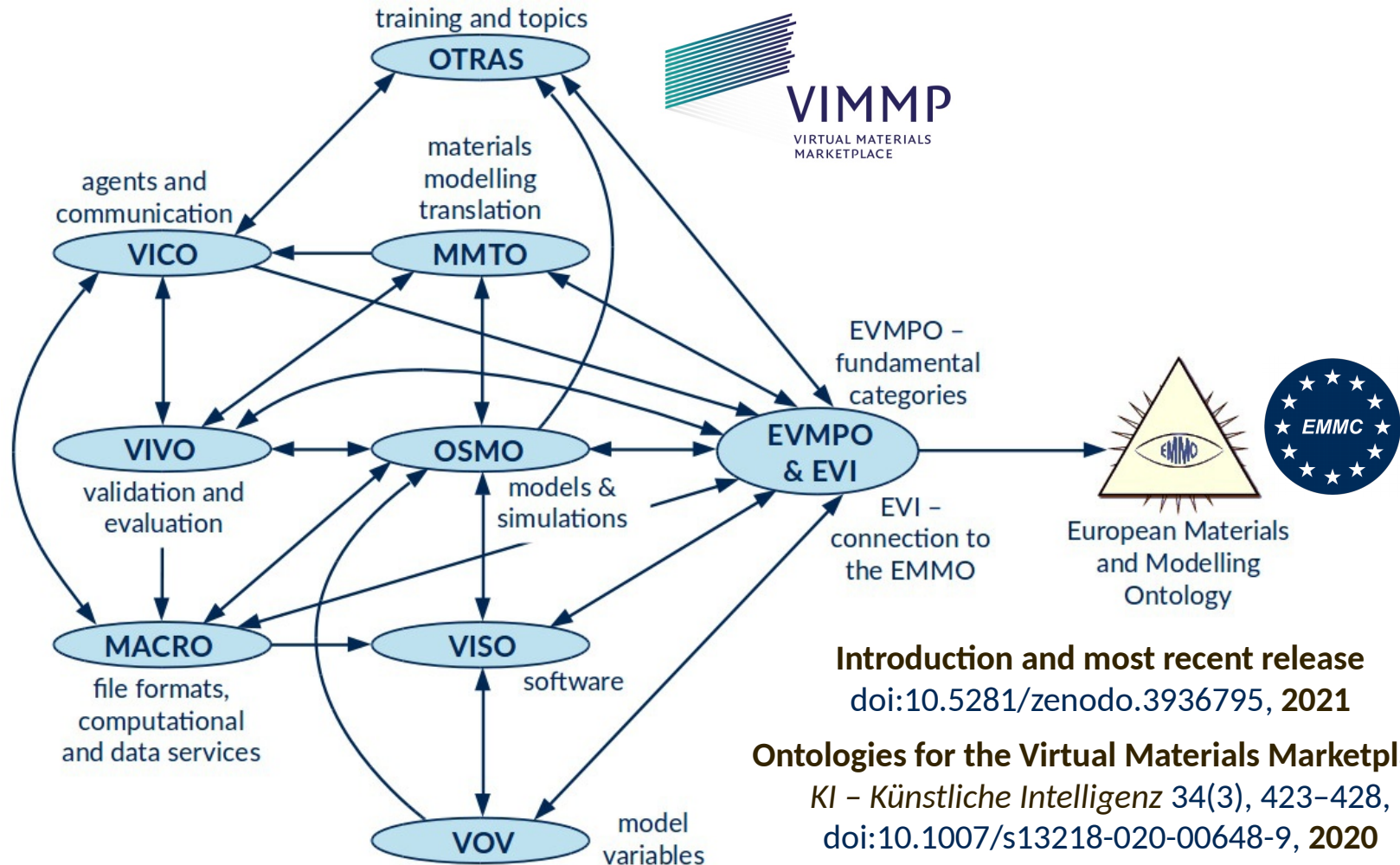
MODA ("Model Data")

CEN workshop agreement

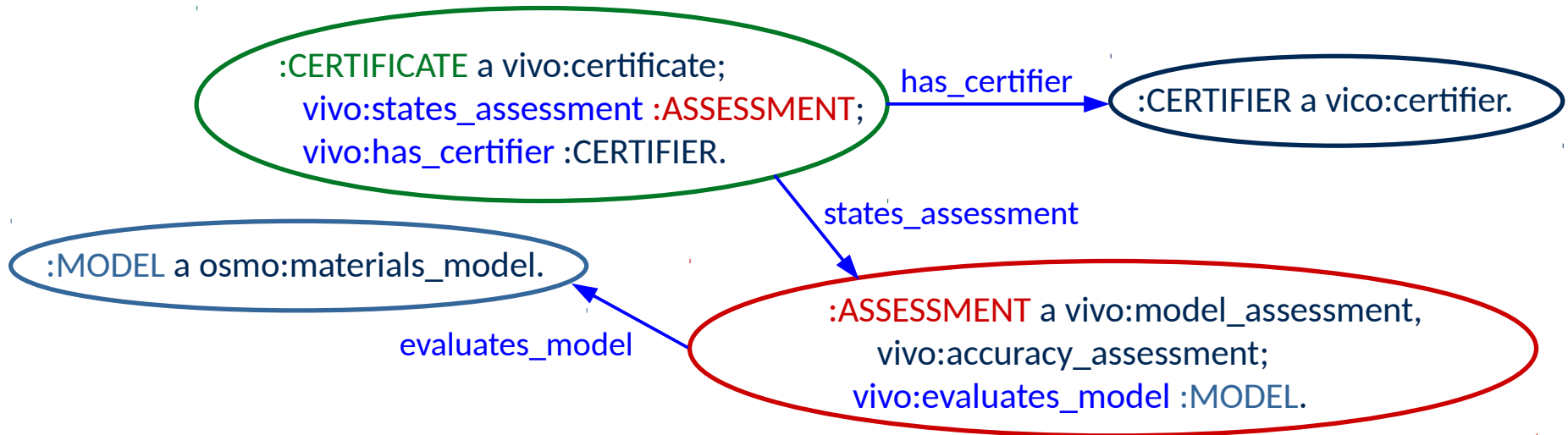
Domain ontologies EMMO top-level ontology



Ontology development in materials modelling

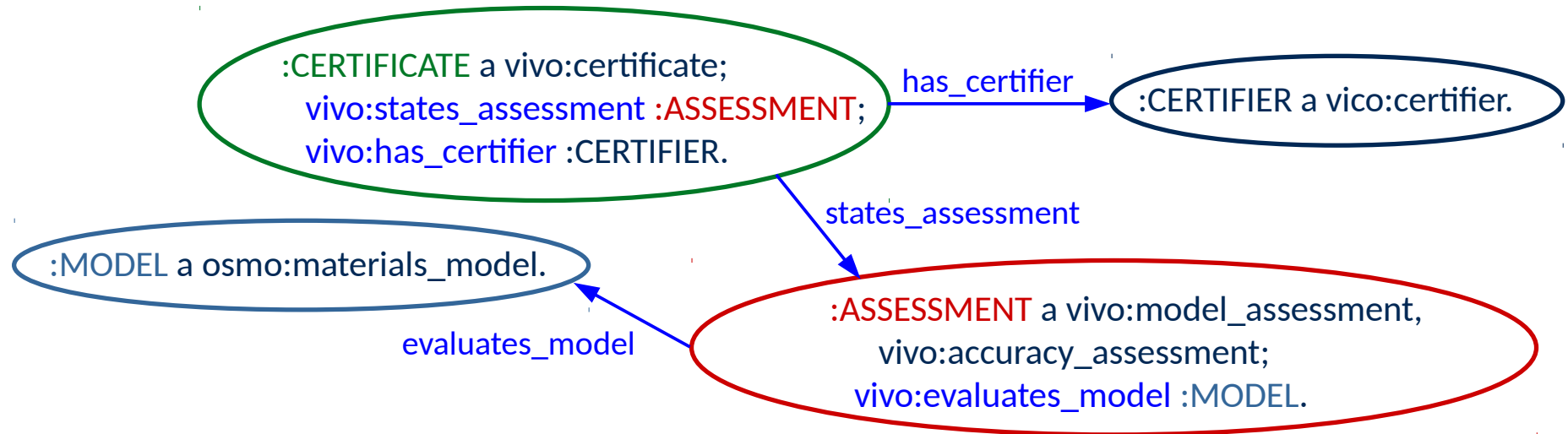


Knowledge graphs



The certifier :CERTIFIER has issued a certificate (the IRI of which is :CERTIFICATE) stating a model accuracy assessment (the IRI of which is :ASSESSMENT) that evaluates the materials model :MODEL.

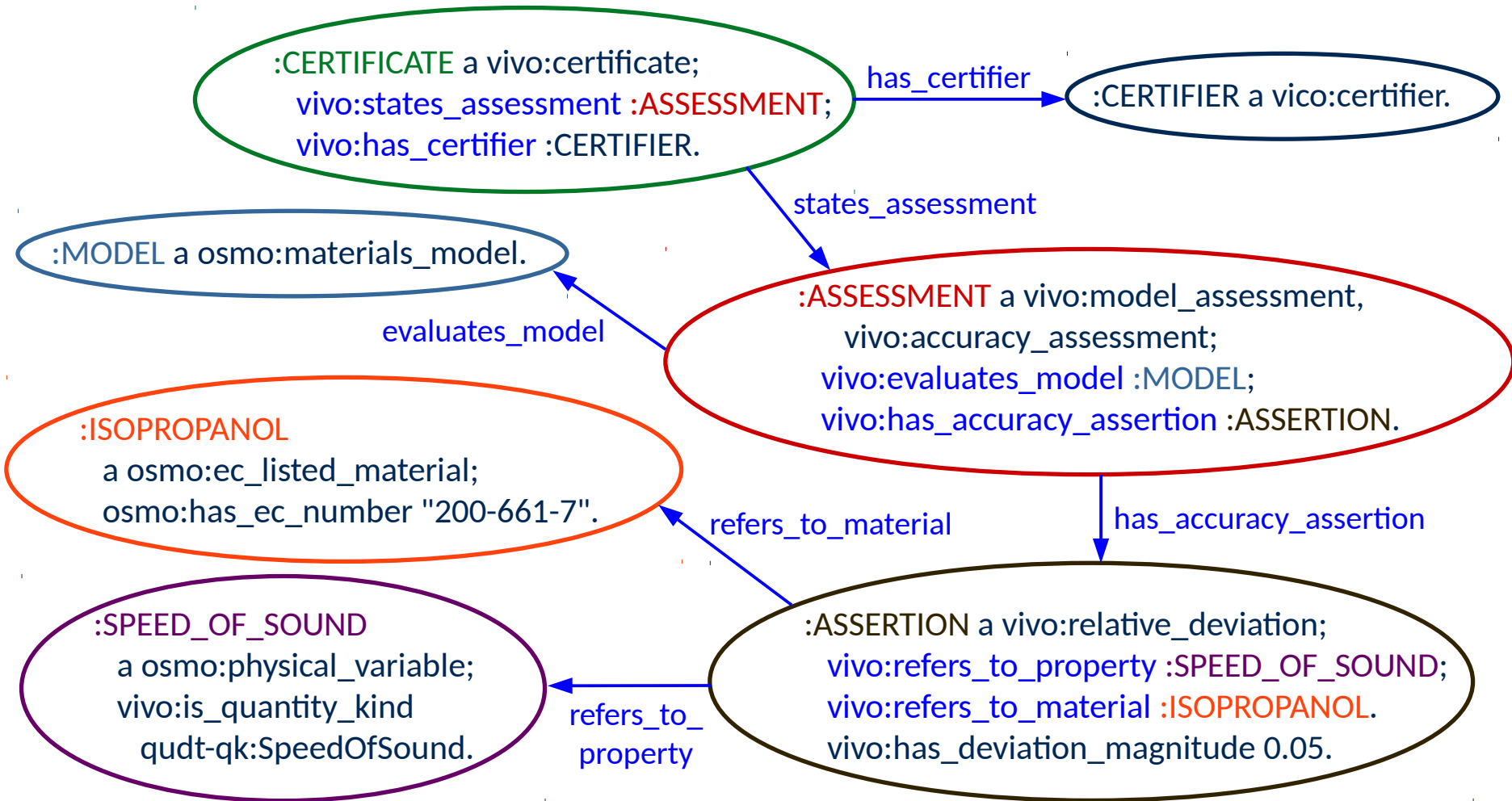
Knowledge graphs



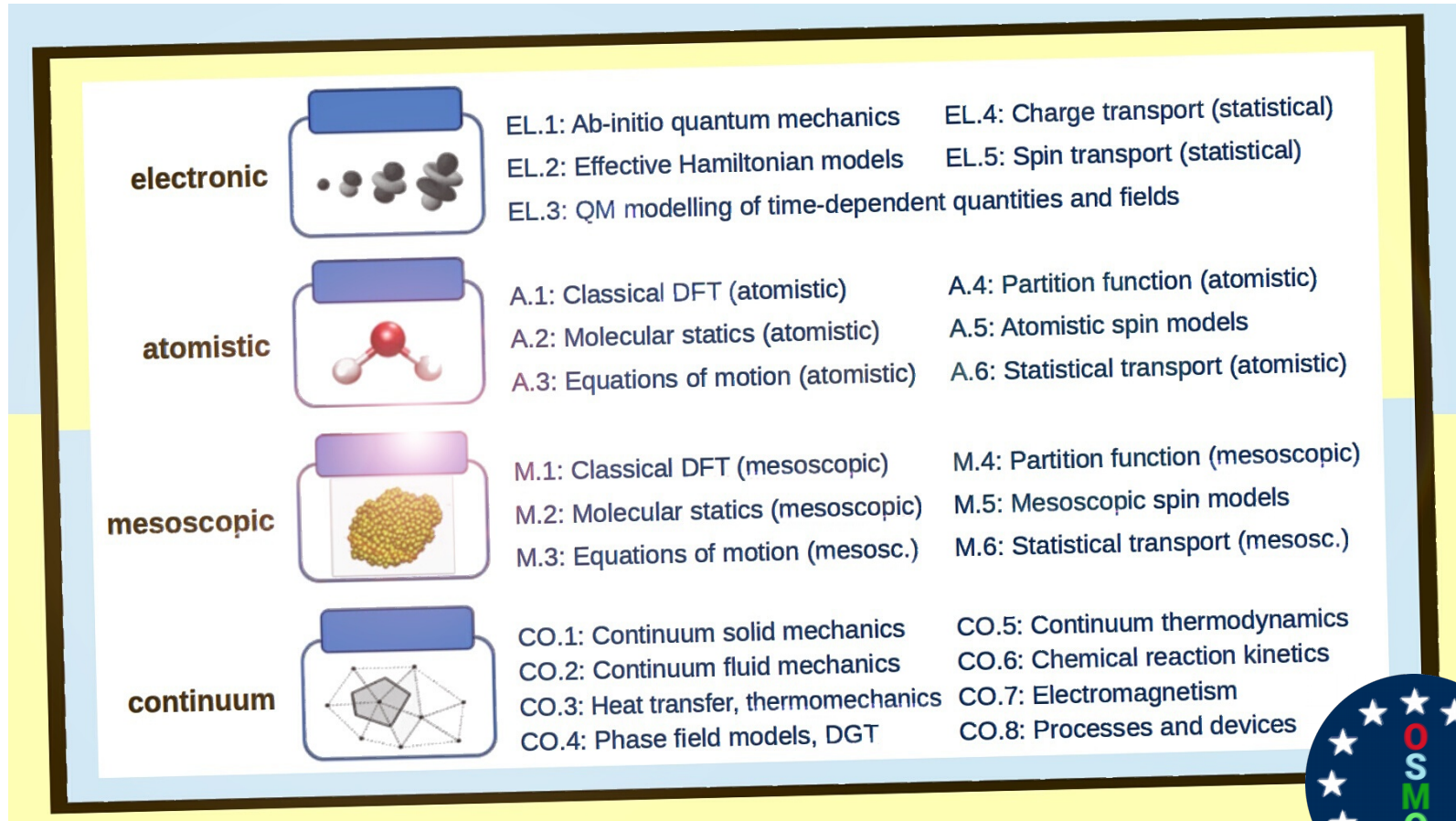
The certifier **:CERTIFIER** has issued a certificate (the IRI of which is **:CERTIFICATE**) stating a model accuracy assessment (the IRI of which is **:ASSESSMENT**) that evaluates the materials model **:MODEL**.

In the model accuracy assessment **:ASSESSMENT**, it is asserted that the materials model **:MODEL** has a relative error of 5% for the speed of sound of isopropanol.

Knowledge graphs



Simulation data provenance



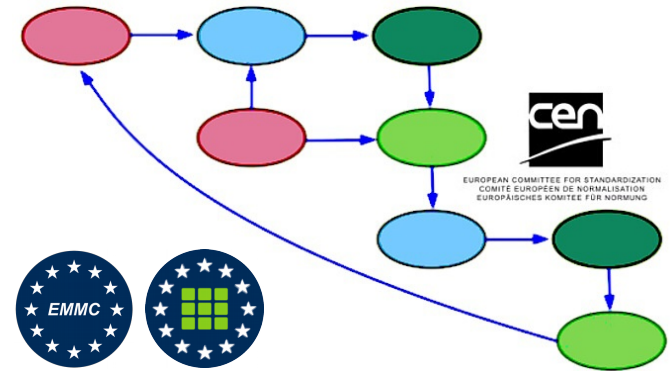
Ontology for Simulation, Modelling, and Optimization (OSMO)

J. Chem. Eng. Data 65(3), 1313–1329, 2020



Simulation data provenance

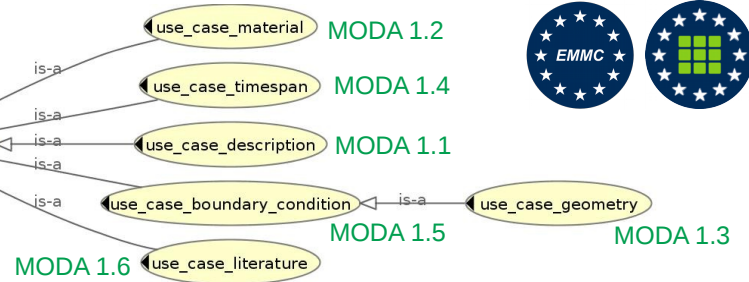
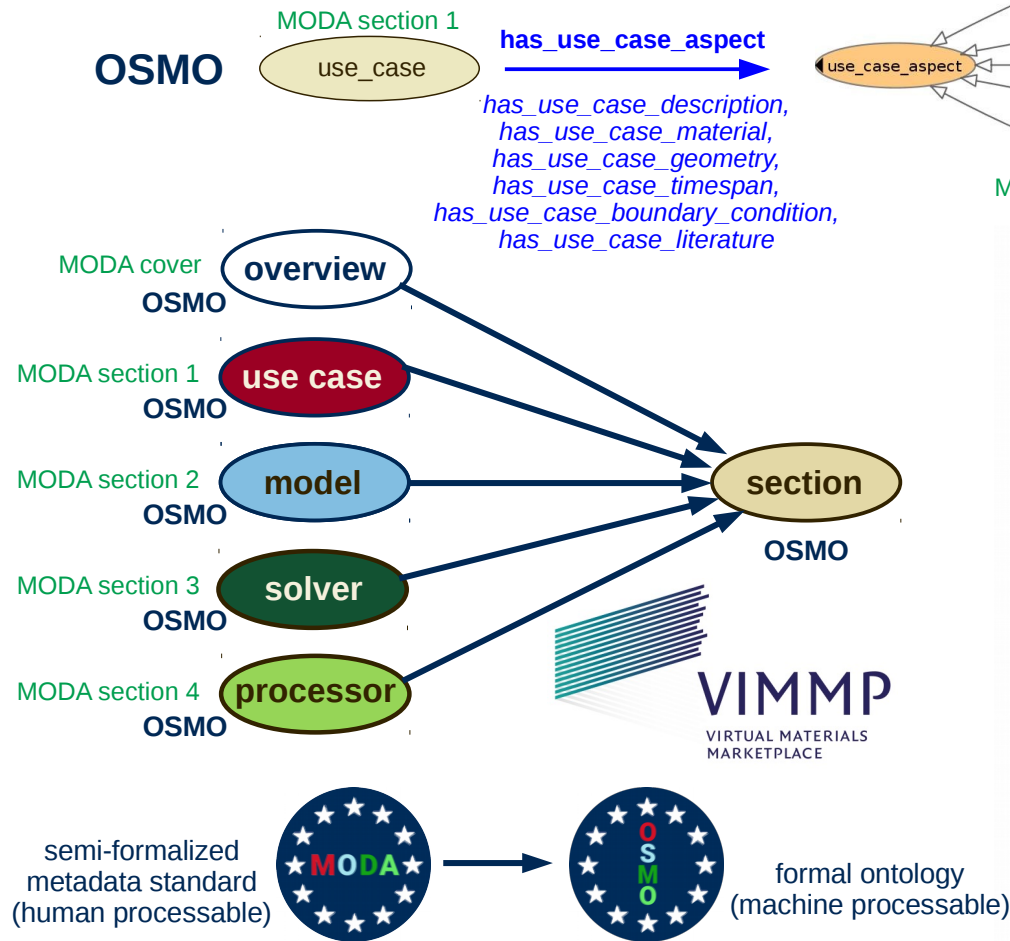
| 3 SOLVER AND COMPUTATIONAL TRANSLATION OF THE SPECIFICATIONS | | | |
|--|--|---|--|
| 3.1 | <p>NUMERICAL SOLVER</p> <p>Please give name and type of the solver e.g. Monte Carlo, SPH, FE, ...iterative, multi-grid, adaptive,...</p> | | |
| 3.2 | <p>SOFTWARE TOOL</p> <p>Please give the name and if this is your own code, please specify if it can be shared with an evt link to website/publication.</p> | | |
| 3.3 | <p>TIME STEP</p> <p>If applicable, please give the time step used in the solving operations. This is the numerical time step and this is not the same as the time lapse of the case to be simulated (see 1.4)</p> | | |
| 3.4 | <table border="1" style="width: 100%;"> <tr> <td style="width: 20%; text-align: center;">PHYSICS EQUATION, MATERIAL RELATIONS, MATERIAL</td> <td> <p>Computational representation of the physics equation, materials relation and material.</p> <p>There is no need to repeat user case info.</p> <p>“Computational” means that this only needs to be filled in when your computational solver represents the material, properties, equation variables, in a specific way.</p> </td> </tr> </table> | PHYSICS EQUATION, MATERIAL RELATIONS, MATERIAL | <p>Computational representation of the physics equation, materials relation and material.</p> <p>There is no need to repeat user case info.</p> <p>“Computational” means that this only needs to be filled in when your computational solver represents the material, properties, equation variables, in a specific way.</p> |
| PHYSICS EQUATION, MATERIAL RELATIONS, MATERIAL | <p>Computational representation of the physics equation, materials relation and material.</p> <p>There is no need to repeat user case info.</p> <p>“Computational” means that this only needs to be filled in when your computational solver represents the material, properties, equation variables, in a specific way.</p> | | |
| 3.5 | <p>COMPUTATIONAL BOUNDARY CONDITIONS</p> <p>If applicable. Please note that these can be translations of the physical boundary conditions set in the user case or they can be pure computational. (e.g. a unit cell with mirror b.c. to simulate an infinite domain).</p> | | |
| 3.6 | <p>ADDITIONAL SOLVER PARAMETERS</p> <p>Please specify pure internal numerical solver details (if applicable), like</p> <ul style="list-style-type: none"> • Specific tolerances • Cut-offs, convergence criteria • Integrator options | | |



- MODA cover
- MODA section 1
- MODA section 2
- MODA section 3
- MODA section 4



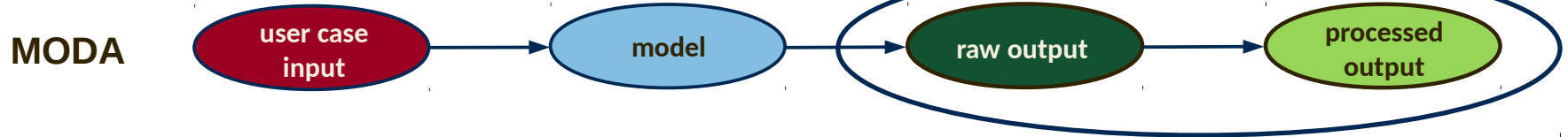
Simulation data provenance



| 3 SOLVER AND COMPUTATIONAL TRANSLATION OF THE SPECIFICATIONS | | |
|--|-----------------------------------|--|
| 3.1 | NUMERICAL SOLVER | Please give name and type of the solver e.g. Monte Carlo, SPH, FE, ...iterative, multi-grid, adaptive,... |
| 3.2 | SOFTWARE TOOL | Please give the name and if this is your own code, please specify if it can be shared with an evtl link to website/publication. |
| 3.3 | TIME STEP | If applicable, please give the time step used in the solving operations. This is the numerical time step and this is not the same as the time lapse of the case to be simulated (see 1.4) |
| 3.4 | COMPUTATIONAL REPRESENTATION | <p>PHYSICS EQUATION, MATERIAL RELATIONS, MATERIAL</p> <p>Computational representation of the physics equation, materials relation and material.</p> <p>There is no need to repeat user case info.</p> <p>"Computational" means that this only needs to be filled in when your computational solver represents the material, properties, equation variables, in a specific way.</p> |
| 3.5 | COMPUTATIONAL BOUNDARY CONDITIONS | If applicable. Please note that these can be translations of the physical user case or they can be pure computational. (e.g. simulate an infinite domain). |
| 3.6 | ADDITIONAL SOLVER PARAMETERS | <p>Please specify pure internal numerical solver details:</p> <ul style="list-style-type: none"> • Specific tolerances • Cut-offs, convergence criteria • Integrator options |



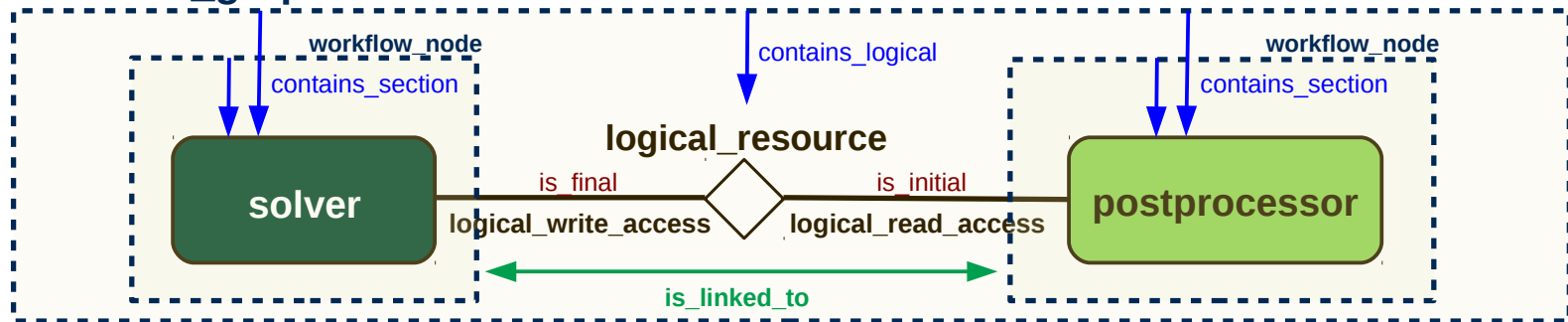
Simulation data provenance



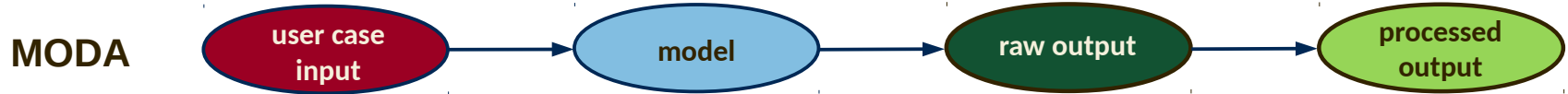
“What is the exact meaning of the blue arrows?”

OSMO: Characterization of workflow semantics by logical data transfer (LDT) graphs

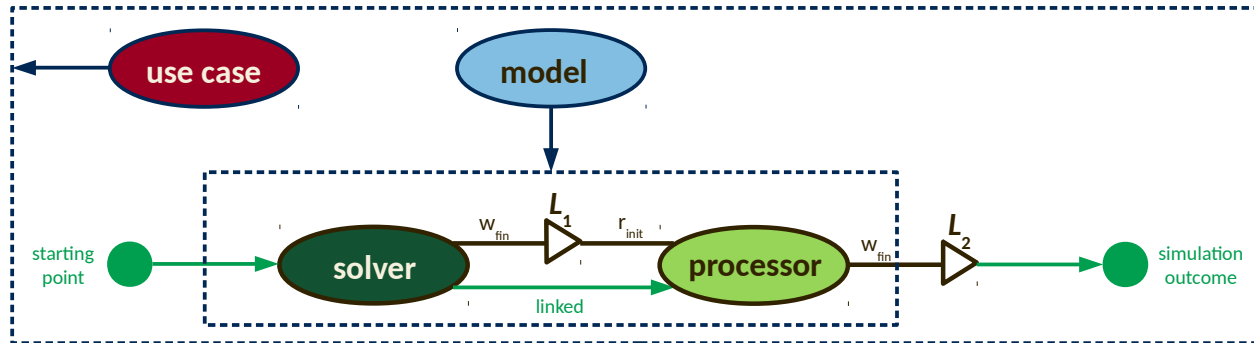
workflow_graph



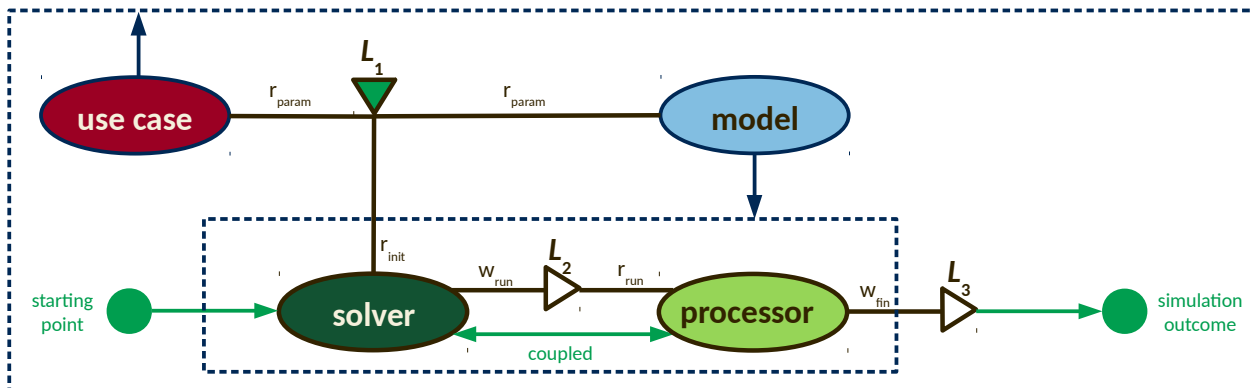
Simulation data provenance



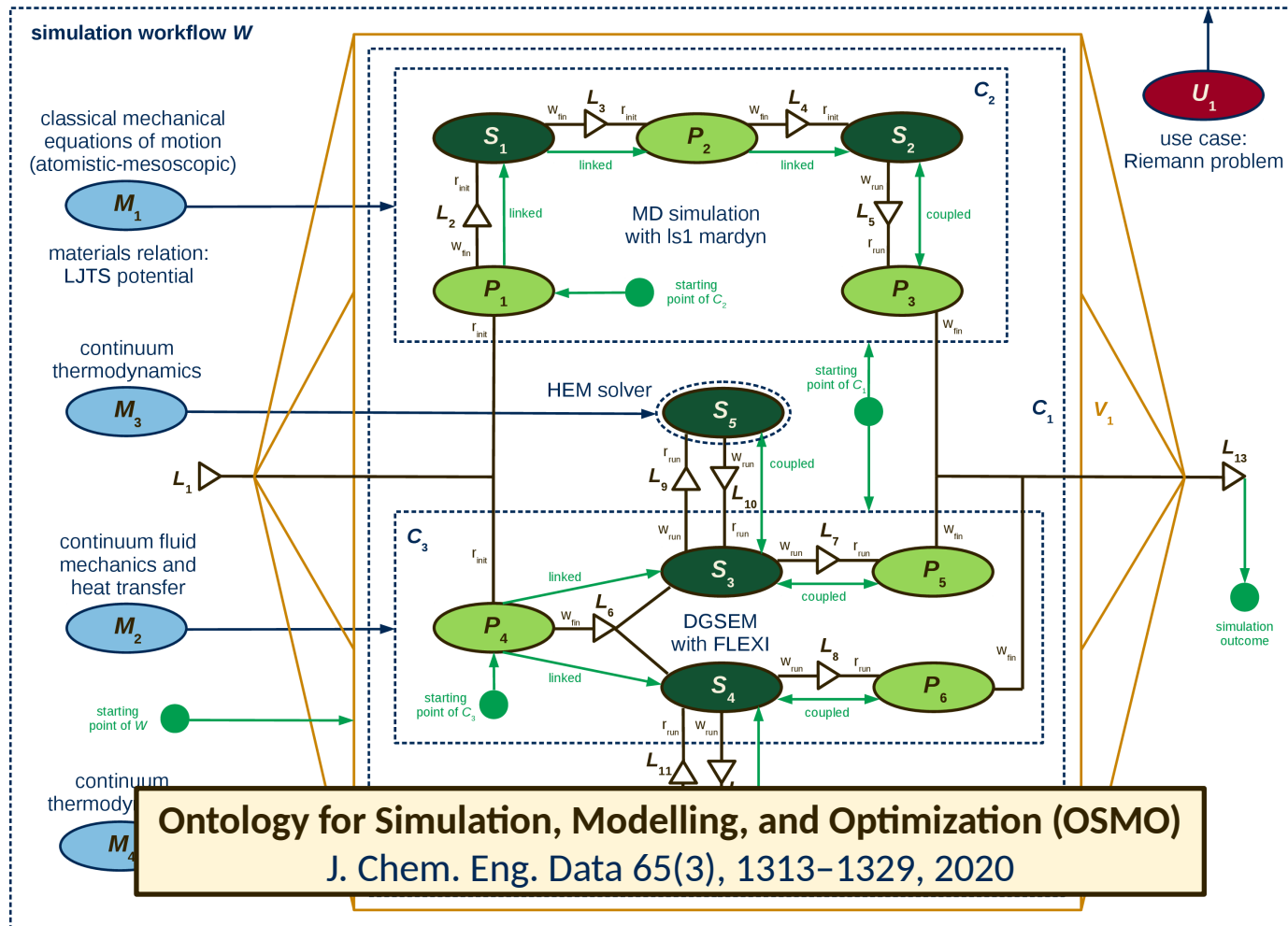
LDT
case 1



LDT
case 2



Simulation data provenance



OSMO-based
**provenance
description** as an
extension of the
MODA workflow
meta-
data standard:

For all elements of
the graph notation,
there are
corresponding
concepts and
relations from the
ontology OSMO.



Annotating molecular models

Geometry

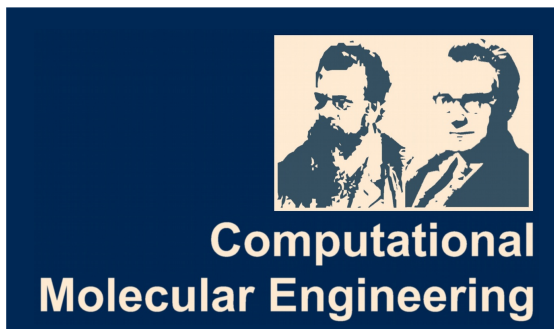
Types and positions
of interaction sites

Dispersion and repulsion

Lennard-Jones or Mie potential:
Size and energy parameters

Electrostatics

Point charge or multipole
(point dipole or quadrupole):
Magnitude and orientation

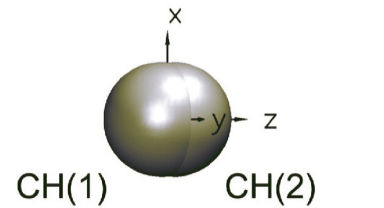
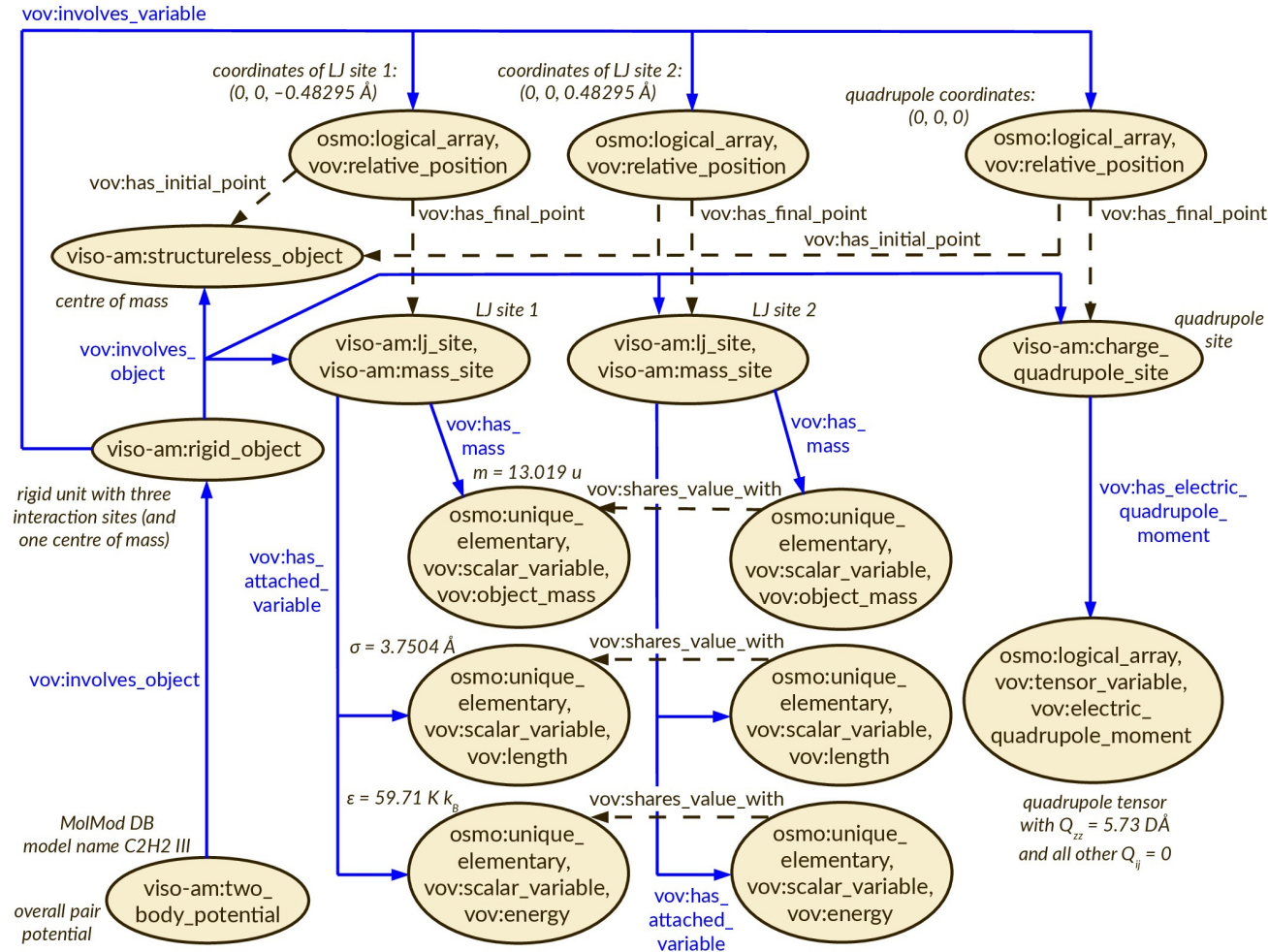


Molecular model database (MolMod DB)

<http://molmod.boltzmann-zuse.de/>

Pair potentials for over 150 molecular fluids

Annotating molecular models



MolMod DB
(Molecular Model Database)

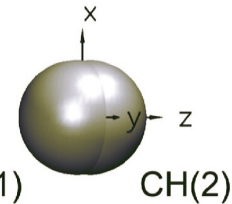
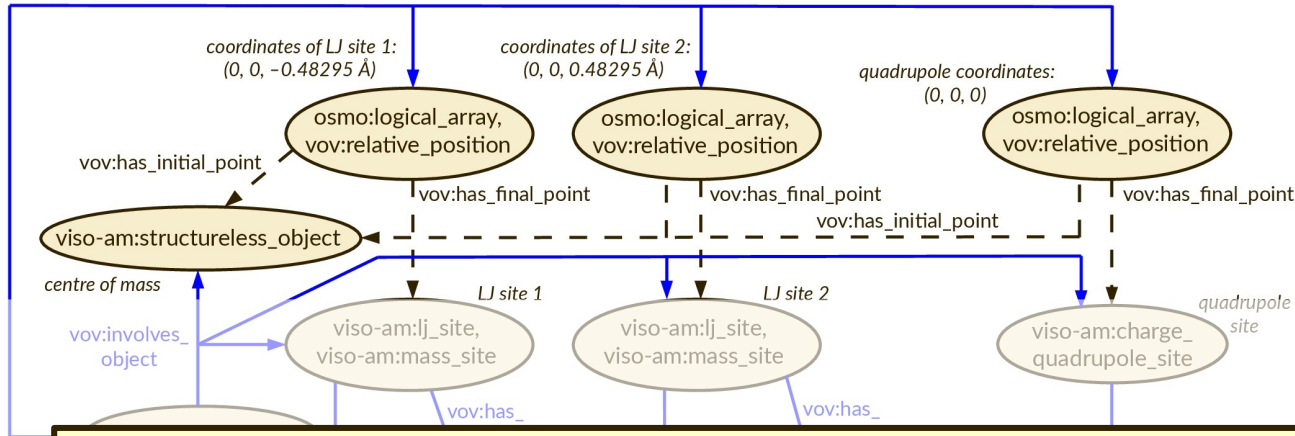


<http://molmod.boltzmann-zuse.de/>

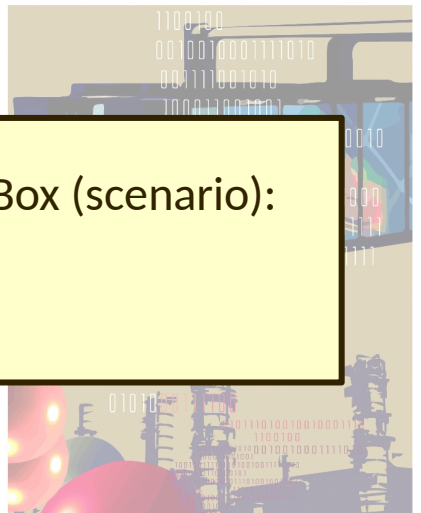
pair potentials for
over 150 molecular fluids

Annotating molecular models

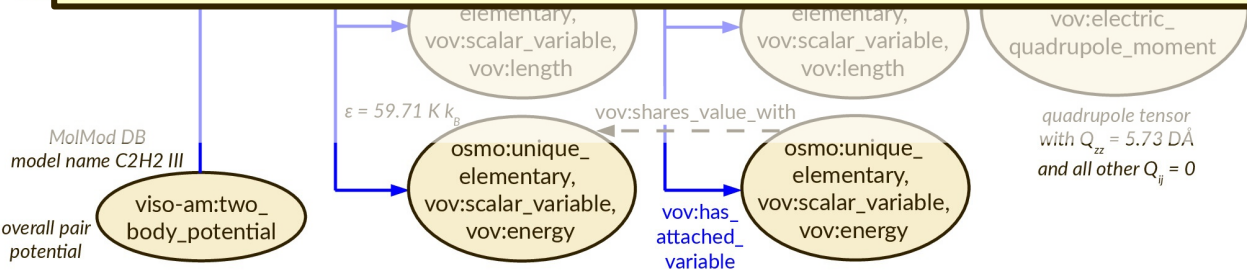
vov:involves_variable



MolMod DB
(Molecular Model Database)



JSON-LD file containing a hierarchical representation of the ABox (scenario):
material-D/acetylene-model-cecam.json



<http://molmod.boltzmann-zuse.de/>

pair potentials for
over 150 molecular fluids

Practical use of research data infrastructures

What values did x and p have?

How was the data point obtained?

What is the margin of error, how was the error defined, and what software

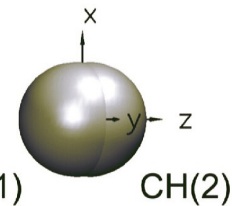
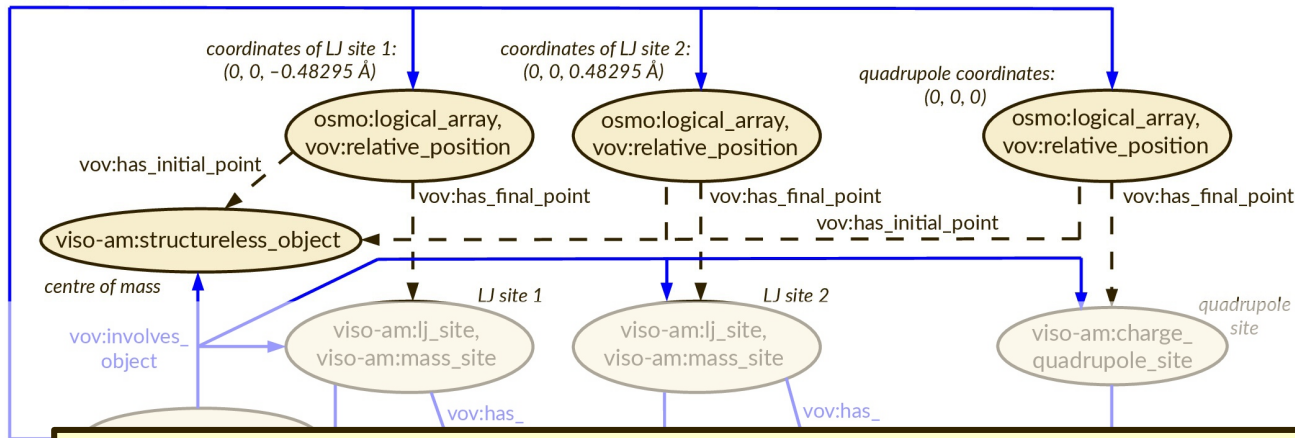
Access <https://www.menti.com/> and type the code 8878 5997.

competency
questions

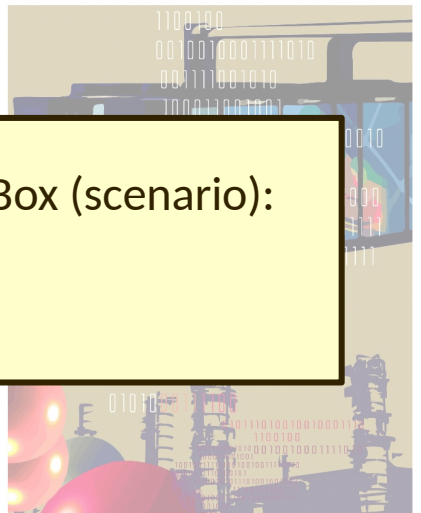
„What questions would you ask about data provenance when looking for simulation results in a research data infrastructure?“

Tools for working with ontologies

vov:involves_variable



MolMod DB
(Molecular Model Database)

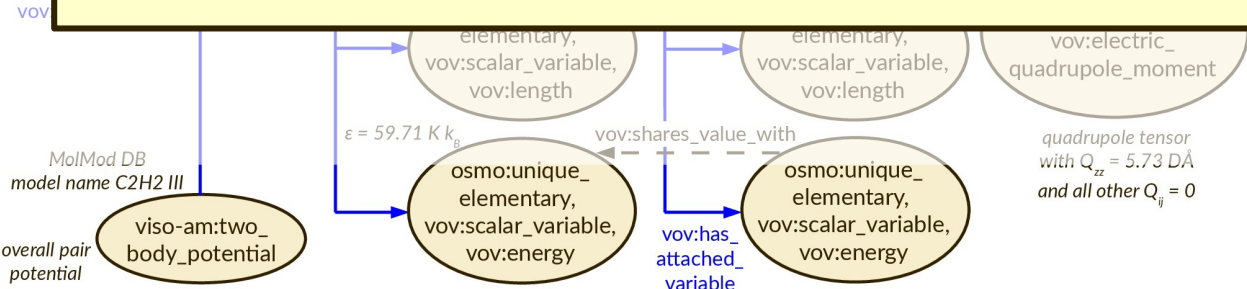


<http://molmod.boltzmann-zuse.de/>

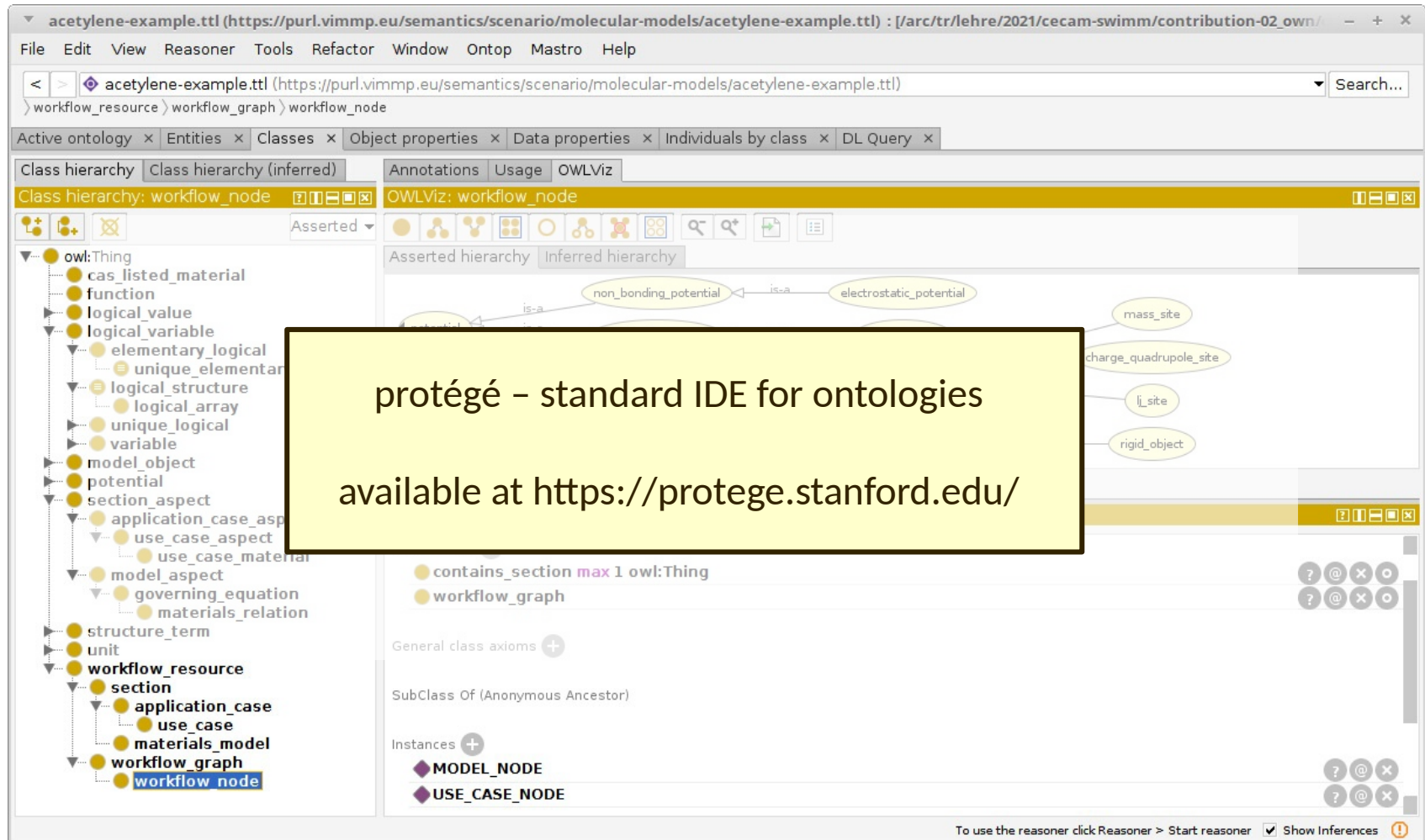
pair potentials for
over 150 molecular fluids

TTL file including relevant parts of the TBox (ontology) and ABox (scenario):

material-G/acetylene-model-cecam.ttl

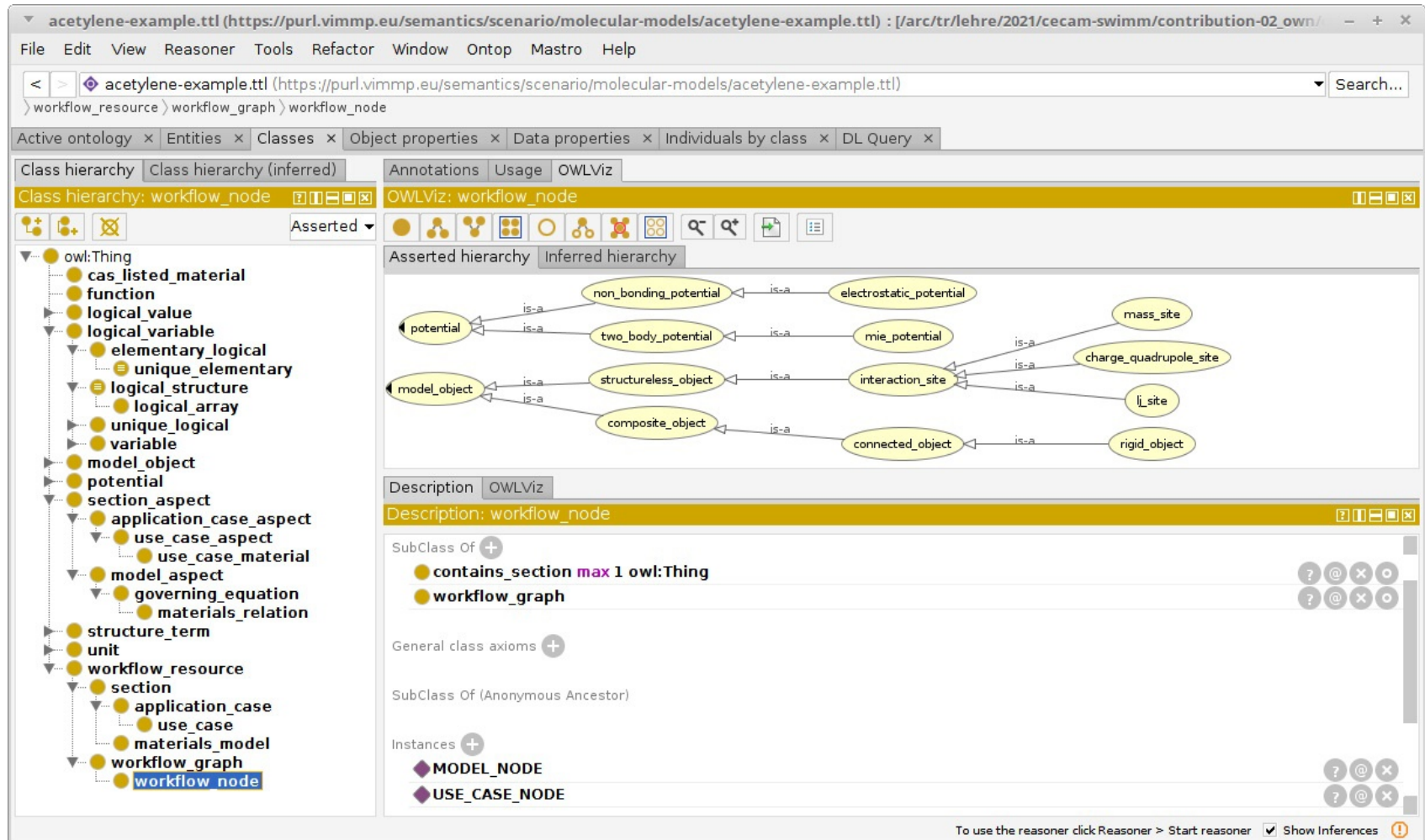


Tools for working with ontologies



The screenshot shows the Protégé ontology editor interface. The main window displays a class hierarchy on the left and an OWLViz diagram in the center. The OWLViz diagram shows a class hierarchy where `non_bonding_potential` is a subclass of `electrostatic_potential`. The interface includes a menu bar (File, Edit, View, Reasoner, Tools, Refactor, Window, Ontop, Mastro, Help), a search bar, and various toolbars for navigation and editing. A yellow callout box is overlaid on the interface, containing the text: "protégé – standard IDE for ontologies available at <https://protege.stanford.edu/>".

Tools for working with ontologies



The screenshot shows the Protege ontology editor interface. The top menu bar includes File, Edit, View, Reasoner, Tools, Refactor, Window, Ontop, Mastro, and Help. The address bar shows the URL for 'acetylene-example.ttl'. The main workspace is divided into several panes:

- Class hierarchy:** A tree view on the left showing the ontology's structure, with 'workflow_node' selected.
- OWLviz:** A central diagram showing the 'Asserted hierarchy' of classes. It includes nodes like 'potential', 'model_object', 'non_bonding_potential', 'two_body_potential', 'structureless_object', 'composite_object', 'electrostatic_potential', 'mie_potential', 'interaction_site', 'connected_object', 'mass_site', 'charge_quadrupole_site', 'lj_site', and 'rigid_object', all connected by 'is-a' relationships.
- Description:** A panel on the right showing the description for 'workflow_node', including sub-classes like 'contains_section max 1 owl:Thing' and 'workflow_graph', and instances like 'MODEL_NODE' and 'USE_CASE_NODE'.

Tools for working with ontologies

SPARQL ENDPOINT
CONTENT TYPE (SELECT)
CONTENT TYPE (GRAPH)

JSON

Turtle

```

1 prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
2 prefix osmo: <https://purl.vimmp.eu/semantics/osmo/osmo.ttl#>
3 prefix vov: <https://purl.vimmp.eu/semantics/vov/vov.ttl#>
4
5 SELECT ?magnitude ?unit
6 WHERE {
7   ?iri rdf:type
8   ?iri osmo:ha
9   ?elval osmo:
10  ?iri osmo:ha
11 }
12

```

fuseki SPARQL server

available at

<https://jena.apache.org/documentation/fuseki2/>

QUERY RESULTS

Table
Raw Response
Download

Showing 1 to 2 of 2 entries Search: Show entries

| | magnitude | unit |
|---|-----------------------|---|
| 1 | "59.71"^^xsd:decimal | <https://purl.vimmp.eu/semantics/vivo/vivo.ttl#UNIT_KELVIN_BOLTZMANN> |
| 2 | "3.7504"^^xsd:decimal | <http://qudt.org/vocab/unit#Angstrom> |

Showing 1 to 2 of 2 entries

Tools for working with ontologies

SPARQL ENDPOINT: /MOLMOD/query

CONTENT TYPE (SELECT): JSON

CONTENT TYPE (GRAPH): Turtle

```

1 prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
2 prefix osmo: <https://purl.vimmp.eu/semantics/osmo/osmo.ttl#>
3 prefix vov: <https://purl.vimmp.eu/semantics/vov/vov.ttl#>
4
5 SELECT ?magnitude ?unit
6 WHERE {
7   ?iri rdf:type vov:pair_variable.
8   ?iri osmo:has_elementary_value ?elval.
9   ?elval osmo:is_decimal ?magnitude.
10  ?iri osmo:has_variable_unit ?unit.
11 }
12

```

query

59.71 K·k_B, 3.7504 Å

QUERY RESULTS

Table Raw Response

Showing 1 to 2 of 2 entries

Search: Show 50 entries

| | magnitude | unit |
|---|-----------------------|---|
| 1 | "59.71"^^xsd:decimal | <https://purl.vimmp.eu/semantics/vivo/vivo.ttl#UNIT_KELVIN_BOLTZMANN> |
| 2 | "3.7504"^^xsd:decimal | <http://qudt.org/vocab/unit#Angstrom> |

Showing 1 to 2 of 2 entries

Query languages

History: SQL (Structured Query Language) for relational databases

model_parameters

| id | name | value | unit | category | reference |
|----|-------------------|--------|---------------|-----------------|-----------|
| 1 | "sigma" | 3.7504 | Å | pair_variable | |
| 2 | "epsilon" | 59.71 | $K \cdot k_B$ | pair_variable | |
| 3 | "site mass" | 13.019 | u | object_variable | |
| 4 | "quadrupole" | | DÅ | tensor | 276 |
| 5 | "site 1 position" | | Å | vector | 178 |
| 6 | "site 2 position" | | Å | vector | 179 |

category to be selected

pointers to IDs from other tables

Query languages

History: SQL (Structured Query Language) for relational databases

model_parameters

| id | name | value | unit | category | reference |
|----|-------------------|--------|---------------|-----------------|-----------|
| 1 | "sigma" | 3.7504 | Å | pair_variable | |
| 2 | "epsilon" | 59.71 | $K \cdot k_B$ | pair_variable | |
| 3 | "site mass" | 13.019 | u | object_variable | |
| 4 | "quadrupole" | | DÅ | tensor | 276 |
| 5 | "site 1 position" | | Å | vector | 178 |
| 6 | "site 2 position" | | Å | vector | 179 |

```
SELECT name, value, unit
FROM model_parameters
WHERE category = pair_variable;
```



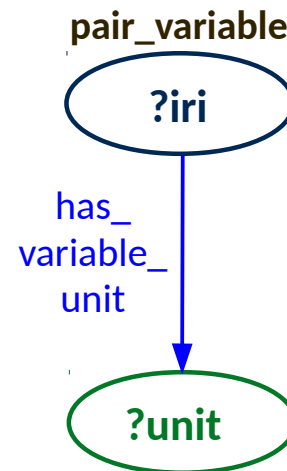
```
„sigma“      3.7504      Å
„epsilon“    59.71       K·kB
```

Query languages

SPARQL („SPARQL Protocol and RDF Query Language“) for the semantic web

SELECT ?x ?y ... WHERE {sequence of triples involving ?x, ?y, ...}

```
SELECT ?unit
WHERE {
  ?iri rdf:type vov:pair_variable.
  ?iri osmo:has_variable_unit ?unit.
}
```

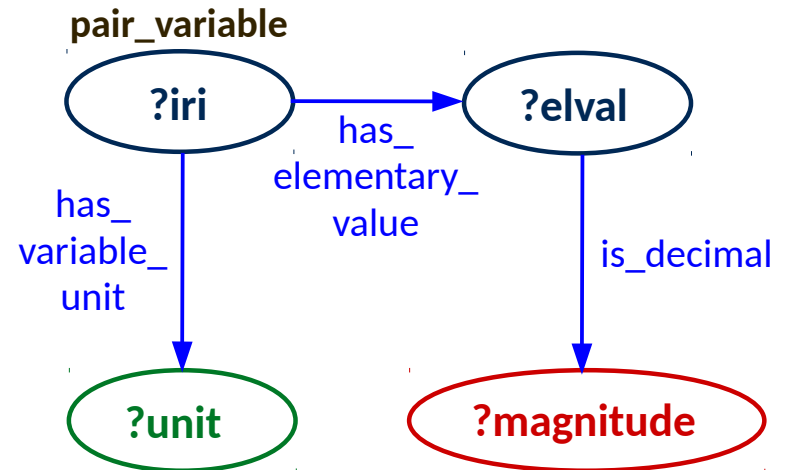


Query languages

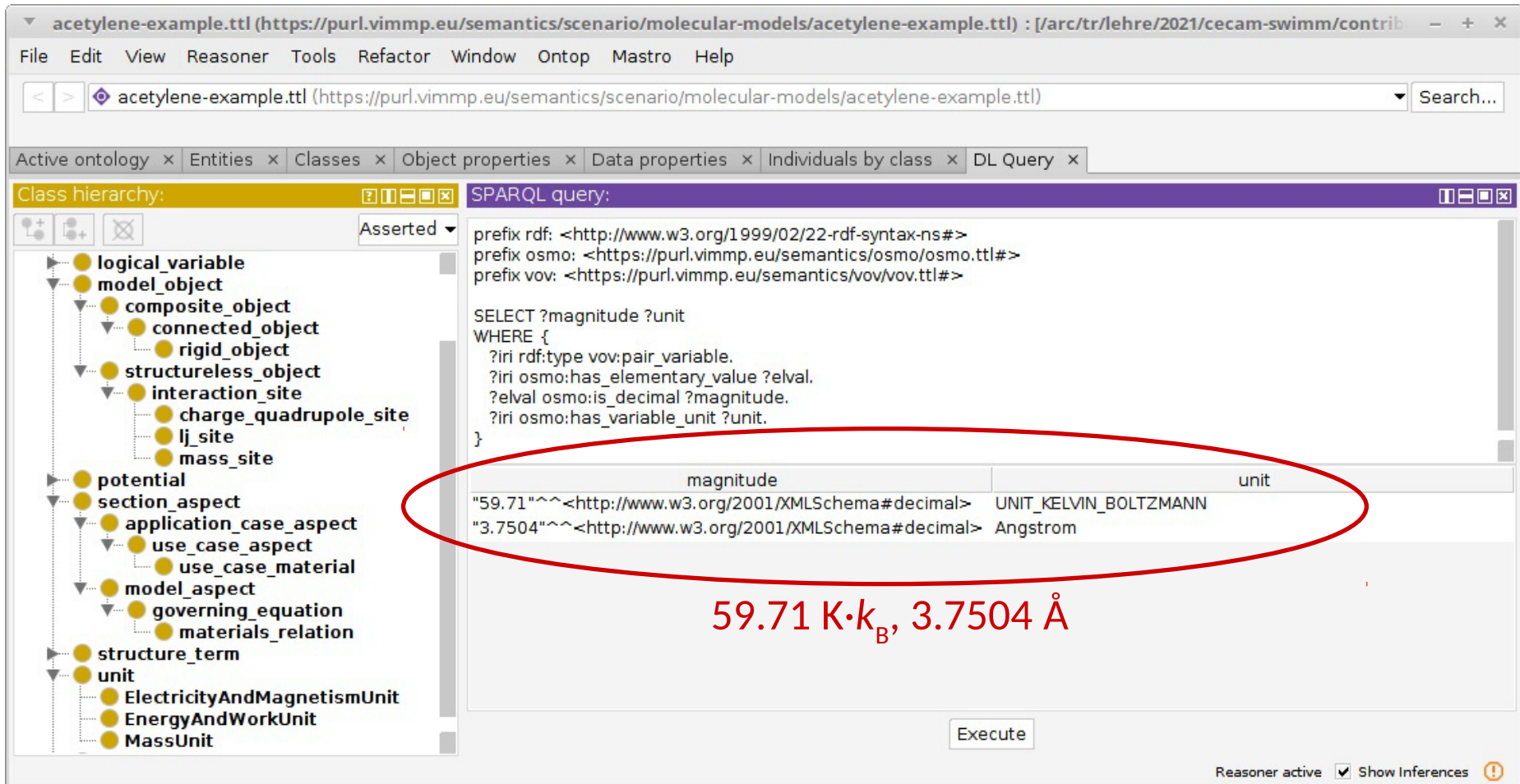
SPARQL („SPARQL Protocol and RDF Query Language“) for the semantic web

SELECT ?x ?y ... WHERE {sequence of triples involving ?x, ?y, ...}

```
SELECT ?magnitude ?unit
WHERE {
  ?iri rdf:type vov:pair_variable.
  ?iri osmo:has_elementary_value ?elval.
  ?elval osmo:is_decimal ?magnitude.
  ?iri osmo:has_variable_unit ?unit.
}
```



Query languages (SPARQL in protégé)



acetylene-example.ttl (https://purl.vimmp.eu/semantics/scenario/molecular-models/acetylene-example.ttl) : [arc/tr/lehre/2021/cecamm-swimm/contrib - + x

File Edit View Reasoner Tools Refactor Window Ontop Mastro Help

acetylene-example.ttl (https://purl.vimmp.eu/semantics/scenario/molecular-models/acetylene-example.ttl) Search...

Active ontology x Entities x Classes x Object properties x Data properties x Individuals by class x DL Query x

Class hierarchy: Asserted

- logical_variable
- model_object
 - composite_object
 - connected_object
 - rigid_object
 - structureless_object
 - interaction_site
 - charge_quadrupole_site
 - lj_site
 - mass_site
 - potential
 - section_aspect
 - application_case_aspect
 - use_case_aspect
 - use_case_material
 - model_aspect
 - governing_equation
 - materials_relation
 - structure_term
 - unit
 - ElectricityAndMagnetismUnit
 - EnergyAndWorkUnit
 - MassUnit

SPARQL query:

```

prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
prefix osmo: <https://purl.vimmp.eu/semantics/osmo/osmo.ttl#>
prefix vov: <https://purl.vimmp.eu/semantics/vov/vov.ttl#>

SELECT ?magnitude ?unit
WHERE {
  ?iri rdf:type vov:pair_variable.
  ?iri osmo:has_elementary_value ?elval.
  ?elval osmo:is_decimal ?magnitude.
  ?iri osmo:has_variable_unit ?unit.
}
  
```

| magnitude | unit |
|--|-----------------------|
| "59.71"^^<http://www.w3.org/2001/XMLSchema#decimal> | UNIT_KELVIN_BOLTZMANN |
| "3.7504"^^<http://www.w3.org/2001/XMLSchema#decimal> | Angstrom |

Execute

Reasoner active Show Inferences

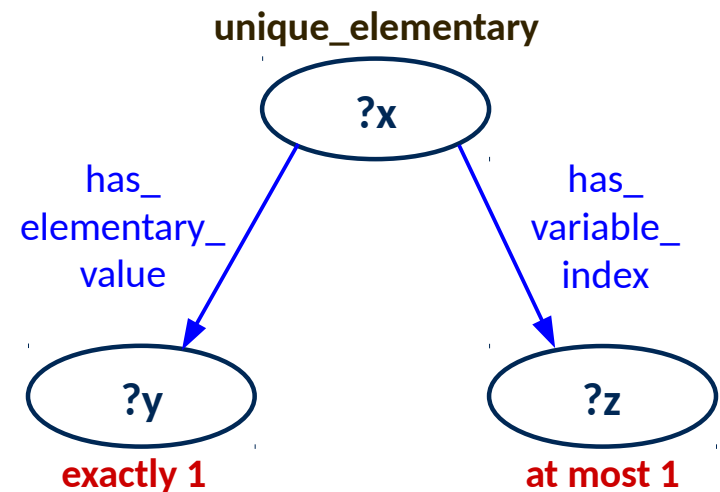
59.71 K·k_B, 3.7504 Å

Constraint language (SHACL)

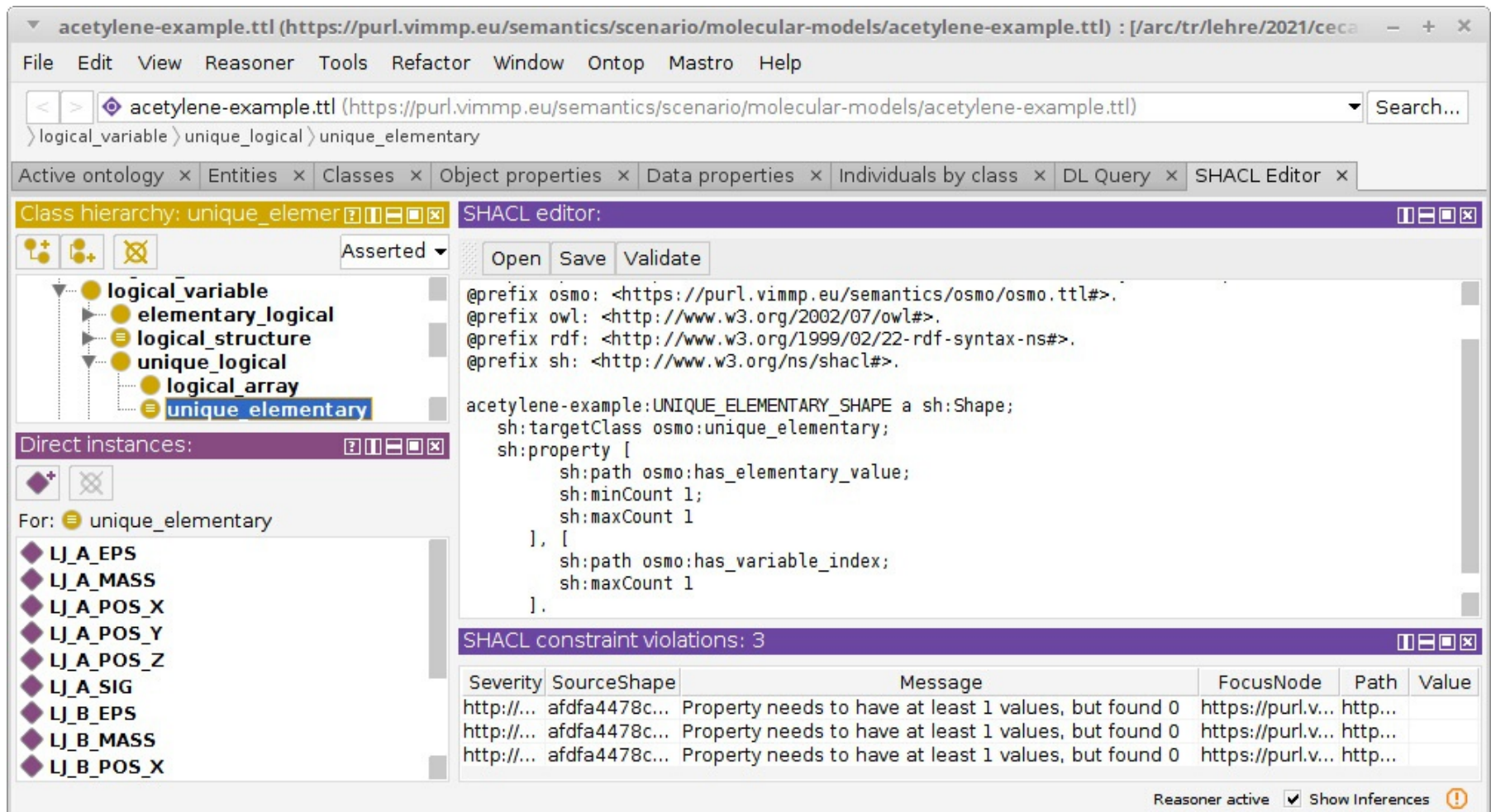
SHACL (Shapes Constraint Language) for validating knowledge graphs

```

:UNIQUE_ELEMENTARY_SHAPE a sh:Shape;
  sh:targetClass osmo:unique_elementary;
  sh:property [
    sh:path osmo:has_elementary_value;
    sh:minCount 1;
    sh:maxCount 1
  ], [
    sh:path osmo:has_variable_index;
    sh:maxCount 1
  ].
  
```



Constraint language (SHACL in protégé)



The screenshot shows the Protégé SHACL Editor interface. The main editor displays the following SHACL constraint:


```

@prefix osmo: <https://purl.vimmp.eu/semantics/osmo/osmo.ttl#>.
@prefix owl: <http://www.w3.org/2002/07/owl#>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix sh: <http://www.w3.org/ns/shacl#>.

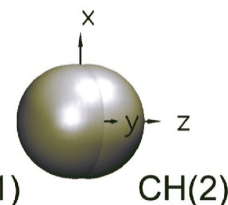
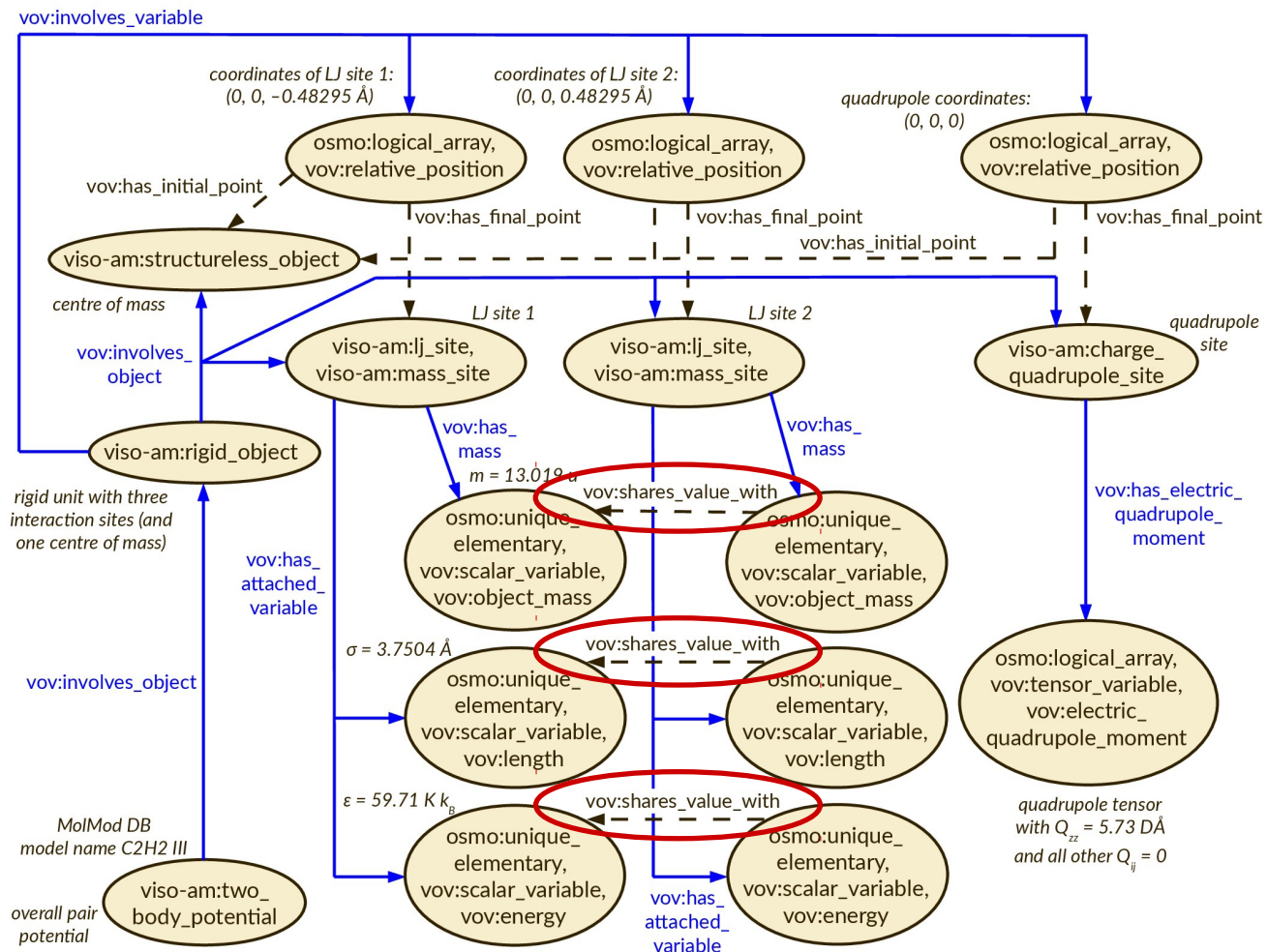
acetylene-example:UNIQUE_ELEMENTARY_SHAPE a sh:Shape;
  sh:targetClass osmo:unique_elementary;
  sh:property [
    sh:path osmo:has_elementary_value;
    sh:minCount 1;
    sh:maxCount 1
  ], [
    sh:path osmo:has_variable_index;
    sh:maxCount 1
  ].
  
```

Below the editor, the SHACL constraint violations are listed:

| Severity | SourceShape | Message | FocusNode | Path | Value |
|------------|---------------|---|-------------------|---------|-------|
| http://... | afdfa4478c... | Property needs to have at least 1 values, but found 0 | https://purl.v... | http... | |
| http://... | afdfa4478c... | Property needs to have at least 1 values, but found 0 | https://purl.v... | http... | |
| http://... | afdfa4478c... | Property needs to have at least 1 values, but found 0 | https://purl.v... | http... | |

At the bottom right, the status bar indicates: Reasoner active Show Inferences 

Constraint language (SHACL)



MolMod DB
(Molecular Model Database)



<http://molmod.boltzmann-zuse.de/>

pair potentials for
over 150 molecular fluids

RDF and OWL libraries

Jena (Java)

<https://jena.apache.org/>



Developer: Apache Software
Foundation

Functionality: TTL and RDF/XML
I/O, SPARQL querying (used by
fuseki), reasoning („Inference API“)

License: Apache Software License

owlready2 (Python)

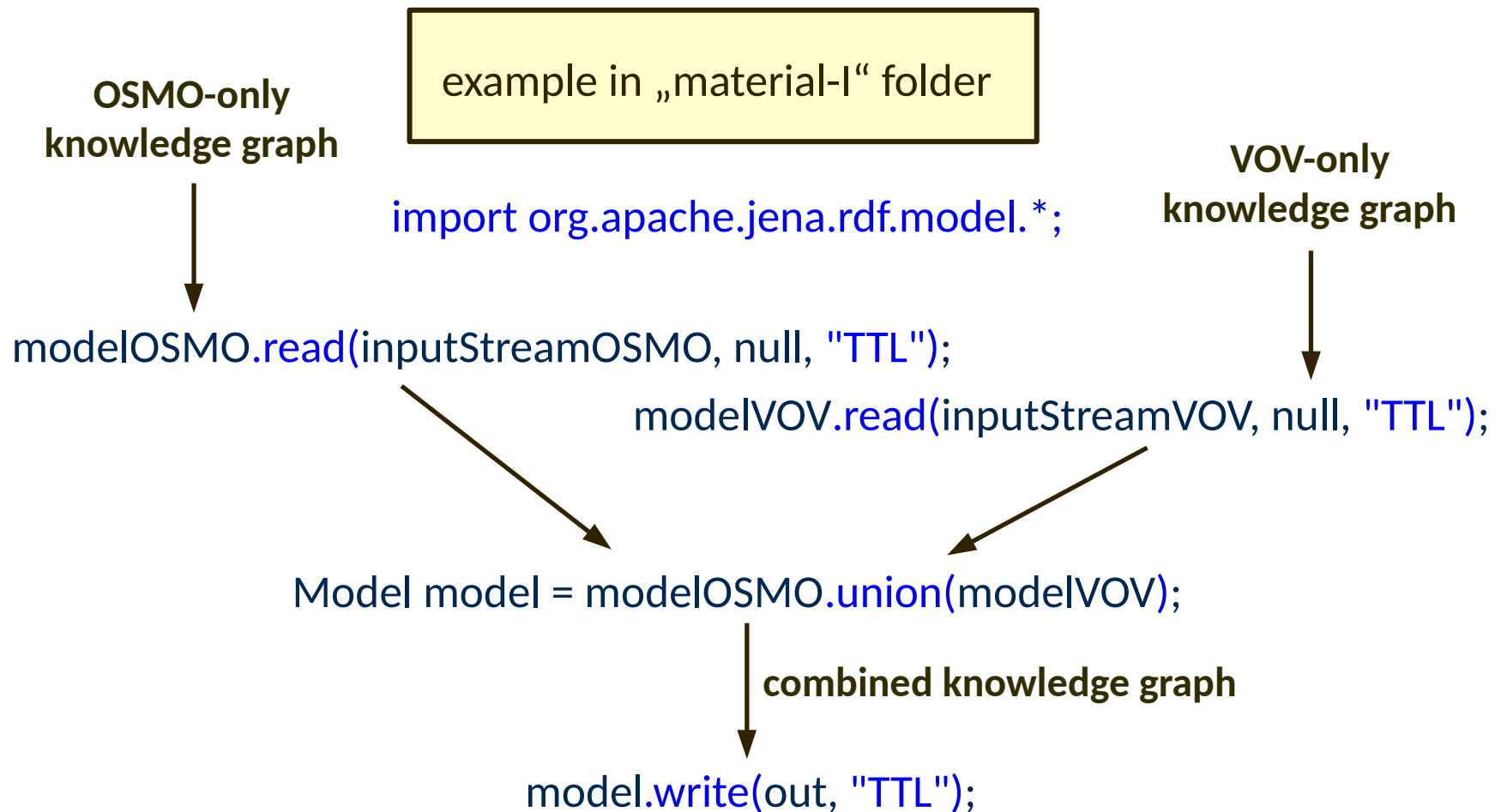
<https://pypi.org/project/Owlready2/>

Functionality: manipulate OWL 2.0
ontologies as Python objects; reasoning;
Ntriples and RDF/XML I/O, OWL/XML as I,
Reasoning, RDF quadstore

Developer: Jean-Baptiste Lamy

License: GNU Lesser General Public
License v3 or later (LGPLv3+)

RDF and OWL libraries: Apache Jena



RDF and OWL libraries: Owlready2

example in „material-L“ folder

`python3 owlready2_example.py`

A toy example to

- **load** an ontology
- **navigate** it (classes and properties)
- **modify it** (create an individual)
- **save** the modified ontology **in a file**
- .. all *via* Python commands

```
myonto = get_ontology("vimmp-ontology-fragment.owl")  
myonto.load()
```

```
classes_list=list(myonto.classes())  
op_list=list(myonto.object_properties())
```

```
my_ind = (my_class)("my_individual", label="my_label")
```

```
myonto.save(file="my_first_test.owl", format = "rdxml")
```

Time for coffee



A sign and the object it (supposedly) refers to

The following (only) refers to the contribution to this presentation from the VIMMP project:

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