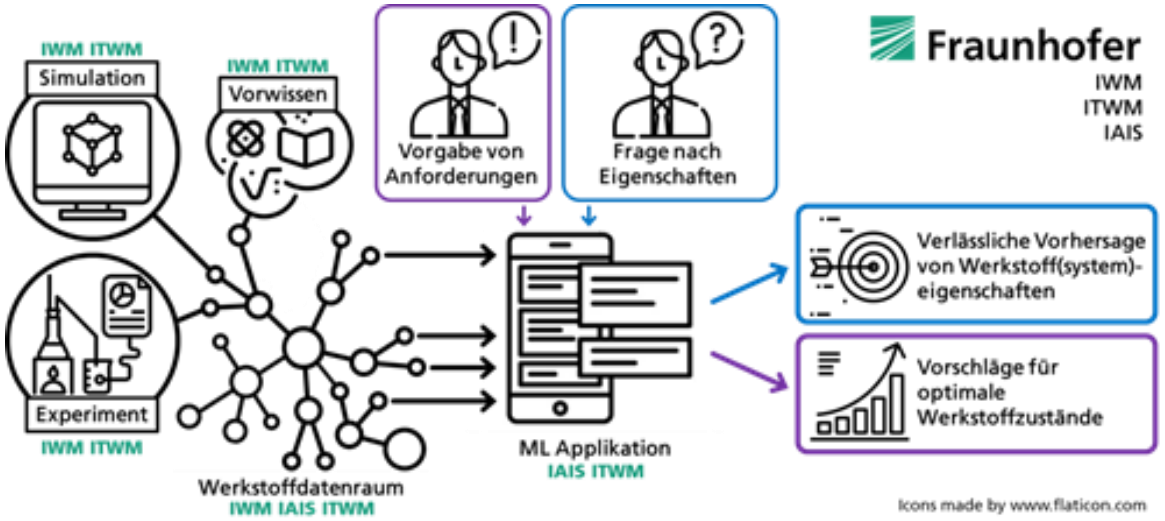
ONLINE-VERANSTALTUNG

Digital verfügbares Werkstoff- und Prozesswissen
Live-Demo der Nutzung von Datenraum-Werkzeugen

Abschlusskolloquium
des Fraunhofer-Konsortiums »UrWerk«
zur Entwicklung von unternehmensspezifischen
Werkstoff(system)-Datenräumen



Moderation Dr. Michael Luke
Projektleiter »UrWerk«
Geschäftsfeldleiter »Bauteilsicherheit und Leichtbau«
am Fraunhofer-Institut für Werkstoffmechanik IWM

24.November 2022

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Digital verfügbares Werkstoff- und Prozesswissen

Live-Demo der Nutzung von Datenraum-Werkzeugen

24.11.2022

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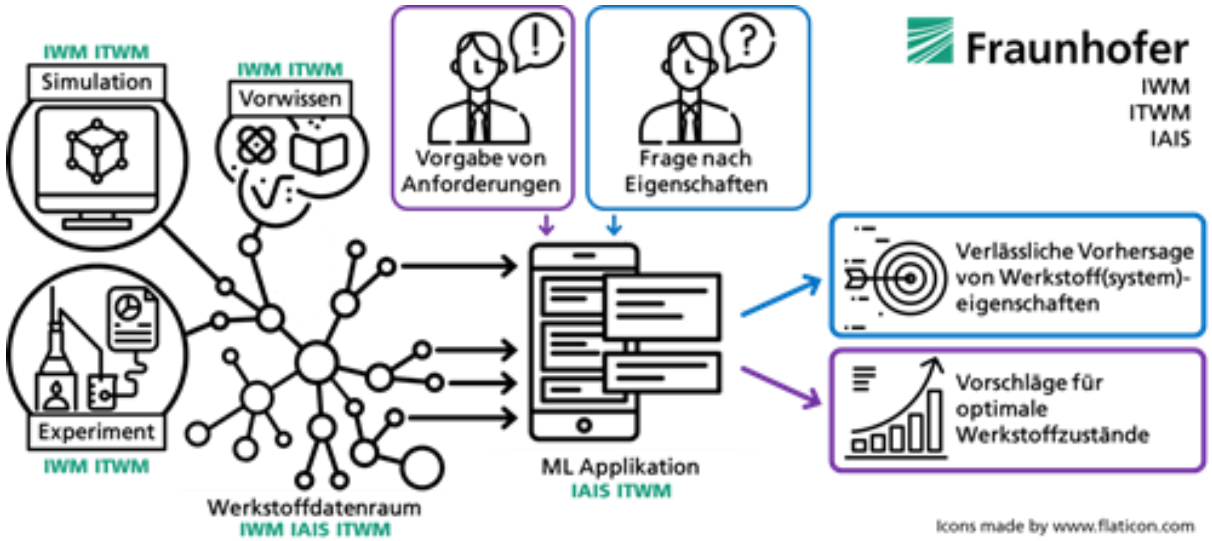

MAVO „UrWerk“ (2019 – 2022)
Unternehmensspezifische Werkstoff-Datenräume zur beschleunigten Produktentwicklung

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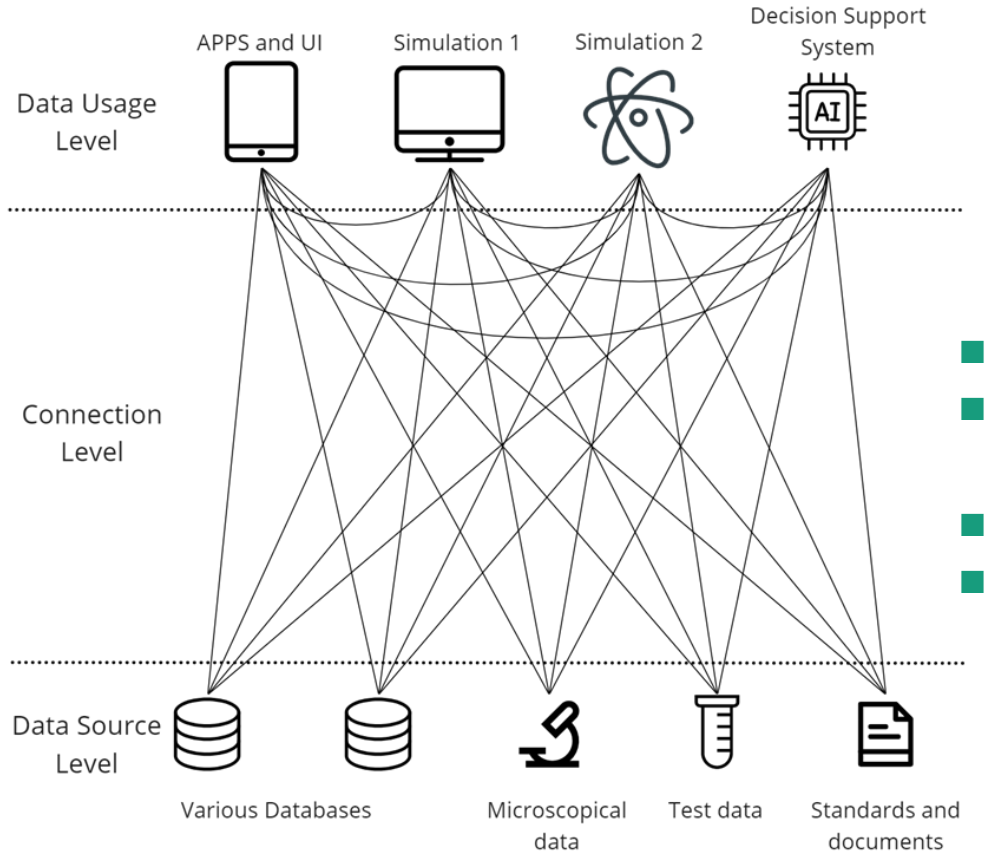
Agenda

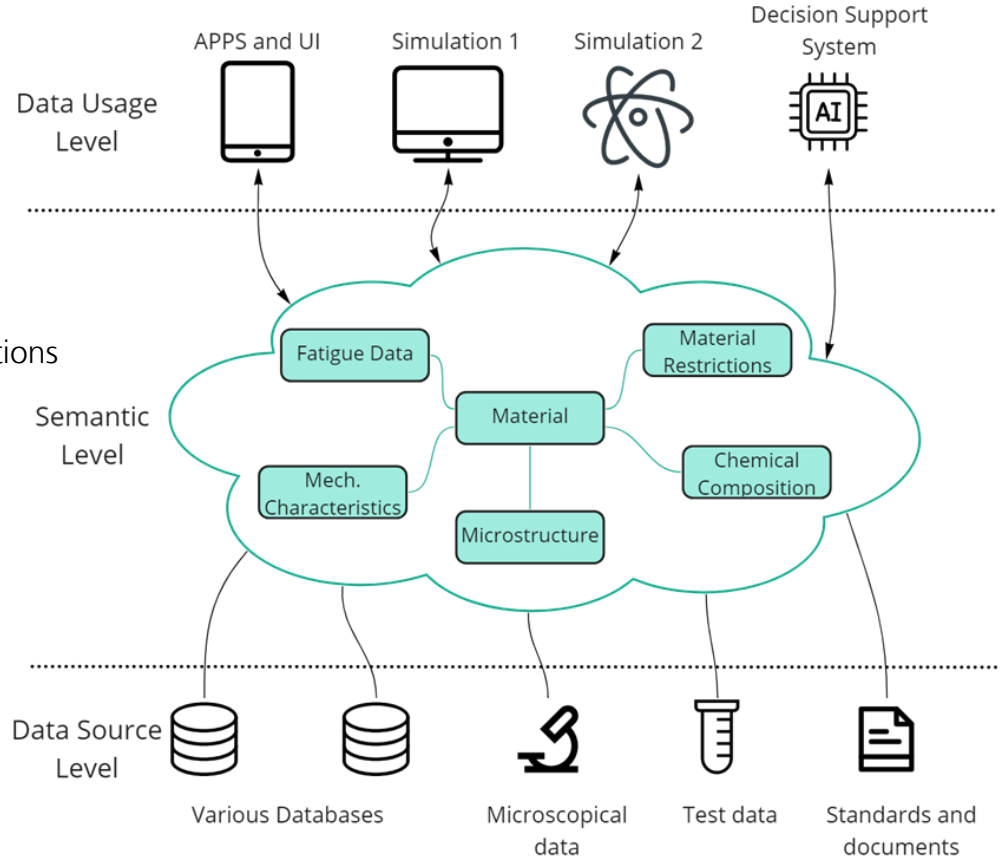
- **Ontologie & Wissensgraph**
  - Einführung
  - Vorgehensweise Ontologieerstellung
  - Datenformat (RDF)
  - Mapping-Workflow
  - Datenabruf (SPARQL)
- **UseCase1: Fatigue Datenbank**
  - Wissensgraph (Miro-Board)
  - Demo SPARQL queries (Select & Filter, Reasoning)
- **UseCase2: 100Cr6 Prozesshistorie**
  - Prozessgraph (Knowledge Base Builder)
  - Demo SPARQL queries (Abfrage Wärmebehandlungshistorie)

Ontology and Knowledge Graph
Motivation

Why use Knowledge Graphs?



- Enrich Data by relations
- Integration of Data Sources
- Interoperability
- Data-Driven



Situation **before** the use of Knowledge Graphs

Situation **after** the use of Knowledge Graphs

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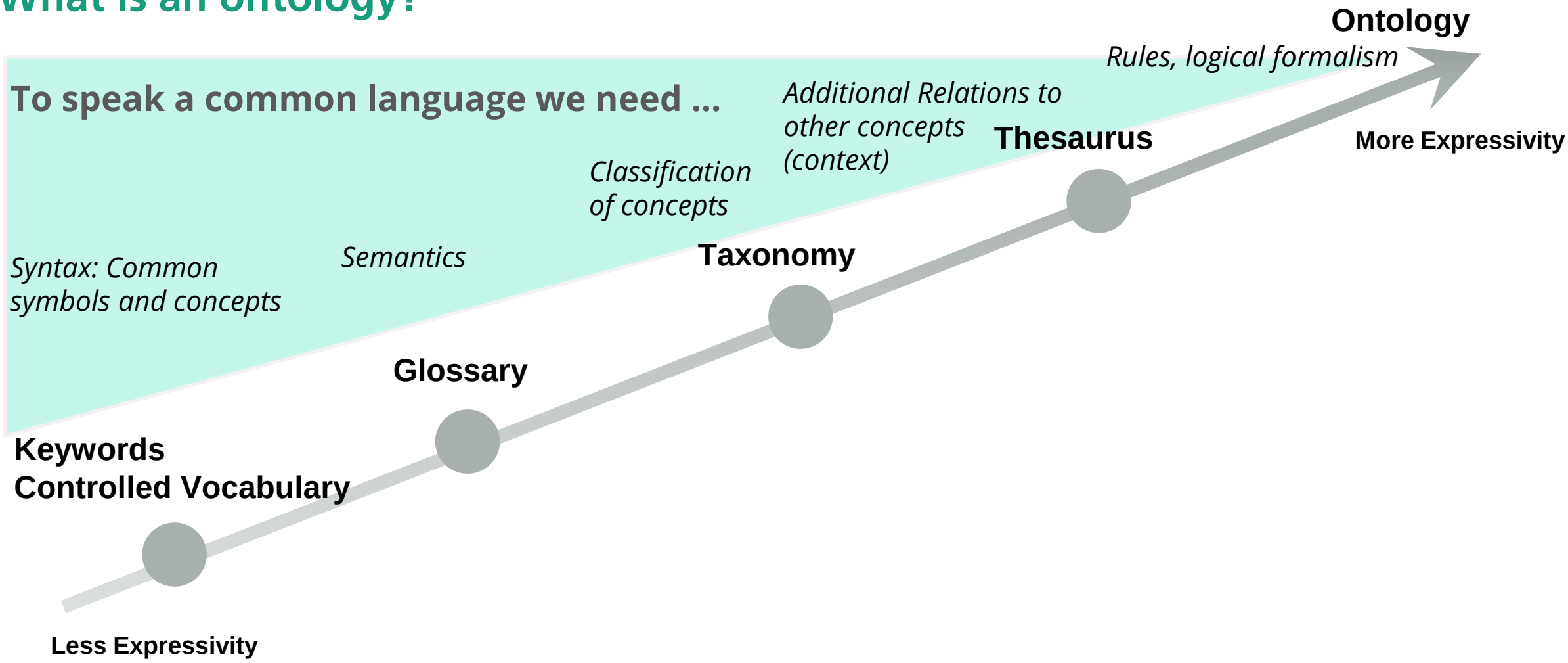
Ontology and Knowledge Graph

What is an ontology?



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Ontology and Knowledge Graph

What is an ontology?

To speak a common language we need …

Syntax: Common symbols and concepts

Semantics

Classification of concepts

Additional Relations to other concepts (context)

Rules, logical formalism

Keywords
Controlled Vocabulary

Glossary

Taxonomy

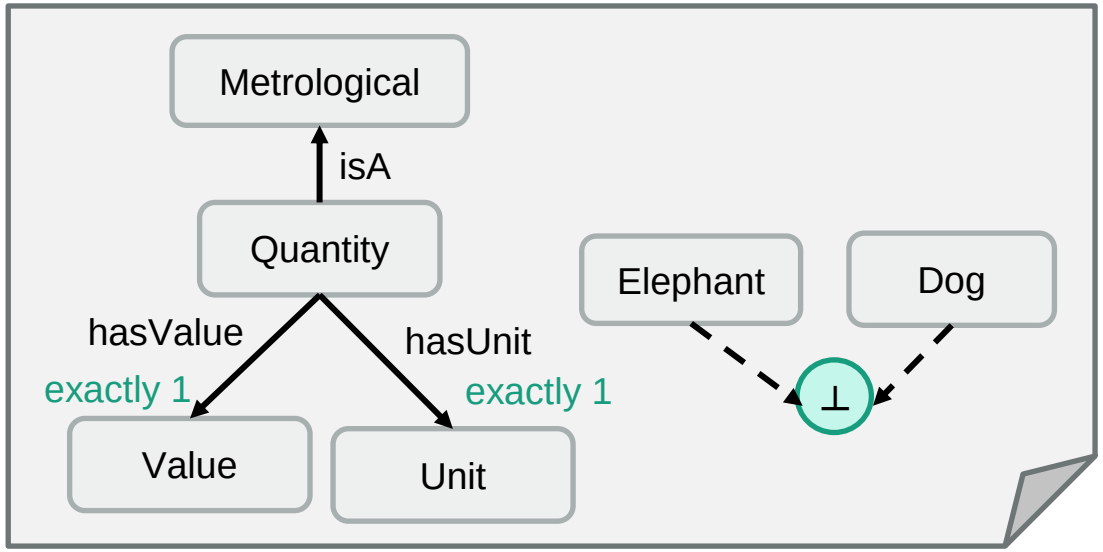
Thesaurus

Ontology

Less Expressivity

More Expressivity

- Relies on formal logics – DL, FOL
- Axioms, inference
- PartOf, Disjointness, Inversiveness



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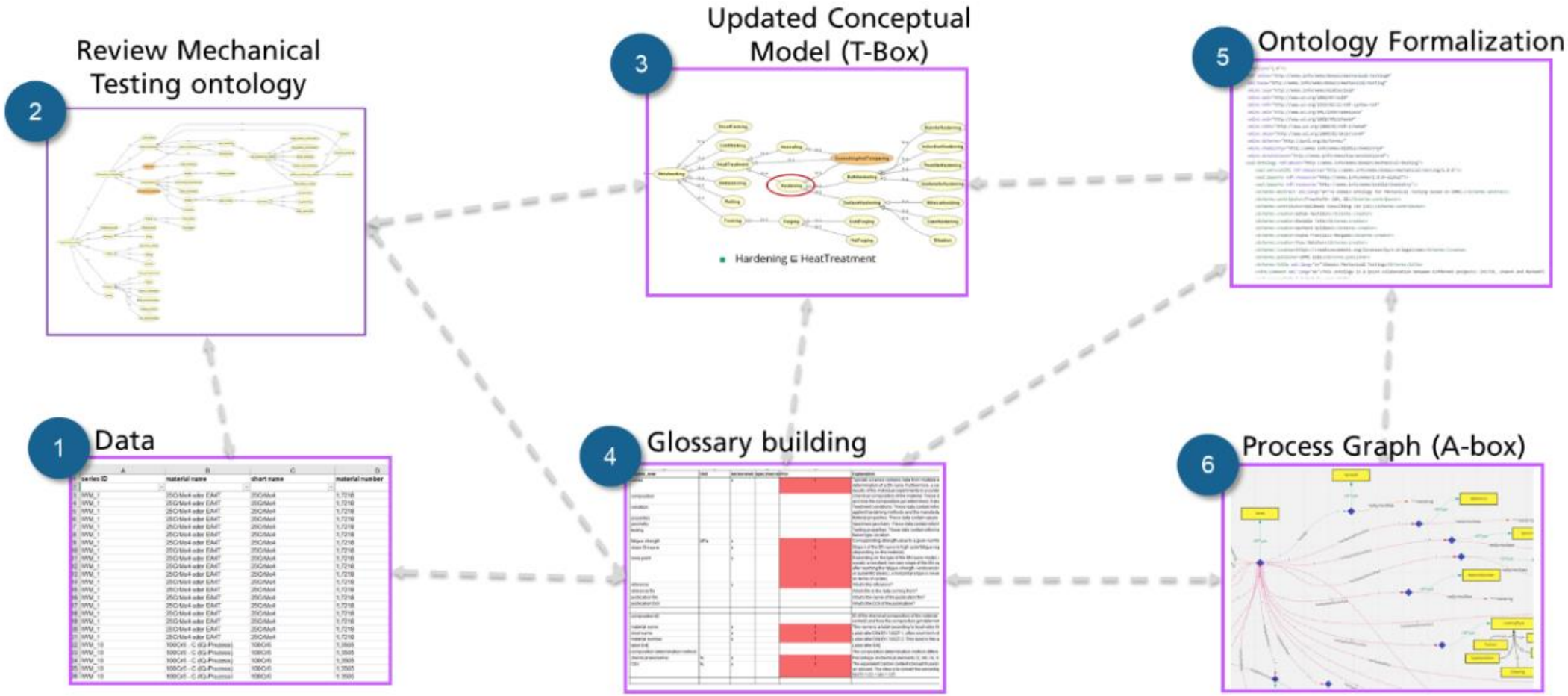
Ontology and Knowledge Graph

Best practise guide

- Vorgehensweise zur Erstellung von Domänenontologie und Wissensgraph



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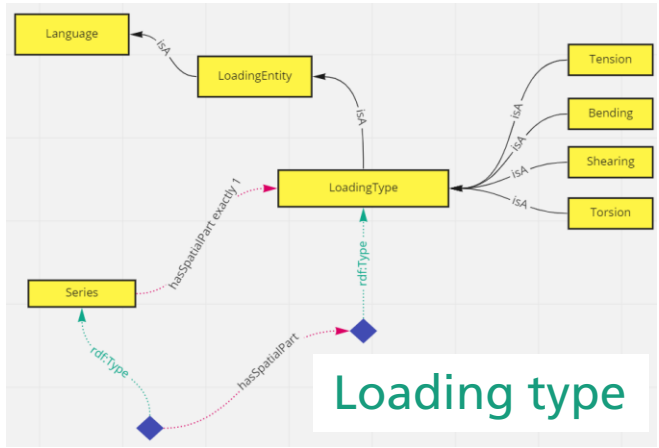
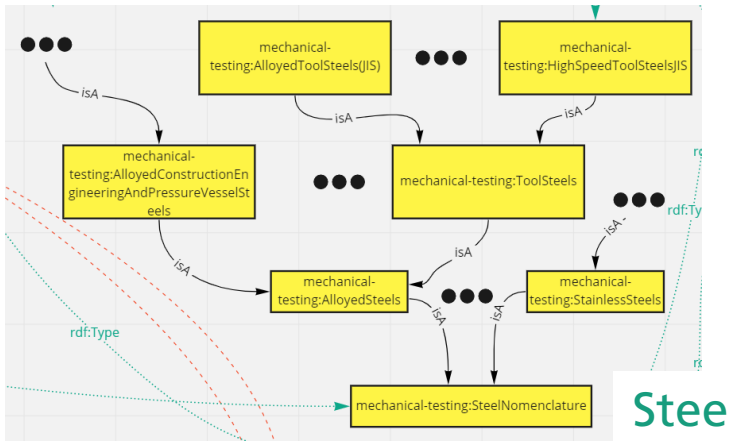
Ontology and Knowledge Graph
Domain ontology

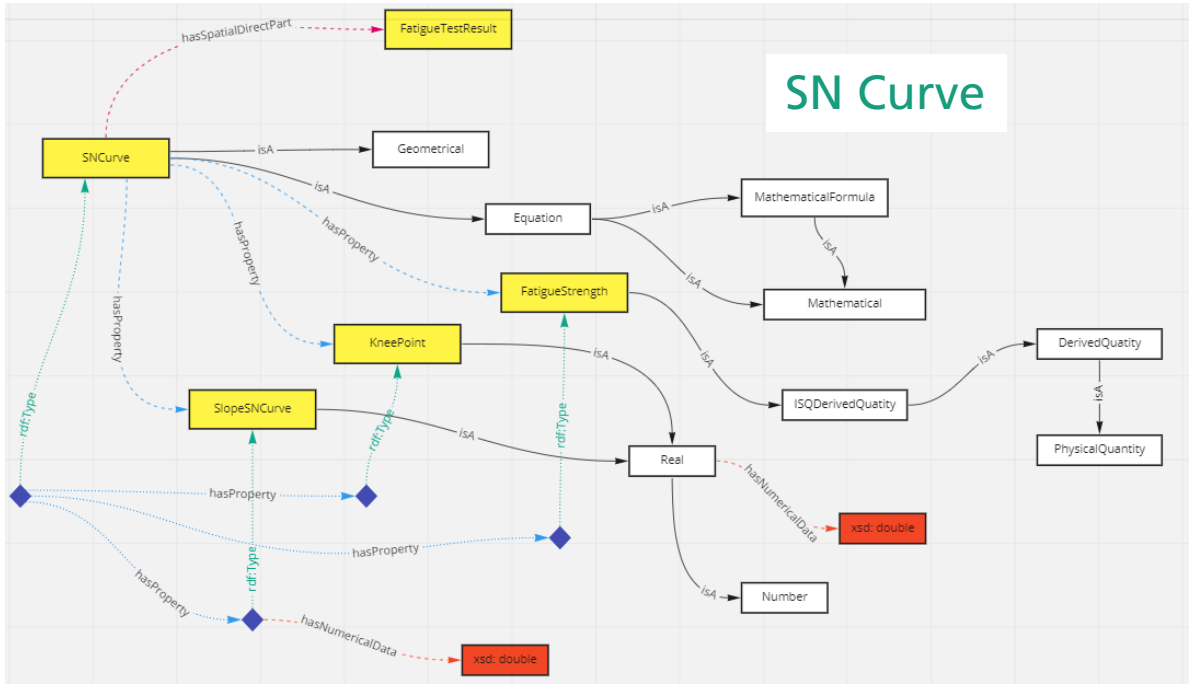
- Defining the fatigue „vocabulary“ in EMMO Mechanical Testing [1]



Loading type



Steel Nomenclature



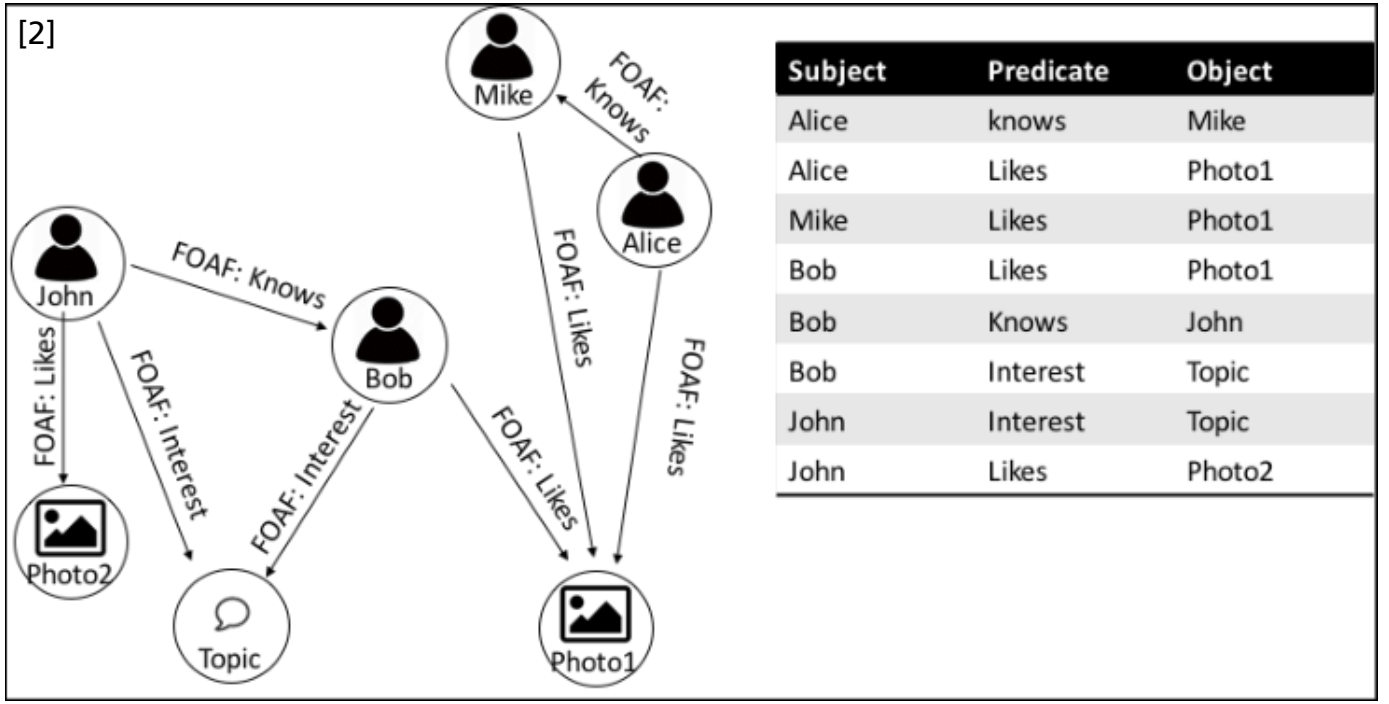
SN Curve

[1] Elemental Multiperspective Material Ontology (EMMO)
Mechanical Testing Domain Ontology: https://github.com/emmo-repo/domain-mechanical-testing

Ontologie & Wissensgraph
Datenformat (RDF)

- Resource Description Framework
- W3C data model standard
  - A *directed graph* consisting of triple statements: subject, predicate and object
  - Text serialization formats: XML-based, JSON-based, turtle…
- Best handled in a triplestore
- Queriable with SPARQL
- Ontology and knowledge graphs can be stored as RDF

[2]

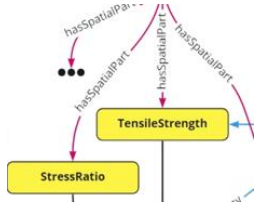


Subject	Predicate	Object
Alice	knows	Mike
Alice	Likes	Photo1
Mike	Likes	Photo1
Bob	Likes	Photo1
Bob	Knows	John
Bob	Interest	Topic
John	Interest	Topic
John	Likes	Photo2

[2] Hajeer, Mustafa & Dasgupta, Dipankar. (2016). Distributed genetic algorithm to big data clustering. 1-9. 10.1109/SSCI.2016.7849864.

Ontologie & Wissensgraph

Vorgehensweise Mapping & Integration



Ontology concepts

RDF
(resource description framework)

Triple store

Query (e.g. SPARQL)

Raw data

series ID	S_a	cycles	...
	MPa		...
TOTMAT_588	392	120000	...
TOTMAT_588	343	570000	...
TOTMAT_588	440	33000	...
...	...	...	...

Data integration

Mapping workflow

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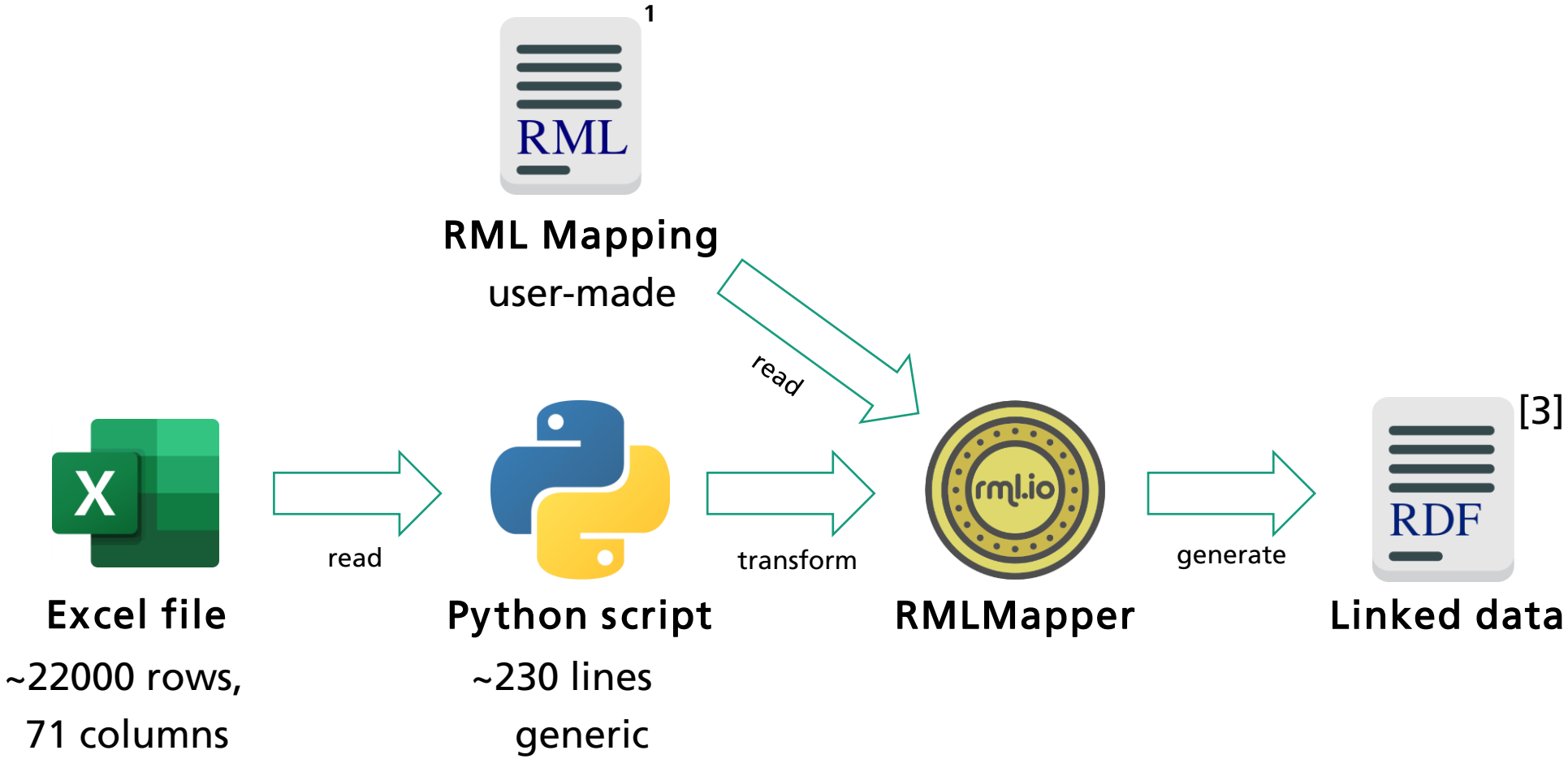
Ontologie & Wissensgraph

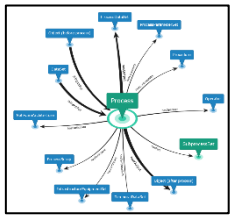
Mapping Workflow: RML Workflow (fatigue database)



[3] By Emoji One, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=60087501.

Ontologie & Wissensgraph

Mapping Workflow: IWM Graph Designer (100Cr6 steels)



KnowledgeBase Builder

Process schema for single process (KDB file)

2. KDB2Excel

Excel process template with triples and „user variables“ prepared to be filled by user with process metadata

3. Excel2RDF

RDF file containing a data set as an ontology with the structure given in the process schema

4. Import

Graph database

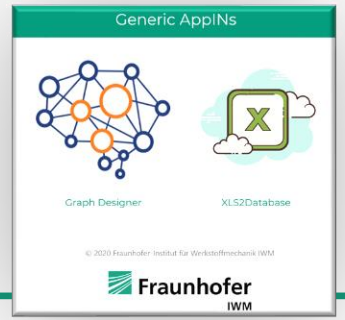
5. SPARQL queries

1. OWL2KDB

Define accepted vocabulary and graph logic

protégé

Graph Designer tool: gdtool.py also available as online apps



jupyter + SPARQL

Knowledge extraktion

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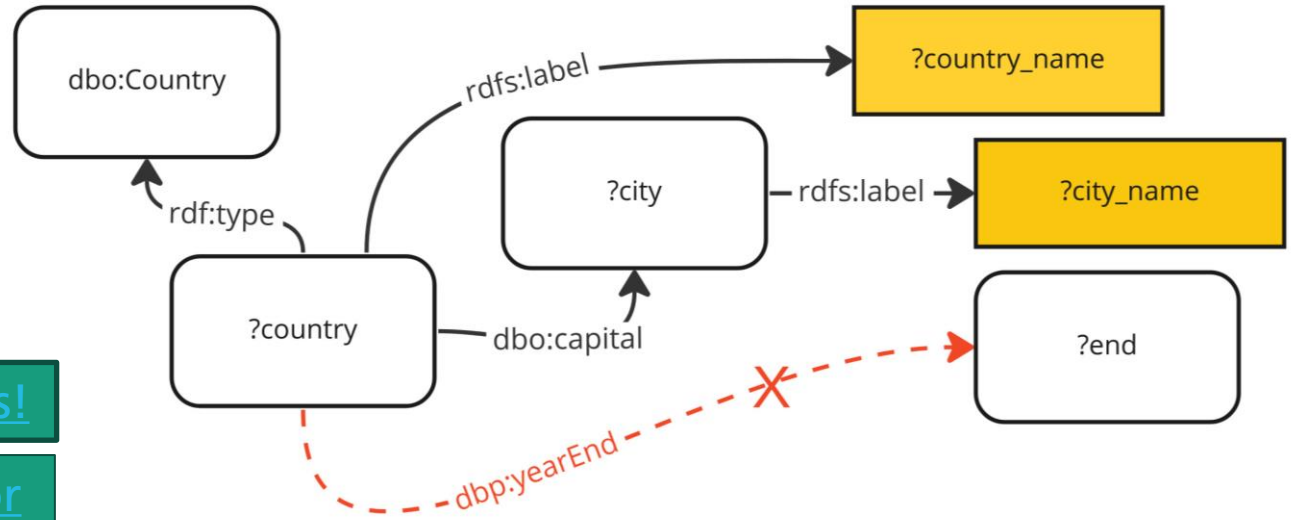
Ontologie & Wissensgraph
Datenabruf (SPARQL)

- SPARQL Protocol And RDF Query Language
- Querying RDF (**R**esource **D**escription **F**ramework) data in graph databases taking into account the relationships between the data
- A SPARQL query describes a **pattern** to match
- Example: match pattern to obtain country names and their capital cities from DBpedia.

```
PREFIX dbo: <http://dbpedia.org/ontology/>
[…]
SELECT DISTINCT ?city_name ?country_name WHERE {
   ?country rdf:type dbo:Country ;
            rdfs:label ?country_name .
   FILTER NOT EXISTS { ?country dbp:yearEnd ?end }
   ?country dbp:capital ?city .
   ?city rdfs:label ?city_name .
   […]
} ORDER BY ?country_name
```

Show results!

Query editor



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UseCase1: Fatigue Datenbank
Einführung

- Large fatigue database for 110 materials (high strength steels)
- AIM: Systematic queries based on domain ontology describing the fatigue use case

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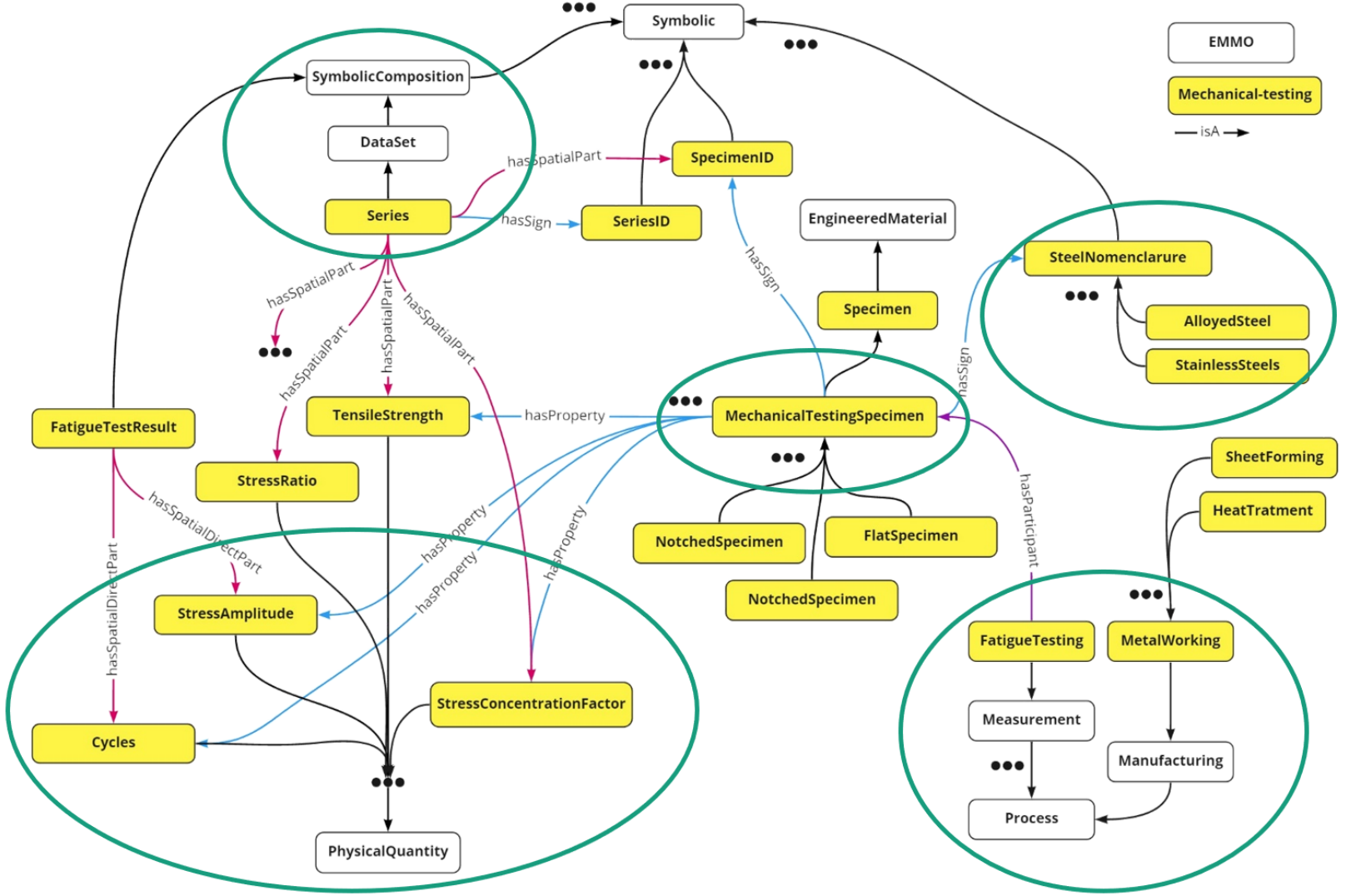
UseCase1: Fatigue Datenbank

Intro & process graph

- Full process graph
  see Miro Board



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UseCase1: Fatigue Datenbank
See live demo (Python Notebook)

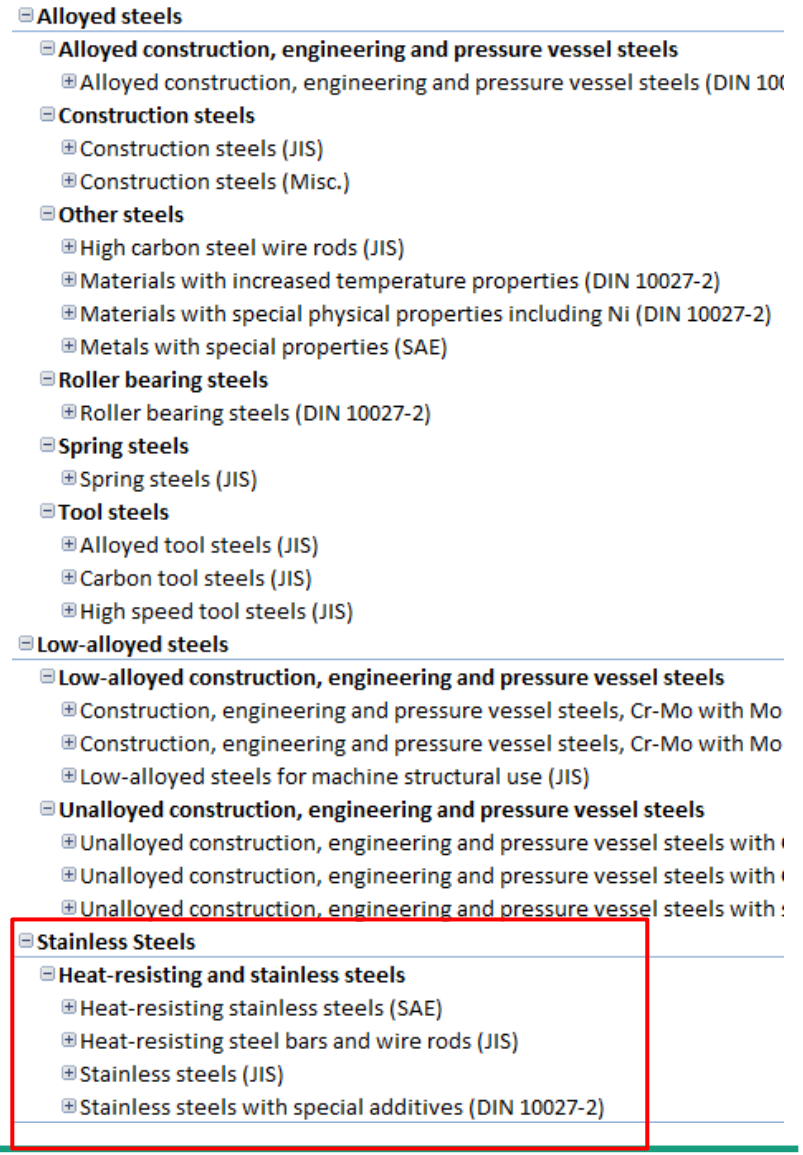
- **Select / filter queries**
  - 1: Select all series / materials with a fatigue strength > 800 MPa. What is the surface hardness and CEV for these materials?
  - 4: Select all specimens, their fatigue strength and their surface hardness.

- **Group / aggregate queries**
  - 5: Group series by loading type, determine min, max, average R ratio.
  - 6: Group all series based on material and select groups with a minimum hardness of 500. Order with decreasing hardness.

UseCase1: Fatigue Datenbank

See live demo (Python Notebook)

- **Examples for reasoning/use of ontology**
  - **Example 1: Steel categories**
    → querying the data from a certain steel category (e.g. StainlessSteels)



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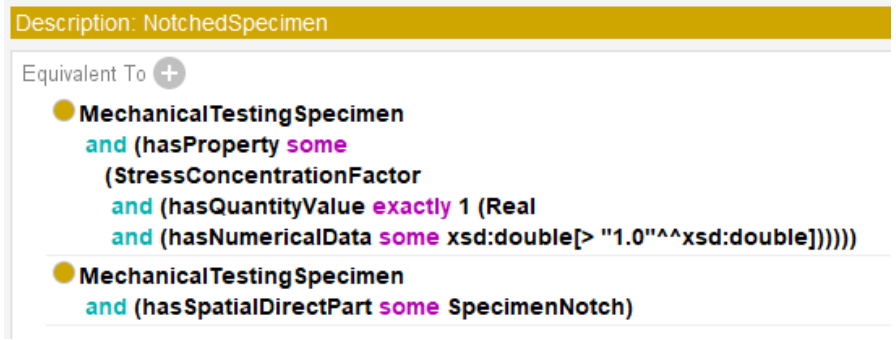
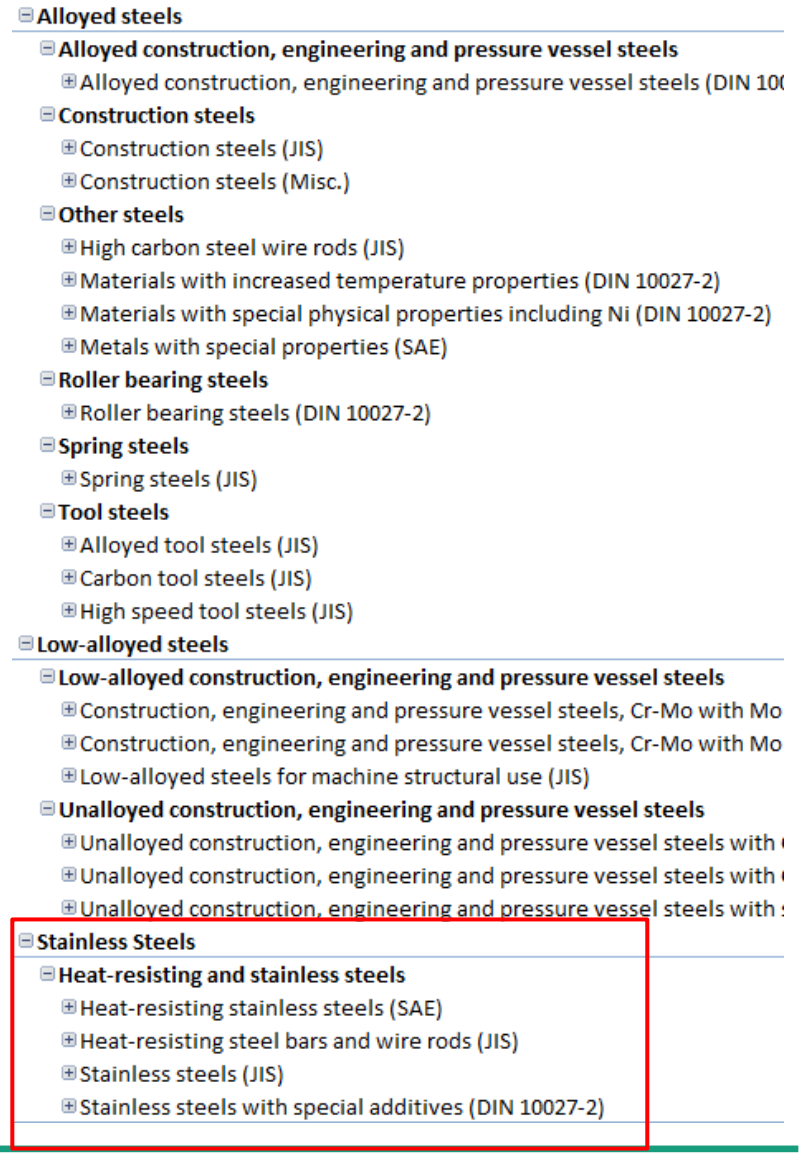
UseCase1: Fatigue Datenbank

See live demo (Python Notebook)

- **Examples for reasoning/use of ontology**
  - **Example 1: Steel categories**
    → querying the data from a certain steel category (e.g. StainlessSteels)
  - **Example 2: Stress concentration factor**
    → Stress concentration factor K_t > 1.0 → specimen features a notch





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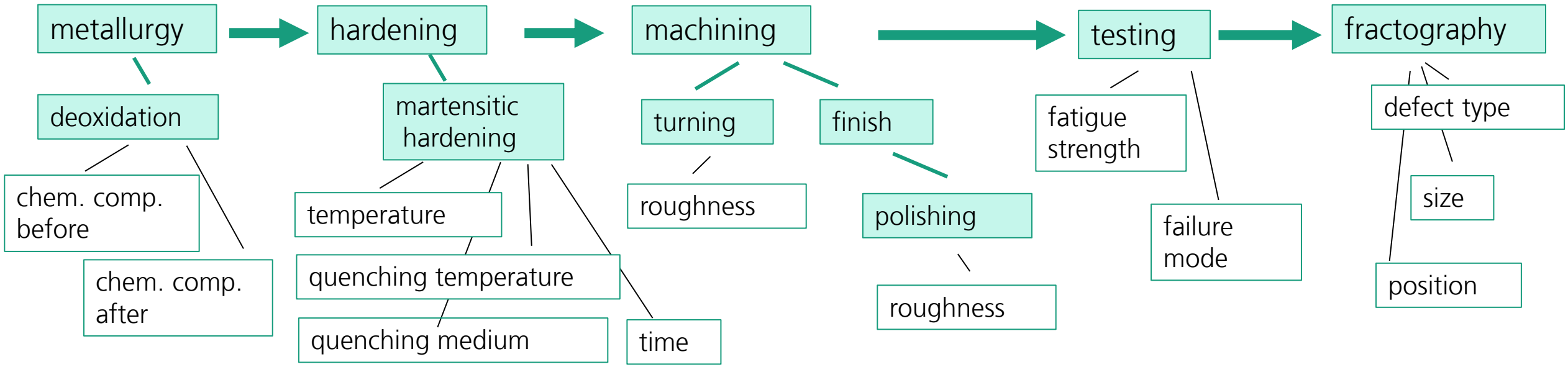
UseCase2: 100Cr6 Prozesshistorie

Intro & process graph

process steps

parameters / numerical values

- Overview process history / modular approach
- Full process graph see Knowledge Base Builder



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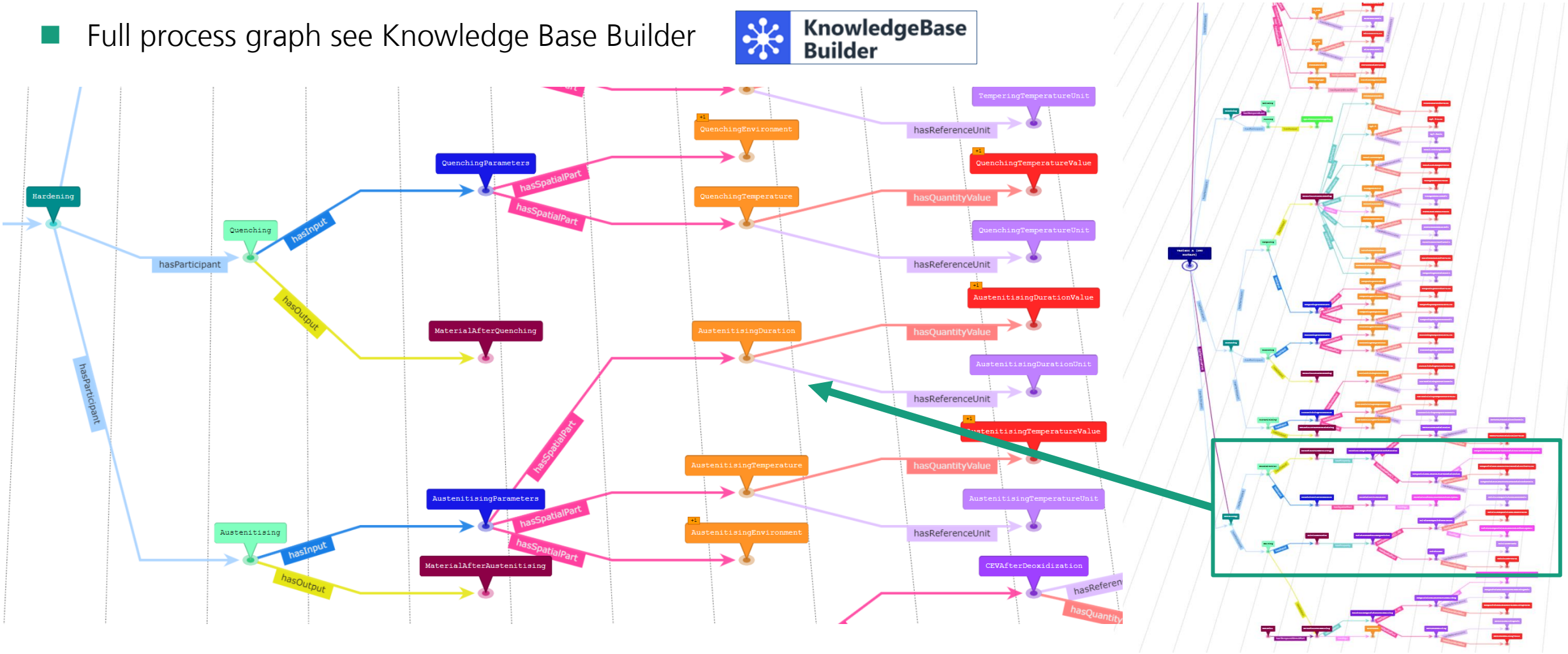
UseCase2: 100Cr6 Prozesshistorie

Intro & process graph

- Full process graph see Knowledge Base Builder



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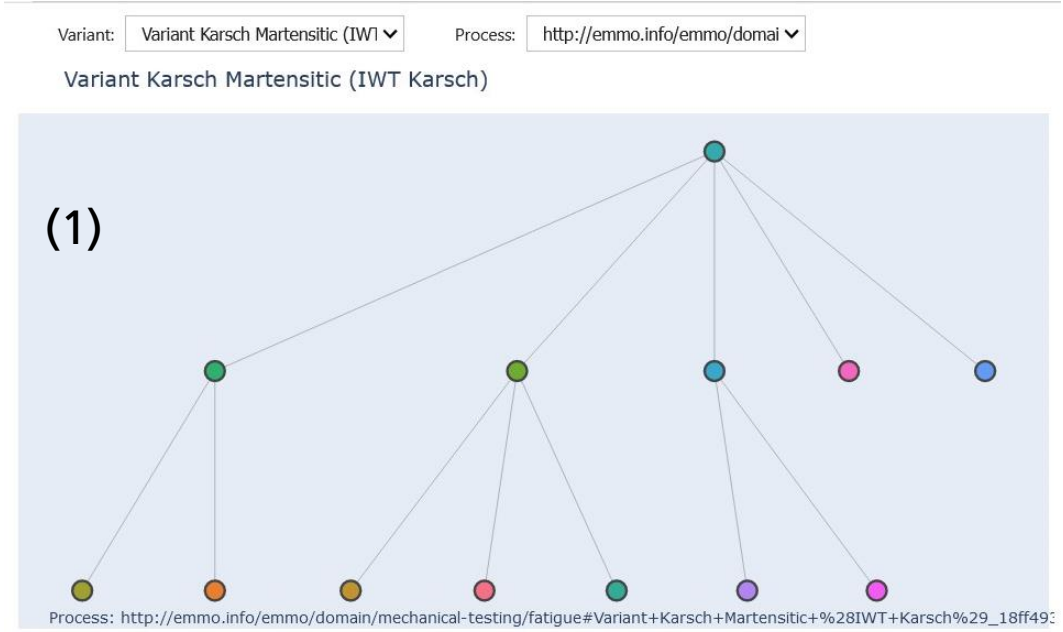
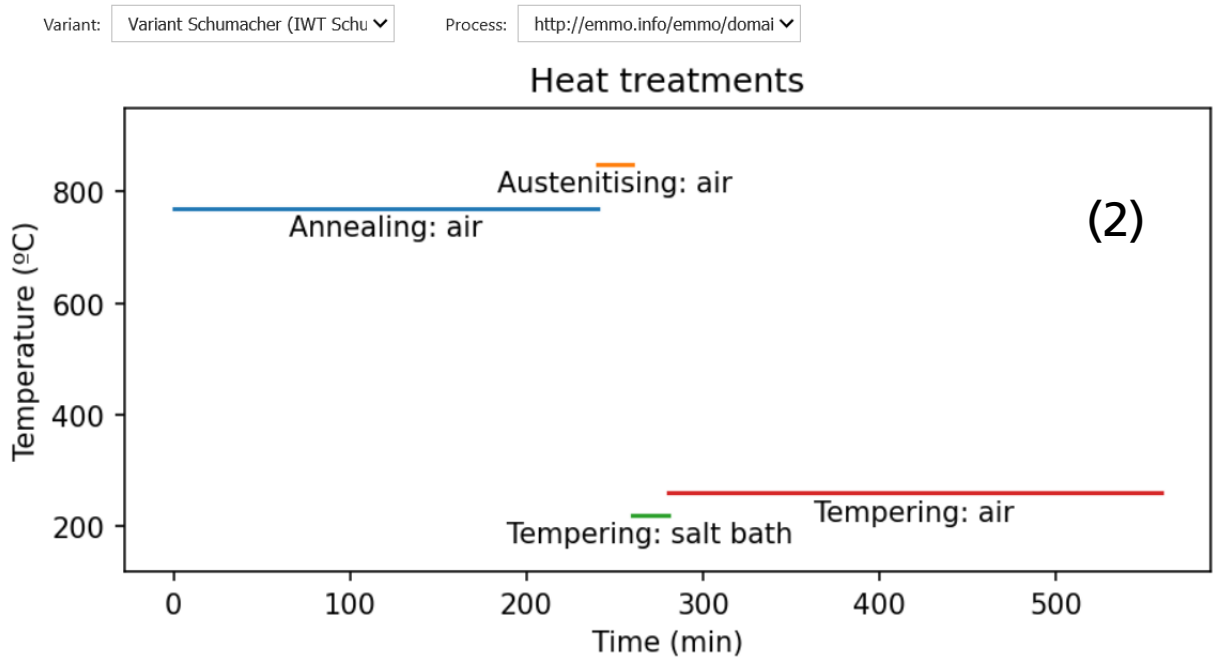
UseCase2: 100Cr6 Prozesshistorie

See live demo (Python Notebook)

- **Demo 1:** Retrieve process sequence by SPARQL and display hierarchical structure by Python widget
- **Demo 2:** Query and plot the heat treatment history for the different material variants





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