

Knowledge Graphs

Lecture 5 – Ontological Engineering for Smarter Knowledge Graphs

5.3 How to design better Ontologies

Prof. Dr. Harald Sack

FIZ Karlsruhe – Leibniz Institute for Information Infrastructure

AIFB – Karlsruhe Institute of Technology

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FIZ Karlsruhe

Leibniz-Institut für Informationsinfrastruktur

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Lecture 5: Ontological Engineering for Smarter Knowledge Graphs

5.1 Beyond the Limits of OWL

Excursion 7: The Semantic Web Rule Language SWRL

5.2 How to design your own Ontology

5.3 How to design better Ontologies

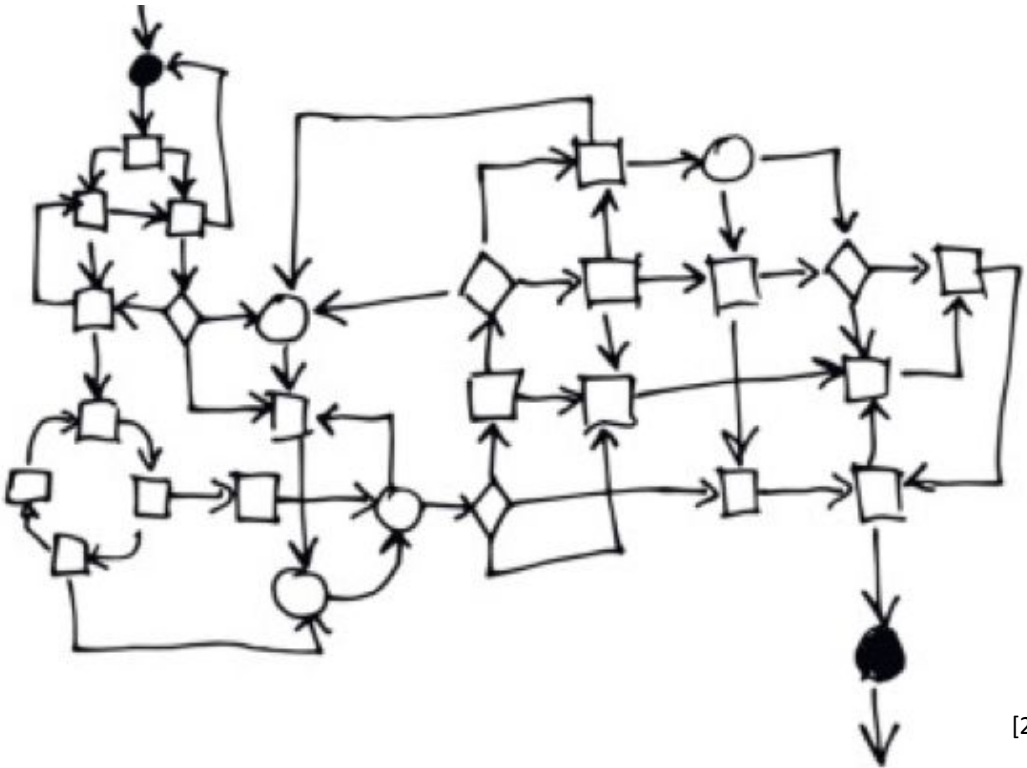
5.4 Ontological Engineering

5.5 Knowledge Graph Construction

5.6 Ontologies & Knowledge Graphs – Best Practices

The Ontology Development Process

SOMETHING



[2]

Great Ontology

How to compare Ontologies?

- **Ontologies** are not the **reality**
- Ontologies are a **context-dependent projection (model)** of the reality
- Ontologies are **engineering artefacts**
- Ontologies are **shared** among different components for potentially different tasks
- Ontologies might be **reused** in unexpected ways
- Ontologies are used to **integrate heterogeneous data sources**

⇒ **Evaluation of Ontologies is necessary, but difficult...**

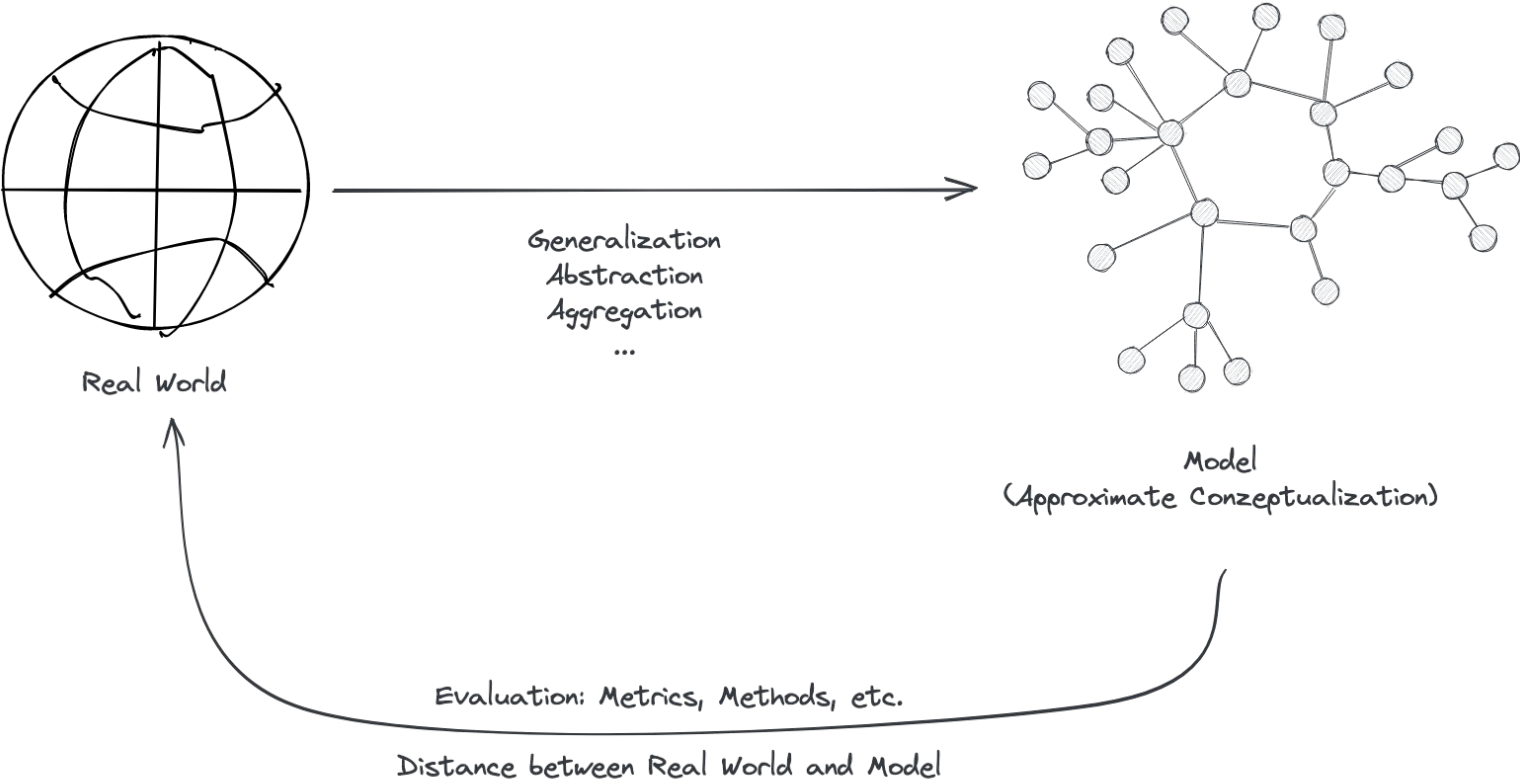
Ontology Evaluation

- **Ontology Evaluation** in general can be defined as the process of **deciding the quality of an ontology** with respect to a particular criterion with the view of determining which in a collection of ontologies would best suit a specific purpose.
- **Goal:**
 - compare the ontology with the **specification requirements** and (if available) gold standards
 - by taking into account **evaluation criteria** and applying various **evaluation approaches**,
 - yielding **evaluation results** and advices on how to improve the ontology.

Contexts of Ontology Evaluation

- **Ontology Verification:**
 - checks the **encoding of the specification**
 - detects **errors**, e.g. circular class hierarchies, redundant axioms, inconsistent naming schemes etc.
 - confirms that the ontology has been built according to certain specified ontology **quality criteria**
- **Ontology Validation:**
 - checks whether the **meaning of the definitions matches** with the **conceptualization** the ontology is meant to specify
 - the goal is to show that the **world model is compliant with the formal model**

Contexts of Ontology Evaluation



Criteria for Ontology Evaluation (1/4)

- **Accuracy:**
 - Do axioms **comply** with the **expertise of the users**?
 - Does the ontology **capture and represent correctly** aspects of the real world?
- **Adaptability:**
 - Does the ontology offer the **conceptual foundation** for a range of anticipated tasks?
 - Can the ontology be **extended and specialized** monotonically, i.e. without the need to remove axioms?
 - Does the ontology **comply** with procedures for **extension, integration, and adaption**?

Criteria for Ontology Evaluation (2/4)

- **Clarity:**

- Does the ontology **communicate** effectively the **intended meaning** of the defined terms?
- Are the definitions **objective** and **independent of context**?
- Does the ontology use **definitions** or (partial) **descriptions**?
- Are the **definitions documented**?
- Is the ontology **understandable**?

- **Completeness:**

- Is the domain of interest appropriately **covered**?
- Are **competency questions** defined and can the ontology answer them?
- Does the ontology include **all relevant concepts** and their lexical representations?

Criteria for Ontology Evaluation (3/4)

- **Computational Efficiency:**
 - How easily and successfully can **reasoners** process the ontology?
 - How fast can the **standard reasoning processes** (satisfiability, instance classification, etc.) be applied to the ontology?
- **Conciseness:**
 - Does the ontology include **irrelevant axioms**?
 - Does the ontology specify the **weakest theory possible** and **define only essential terms**?
 - How weak are the **assumptions** regarding the ontology's **underlying philosophical theory** about reality?

Criteria for Ontology Evaluation (4/4)

- **Consistency:**

- Do the axioms lead to **contradictions** (logical consistency)?
- Are **formal** and **informal** description of the ontology consistent?
- Are any **representation choices** made purely for the convenience of notation or implementation?
- Does the translation from the knowledge level to the encoding show a minimal **encoding bias**?

- **Organisational Fitness:**

- Is the ontology **easily deployed** within the organization?
- Do tools within the organization put **constraints** on the ontology?
- Does the ontology meet **legal requirements**, etc.?

Measures for Ontology Evaluation

- Direct measurement of the mentioned criteria is difficult
- **Ontology Correctness**
 - **Accuracy**, e.g. via precision (*total number correctly found over whole knowledge defined in ontology*) and recall (*total number correctly found over all knowledge that should be found*)
 - **Completeness**, e.g. via coverage of encoded axioms and axioms in specification
 - **Consistency**, e.g. count terms with inconsistent meaning
- **Ontology Quality**
 - **Computational Efficiency**, e.g. via size
 - **Adaptability**, e.g. via coupling (*number of external classes referenced*) and cohesion (*number of root, leaf, avg. inheritance depth, etc.*)
 - **Clarity**, e.g. via number of word senses

Aspects of Ontology Evaluation

- Aspects describe choices (not necessities) being made during ontology design
- **Vocabulary** – set of all names (IRIs and literals)
- **Syntax** – different serialization syntax (RDF/XML, Turtle, n-triples, etc.)
- **Structure** – structure of an underlying RDF graph, can largely vary although representing the same semantics
- **Semantics** – an ontology describes a non-empty, infinite set of possible models, characterized by semantics
- **Representation** – relation between structure and semantics
- **Context** – in how far is the ontology different from other things around it, like an app that uses it, a data source it describes, or rules for using it

A detailed sci-fi illustration of a desert planet. In the foreground, a large, white, spherical floating structure with multiple windows and a small antenna is visible. Behind it, another similar but larger sphere floats. To the right, a tall, slender, metallic structure with a wide, circular top platform stands on the ground. The background features a vast, arid landscape with various industrial and architectural structures under a dark sky with a bright green comet streak and distant blue star-like lights.

Ontological Engineering

Next Lecture...

Bibliographic References:

- Brank, J., Grobelnik, M. & Mladenic, D. (2005). [*A survey of ontology evaluation techniques*](#). In Proceedings of the Conference on Data Mining and Data Warehouses (SiKDD 2005) (pp. 166–170) .
- Hlomani, H., & Stacey, D. (2014). [*Approaches, methods, metrics, measures, and subjectivity in ontology evaluation: A survey*](#). Semantic Web Journal, 1(5), 1–11.
- Vrandečić, D. (2009). [*Ontology evaluation*](#). In Handbook on Ontologies (pp. 293–313). Berlin, Heidelberg: Springer Berlin Heidelberg.

Picture References:

- [1] On this scifi movie poster we see the vibrant construction site of a gigantic space ship in the vast deserts of planet Mars exposing many small details.”, created via ArtBot, Deliberate, 2023, [CC-BY-4.0], <https://tinybots.net/artbot>
- [2] The Software Development Process, Geek & Poke, <http://geekandpoke.typepad.com/geekandpoke/2012/01/simply-explained-dp.html>
- [3] “On this scifi movie poster we see the vibrant construction site of a gigantic space ship in the vast deserts of planet Mars exposing many small details.”, created via ArtBot, Deliberate, 2023, [CC-BY-4.0], <https://tinybots.net/artbot>