TECHNISCHE UNIVERSITÄT DRESDEN

FOUNDATIONS OF SEMANTIC WEB TECHNOLOGIES

Ontology Engineering

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Why Ontology Engineering?

- ontology languages and reqasoners provide the technical infrastructure for using semantic technologies
- however: domain specific knowledge specifications (=ontologies) have to come from somewhere
- questions:
  - how to create (good, useful) ontologies?
  - how to judge ontology quality?

Why Ontology Engineering?

- many aspects of these questions are similar to problems of software engineering
- in both cases, complex artefacts are created (often in a collaborative way) that should be
  - correct
  - functional
  - comprehensible
  - reusable
  - etc.

Requirement Analysis

- ...always a good idea before one starts constructing an ontology:
  - is a semantic representation needed at all? (alternative: database solution)
  - if so, should it be a representation based on formal logic
    (alternative: textual representation, in particular if the purpose is human-to-human information exchange)
    - ✦ contra: cost of setting it up, established practice
    - ✦ pro: flexible usage/exchange
    - ✦ pro: reasoning allows for managing implicit knowledge

Bedarfsanalyse

- tool support
  - does the choice of a certain approach create dependencies to a specific tool?
  - under what license models are the necessary tools available
  - how stable/mature is the software?
  - what support is offered by the vendor?
  - are the available tools sufficiently interoperable?

Bedarfsanalyse

- functional aspects
  - what domain is to be modelled/ what aspects of that domain are to be represented?
  - what is the level of granularity of the information to be specified?
  - what tasks are supposed to be performed using the ontology?
    - browsing a body of knowledge
    - search for information
    - query processing
    - automated inferencing
- what inferences are wanted?

Ontology Creation

- there are many possible sources of knowledge that can be utilized:
  - humans
  - texts
  - webpages
  - databases
- these sources are different in terms of (i) how explicit and (ii) how structured the knowledge is

Humans

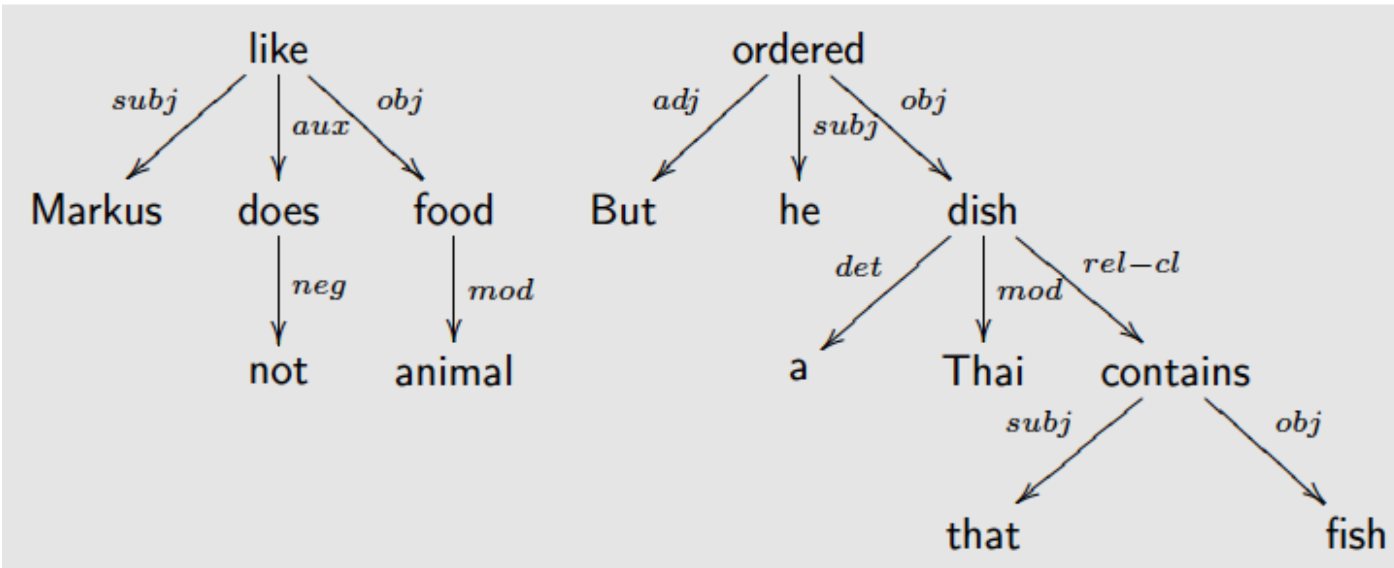
- domain experts = humans who have the required knowledge
- ...are normally not logicians and don‘t know ontology languages
- thus, often *knowledge engineers* are needed as „mediators“
- these must be knowledgeable in formal logic and have good communication skills

Texts

- accessible in a very direct way: digital textual resources, still: text != logic
- possibility: deployment of automated methods for extracting knowledge from text (*Ontology Learning*)
- different approaches:
    - pattern-based search for predefined relations (*Information Extraction*)
    - complete syntactic decomposition and conversion into logical expressions (*deep semantic analysis*)

Deep Semantic Analysis - Example

Markus does not like animal food. But he ordered a Thai dish that contains fish.



$$\neg\exists \texttt{likes}.(\texttt{Animal} \sqcap \texttt{Food})(\texttt{markus})$$
$$\exists \texttt{ordered}(\texttt{Dish} \sqcap \exists \texttt{contains}.\texttt{Fish})(\texttt{markus})$$

Semi-structured Resources

- as opposed to text, other digital documents such as web pages have more explicit structure (mark-up, links, etc.)
- these can be directly converted into e.g. RDF
- other examples:
  - wikis
  - file systems

Structured Resources

- databases are „fully structured“
- for coupling a database with an ontology a mapping is required that connects the database‘s schema part with classes and properties of the ontology
- then the data part of the ontology can be interpreted as ABox

Ontology Evaluation

- what makes a good ontology?
- there are different criteria, e.g.:
  - logical criteria
  - struktural/formal criteria
  - „correctness“

Logical Criteria

- consistency of KB or classes

$$\mathtt{Horse} \sqsubseteq \neg\mathtt{Flies}$$
$$\mathtt{FlyingHorse} \equiv \mathtt{Horse} \sqcap \mathtt{Flies}$$

- logical completeness

$$\mathtt{Bird} \sqsubseteq \neg\mathtt{Mammal} \qquad \mathtt{Bird(ostrich)}$$
$$\mathtt{Bird} \sqsubseteq \mathtt{Oviparous} \qquad \mathtt{Mammal} \sqcap \mathtt{Viviparous(lion)}$$
$$\mathtt{Oviparous} \sqsubseteq \neg\mathtt{Viviparous}$$

$$\mathtt{Mammal} \sqsubseteq \mathtt{Viviparous}$$

$$\mathtt{Mammal} \sqcap \mathtt{Oviparous(platypus)}$$

Structural Criteria

- investigation of class hierarchy:

$$\mathtt{Architecture} \sqsubseteq \mathtt{Faculty} \qquad \mathtt{Faculty} \sqsubseteq \mathtt{University}$$
$$\mathtt{University} \sqsubseteq \mathtt{Building} \qquad \mathtt{Building} \sqsubseteq \mathtt{Architecture}$$

- checking correctness is rather difficult (*grounding problem*)

Typical Modeling "Errors"

- omitting disjointness

$\mathtt{Man} \sqsubseteq \mathtt{Human}$ $\quad$ $\mathtt{Human} \sqsubseteq \mathtt{Man} \sqcup \mathtt{Woman}$ $\quad$ $\mathtt{Woman} \sqsubseteq \mathtt{Human}$

$\mathtt{Man(pascal)}$ $\quad$ $\mathtt{Woman(anne)}$

- omitting role characteristics
- domain / range too specific
- wrong interpretation of universal quantifier

$$\mathtt{Happy} \equiv \forall \mathtt{hasChild.Happy}$$

- mistaking „part of" for „subclass of"

$$\mathtt{Finger} \sqsubseteq \mathtt{Hand} \quad \mathtt{Hand} \sqsubseteq \mathtt{Arm} \quad \mathtt{Arm} \sqsubseteq \mathtt{Body}$$
$$\mathtt{Toe} \sqsubseteq \mathtt{Foot} \quad \mathtt{Foot} \sqsubseteq \mathtt{Leg} \quad \mathtt{Leg} \sqsubseteq \mathtt{Body}$$
$$\mathtt{Arm} \sqcap \mathtt{Leg} \sqsubseteq \bot$$

Typical Modeling “Errors“

- direction of property unclear

```
ex:author   rdfs:range    ex:Publication .
ex:author   rdfs:domain   ex:Person .
ex:macbeth  ex:author     ex:shakespeare .
```

- subclasses vs. equivalence
- too „verbal“ translation...

Modularisation / Patterns

- facilitates reuse
- allows for faster reasoning
- usage of „best practices“

Ontology Refinement

(semi)automatic „improvement“ of ontologies

- ontology repair
- ontology update / evolution
- logical completion of ontologies