TECHNISCHE UNIVERSITÄT DRESDEN

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Foundations of Semantic Web Technologies

Ontology Engineering

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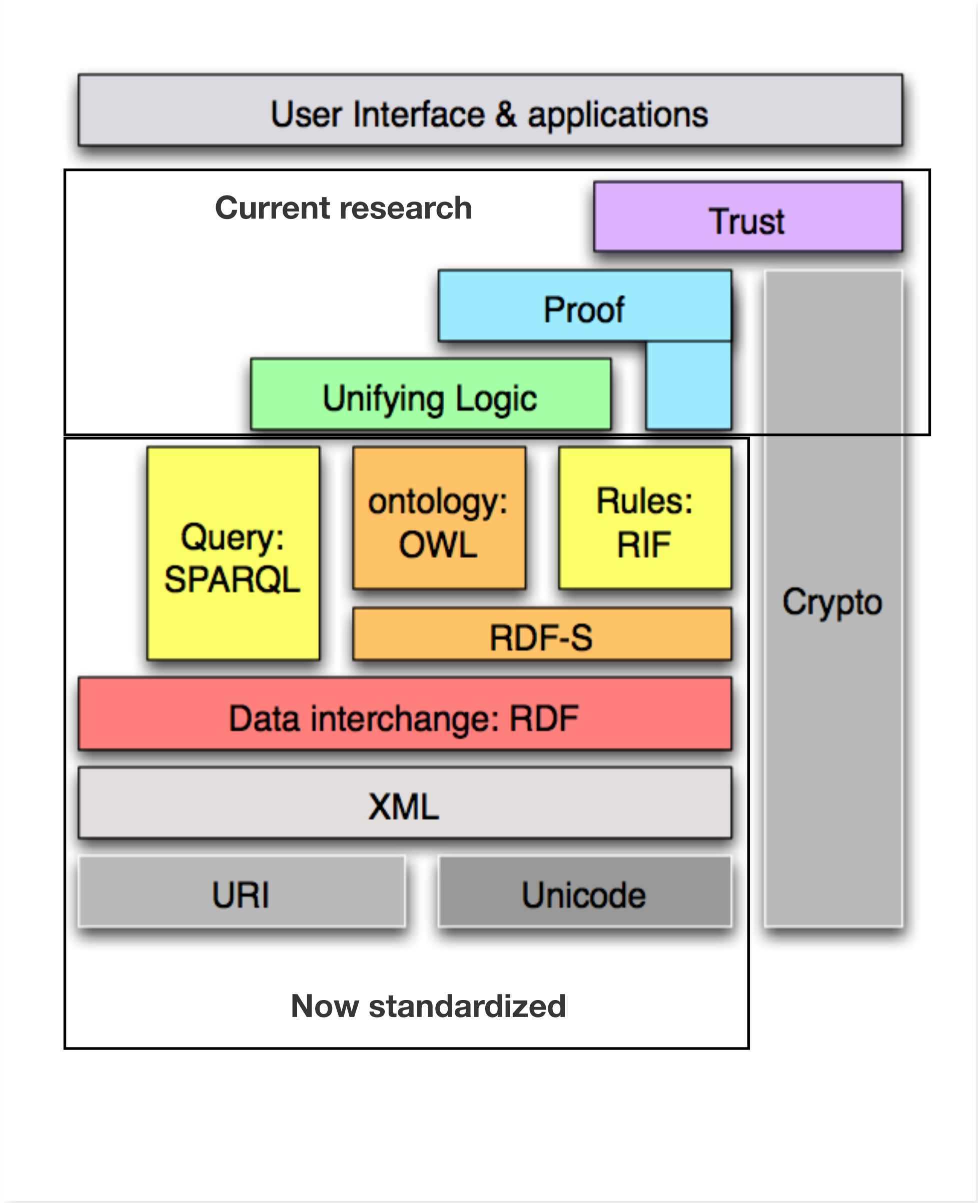
Ontology Engineering



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

Requirement Analysis

- 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?

Requirement Analysis

- 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

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- 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

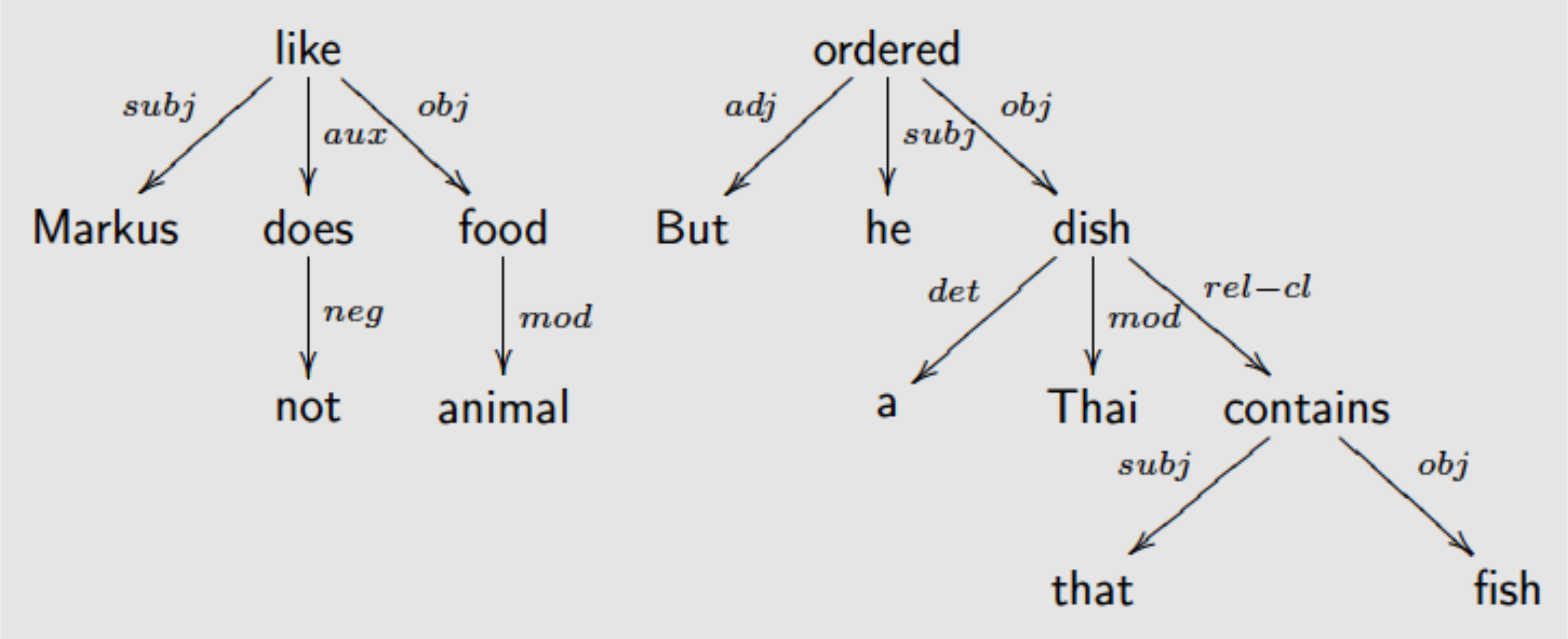
- domain experts = humans who have the required knowledge
- ...are normally not logicians and don‘t know ontology languages
- thus, often *knowledge engineers* are needed as „mediators“
- these must be knowledgeable in formal logic and have good communication skills

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

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

Logical Criteria

- consistency of KB or classes

$$\begin{aligned} \texttt{Horse} &\sqsubseteq \neg\texttt{Flies} \\ \texttt{FlyingHorse} &\equiv \texttt{Horse} \sqcap \texttt{Flies} \end{aligned}$$

- logical completeness

$$\begin{aligned} \texttt{Bird} &\sqsubseteq \neg\texttt{Mammal} & \texttt{Bird(ostrich)} \\ \texttt{Bird} &\sqsubseteq \texttt{Oviparous} & \texttt{Mammal} \sqcap \texttt{Viviparous(lion)} \\ \texttt{Oviparous} &\sqsubseteq \neg\texttt{Viviparous} \end{aligned}$$

$$\texttt{Mammal} \sqsubseteq \texttt{Viviparous}$$

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

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Structural Criteria

- investigation of class hierarchy:

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

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

Typical Modeling "Errors"

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- omitting disjointness

$$\text{Man} \sqsubseteq \text{Human} \qquad \text{Human} \sqsubseteq \text{Man} \sqcup \text{Woman} \qquad \text{Woman} \sqsubseteq \text{Human}$$
$$\text{Man(pascal)} \qquad \text{Woman(anne)}$$

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

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

- mistaking „part of“ for „subclass of“

$$\text{Finger} \sqsubseteq \text{Hand} \qquad \text{Hand} \sqsubseteq \text{Arm} \qquad \text{Arm} \sqsubseteq \text{Body}$$
$$\text{Toe} \sqsubseteq \text{Foot} \qquad \text{Foot} \sqsubseteq \text{Leg} \qquad \text{Leg} \sqsubseteq \text{Body}$$
$$\text{Arm} \sqcap \text{Leg} \sqsubseteq \bot$$

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