Reasoning with Ontology Mappings

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The Semantic Web

- Movement led by the World Wide Web Consortium (W3C)
  - Common formats for integration and combination of data
  - Knowledge representation of how data relates to real-world objects

"A web of data that can be processed directly and indirectly by machines."

– Tim Berners-Lee [2]

What is the Problem?

- Many tasks require correct and meaningful communication and integration among intelligent agents and information resources

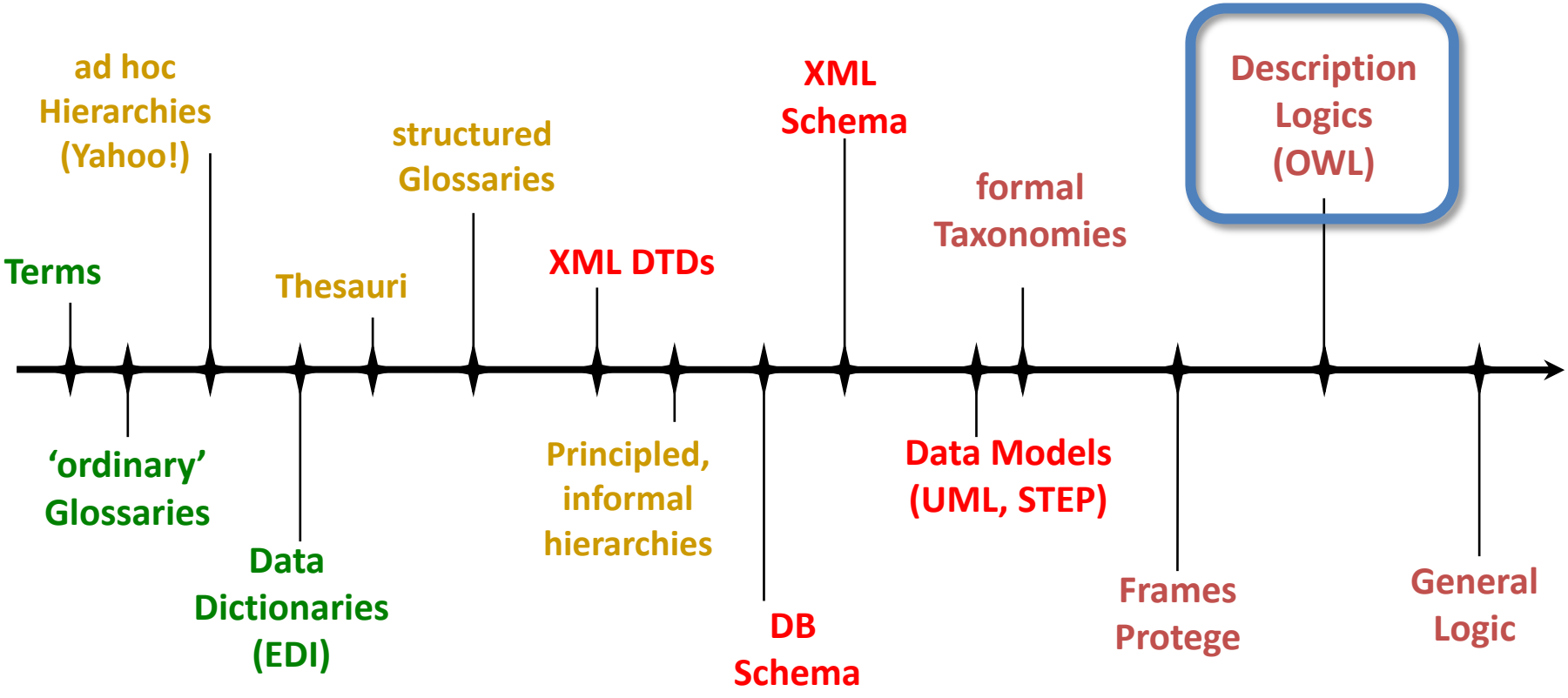
- Barriers to *semantic* interoperability [3]:
  - Different applications
  - Different databases
  - Different web agents

- All assign different meanings to the same terms or use distinct terms to convey the same meaning

What are ontologies? How do we use them?

- Ontology – commonly shared conceptualisation of knowledge with a specification of the meaning (*semantics*) of terms
  - Examples: different meanings for the word ‘spring’
- Applications [5][8]:
  - Common access to information
  - Ontology-based search (e.g., Swoogle)
  - Software specification with automation
- How do we represent ontologies in a way computers can use them?

Kinds of Ontologies



Glossaries & Data Dictionaries

Thesauri, Taxonomies

Metadata, XML Schemas, & Data Models

Formal Ontologies & Inference

Figure 2 in [8]

Representing Concepts in OWL

- Web Ontology Language (OWL)
  - Official language of the W3C
  - Used especially in biomedical ontologies (OBO Foundry, NCBO BioPortal) and search engines (Swoogle)

```
<owl:Class rdf:ID="spring">
  <owl:intersectionOf rdf:parseType="Collection">
    <owl:Class rdf:about="#Artifact"/>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#component"/>
      <owl:hasValue rdf:Resource="#Mechanical"/>
    </owl:Restriction>
  </owl:intersectionOf>
</owl:Class>
```

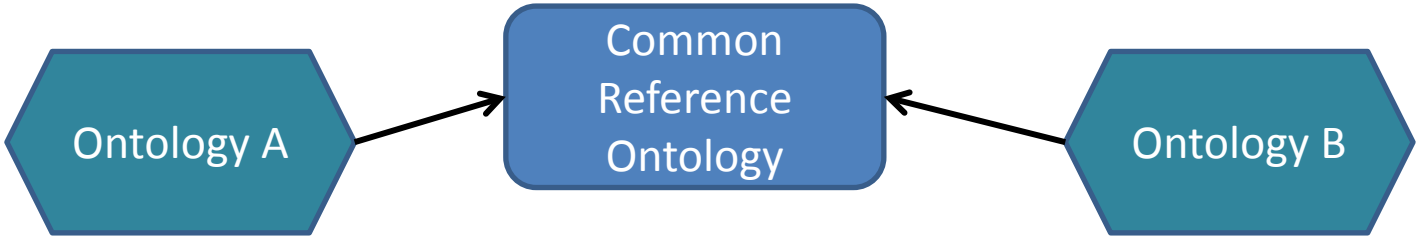
Why bother?

- To preserve semantics for seamless exchange of information, *mappings* need to be made between *logically equivalent concepts* in each ontology [6]

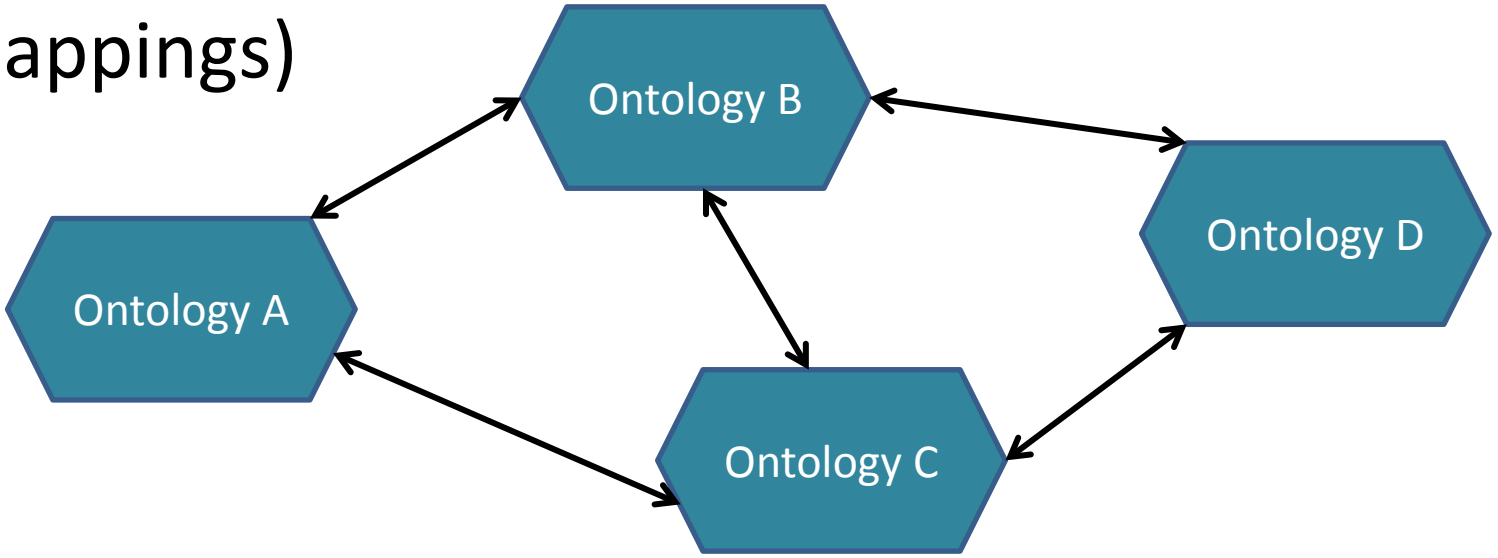
- Challenges that arise:
  - Generating these mappings,
  - Determining that they are correct, and
  - Providing a vehicle for executing the mappings
    - Translating terms from one ontology into another.

Current Mapping Solutions

- Interlingua (Upper Level Ontologies)



- Network of Ontologies (Chain/Community Mappings)



Key Questions to Address

- How do researchers in the community represent their ontologies (input) and mappings (output)?
  - Represented in natural language (text) or KR languages like OWL?
- Is their mapping representation computer-interpretable?
  - Can we reason and make inferences using these mappings?
- How are these mappings used in practice? Are they *sound* and *complete*?
- Is ontology mapping the same as ontology design?
  - Do mapping techniques in literature arise from incomplete ontologies?
  - If so, how does one go about improving the ontologies before mapping?

Current Findings

- Majority of mappings are produced differently
  - Not everyone represents them in OWL, some are just listed as natural language
  - What is the standard? Is there a standard?

- Greater focus on mapping algorithms than reasoning aspects
  - Many tools for mappings (OntoMap, ToMas, OntoMerge, OMEN, DCM Framework, etc.)
  - Little discussion about reasoning with these generated mappings

Future Work

- Verification of mappings using semi-automatic theorem proving with Prover9 software:
  - Determine the mappings between Hilbert and Tarski's axioms for geometry
  - Determine the mappings between time interval and time point ontologies in the COmmon Logic Ontology REpository (COLORE) developed by STL

- Demonstrate that reasoning can be applied in CAD systems that use two different ontologies for measurements
  - Catia V5, SolidWorks, etc.

Future Work: Reasoning with Mappings in CAD Systems

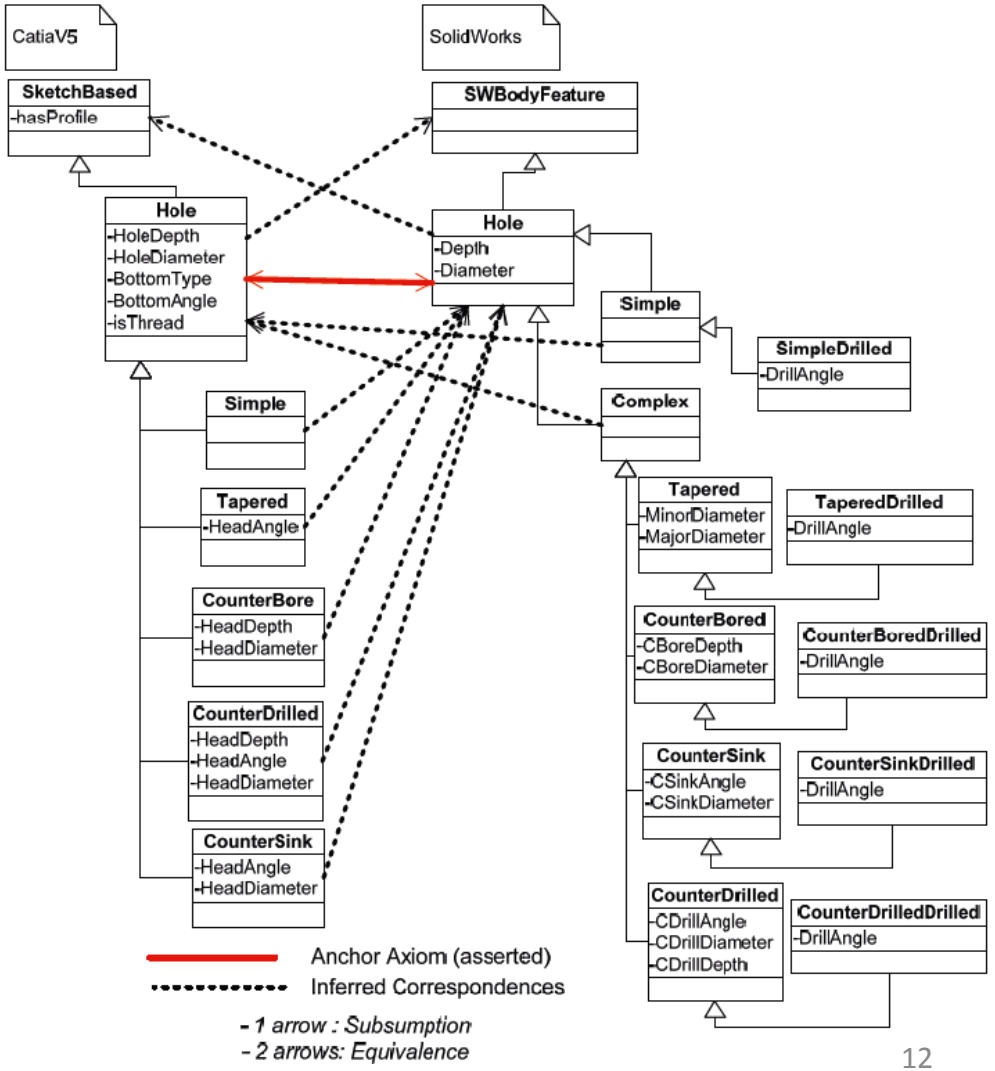
Catia V5, SolidWorks

- Classification of ‘Hole’
- Represented differently in both
  - Ex: defining the bottom angle of a hole

Catia:hasBottomAngle (Catia:Hole, Angle)
SW:hasDrillAngle (SW:ComplexHole, Angle)

- After mapping, inferences made:

$$SW:SimpleDrilled \sqsubseteq Catia:Hole$$
$$SW:TaperedDrilled \sqsubseteq Catia:Hole$$
$$SW:CounterBoreDrilled \sqsubseteq Catia:Hole$$
$$SW:CounterSinkDrilled \sqsubseteq Catia:Hole$$
$$SW:CounterDrilledDrilled \sqsubseteq Catia:Hole$$



Source Material from Figure 2 in [1], and [2]

Any questions?

THANK YOU

References

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