Domain Reference Ontologies

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What is a domain reference ontology?

Three main criteria for classifying ontologies:

1. **Purpose**

2. **Scope**
   - Top-level (upper or foundational) ontologies (like BFO or DOLCE)
   - Generic (mid-level) ontologies (like OWL-Time, Geosparql, SOSA, ...)
   - Domain ontologies
     - Domain reference ontologies: *unifying a domain and tying the various domain ontologies to top-level and generic ontologies*
     - Application ontologies

3. **Representation Format**

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What does a domain reference ontology look like?

- Exhibits many characteristics of foundational ontologies: 
  *foundational for their domain*

1. Foundationally grounded
2. Broad coverage on the highest level in the domain: focuses on the key concepts and relations in the domain; but does not aim to capture the domain comprehensively
   - concepts that allow to link concepts and relations across domain ontologies
3. Specified in a highly expressive and fully machine-interpretable ontology language
   Provides “neutral” language to express semantic differences; Purpose is not to directly define the scientific terms (e.g. aquifer), but ontological helper concepts and relations
What does a domain reference ontology look like?

<table>
<thead>
<tr>
<th>Top-level Ontology</th>
<th>e.g., BFO, DOLCE, UFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic Ontology</td>
<td>e.g., HyFO</td>
</tr>
<tr>
<td>Domain Reference Ontology</td>
<td>e.g., GWML, INSPIRE</td>
</tr>
<tr>
<td>Domain Ontology</td>
<td>e.g., NHD</td>
</tr>
<tr>
<td>Application Ontology</td>
<td></td>
</tr>
</tbody>
</table>

- e.g., Location, Time
- e.g., HyFO
How is a domain reference ontology useful?

... not just another standard but represents deep knowledge of core domain concepts in a level of detail such that other domain ontologies/standards can be expressed using this terminology.

Example: Hydro Foundational Ontology (HyFO) as a domain reference ontology for the hydrology domain

- Role similar to an upper ontology but more specific about water concepts
- Helps to clarify semantics of water data standards in a unified language
- Supports formal ontological analysis of existing water data standards (e.g., GWML2)

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**DOLCE**
- Non-Agentive Physical Object
  - Hydro Rock Body
  - Geologic Unit
  - Aquifer Unit
  - Aquifer
  - Aquifer System
  - Basin
  - Confining Bed

**HyFO**
- Dependent Place Feature
  - Hydro Void
  - Hydrogeo Void
  - Aquifer Unit
  - Well
  - Well Water Body
  - Basin
  - Aquifer

**GWML2**
- Matter
  - Water Matter
  - Earth Material
  - Constituent
  - FB Surface
  - Spring
  - Interflow
  - Intraflow
  - Flow
  - Discharge
  - Recharge

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- Supports formal ontological analysis of existing water data standards (e.g., GWML2)
  - Axiomatic foundation for integrating existing water data standards via logical extension

HyFO as Domain reference ontology

Container Object
The solid object where water can be located; e.g., the channel of a river, the rock body in an aquifer.

Matter
Material that constitutes a container or water object; e.g., solid rock matter, water matter.

Water Object
The liquid object located in the container/void; e.g. the spatio-temporal object that encompasses all the water in an aquifer.

Void
Space(s) in the container that can be filled with water; e.g., pores in an aquifer, depression in a channel.

When we talk about a “lake” or “river” in many domain ontologies, it may refer to different aspects:

1. the container: e.g. distinctions based on the river bed
2. the void: e.g. its shape or describing the maximum depth
3. the water object (e.g. water quality measurements)
4. or a combination of those:
   - “Water Features” = a (ever changing) water object and container and/or void that host it

Ongoing work on domain reference ontologies

- FEO: Forest Ecology Ontology *(applicable to other ecological domains)*
- Identifies and distinguishes key concepts:
  - Tree vs. TreeSpecies
  - Forest (land use classification) vs. ForestedArea (environmental system)
- Connect them to another and to other ontologies (e.g. Envo)
Other related ongoing efforts

❑ A domain reference ontology typically employs one or more patterns, but is intended to be reusable as an artifact (not just a template)

❑ Other ongoing effort on developing patterns and domain reference ontologies:
  ❑ Utility Connection pattern (utility infrastructure and their service interdependencies, e.g. medical facilities depending on clean water and power)
  ❑ Spatial and Temporal Aggregated Data (STAD) pattern (aggregated data like climate normal)

❑ Tools: macleod: https://github.com/thahmann/macleod
  ❑ automated reasoning with Common Logic ontologies (via translation to TPTP)
  ❑ automated extraction of OWL ontologies from Common Logic Ontologies
    ❑ using deeply axiomatized CL ontologies to produce more widely used versions

Hahmann, Powell: Automatically Extracting OWL Versions of FOL Ontologies. Proc. of ISWC 2021, 10.1007/978-3-030-88361-4_15
If you can, please join us for FOIS 2023: [https://fois2023.griis.ca/](https://fois2023.griis.ca/)

- Sherbrooke, Quebec: July 17-20th
  - ontology showcase and workshops still accept submissions
- Online portion: September 18-20th
  - 2h block each day with 3 presentations

Registration will open soon!

Maybe room for a summary from the Summit