Domain Reference Ontologies

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Slides based on presentation by T. Hahmann and S. Stephen: “An Ontological Framework for Characterizing Hydrological Flow Processes” at COSIT 2017

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**

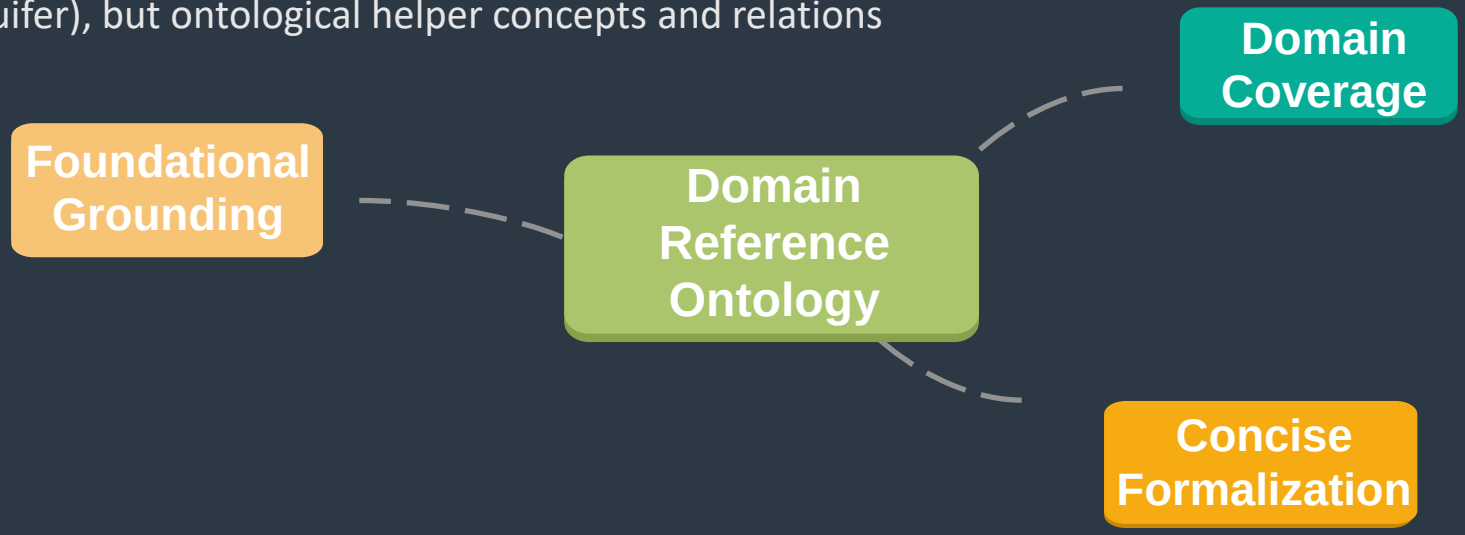
Hahmann, T. (2021). Ontology. In: Daya Sagar, B., Cheng, Q., McKinley, J., Agterberg, F. (eds) Encyclopedia of Mathematical Geosciences. Encyclopedia of Earth Sciences Series. Springer, Cham. https://doi.org/10.1007/978-3-030-26050-7_231-1

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



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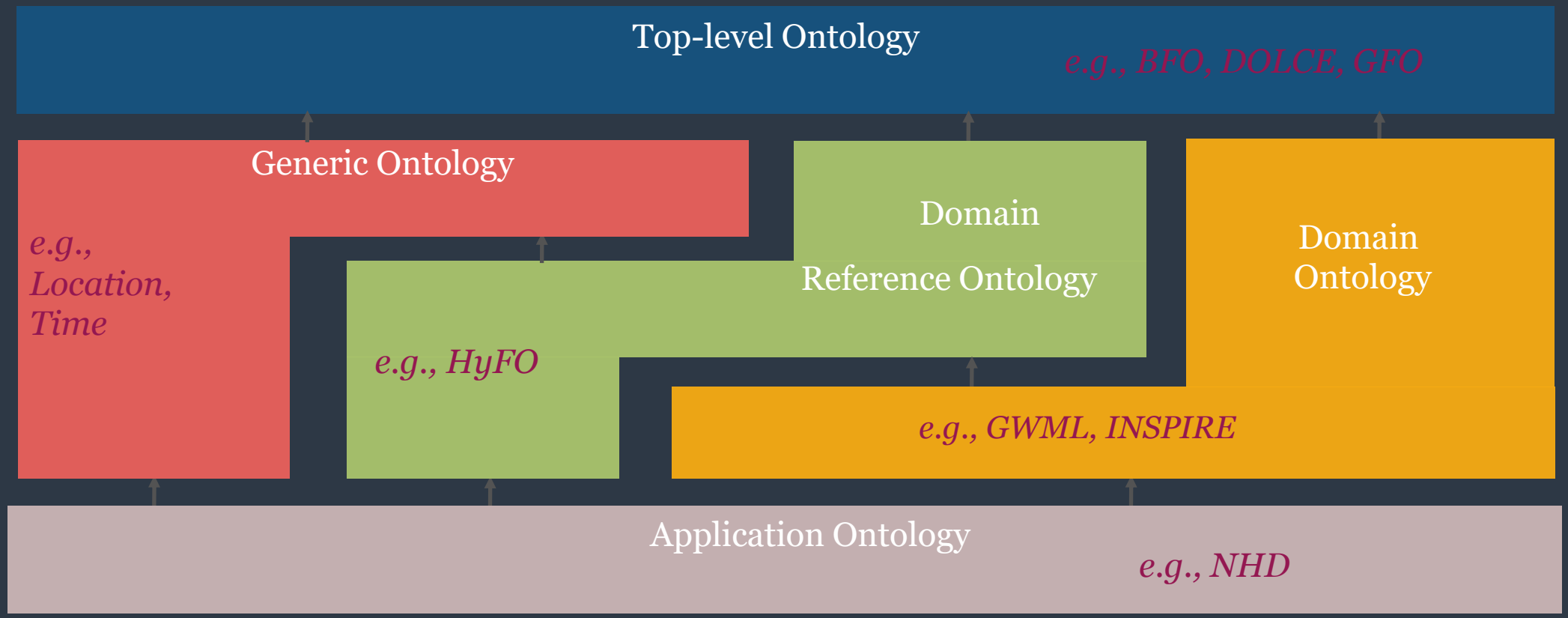
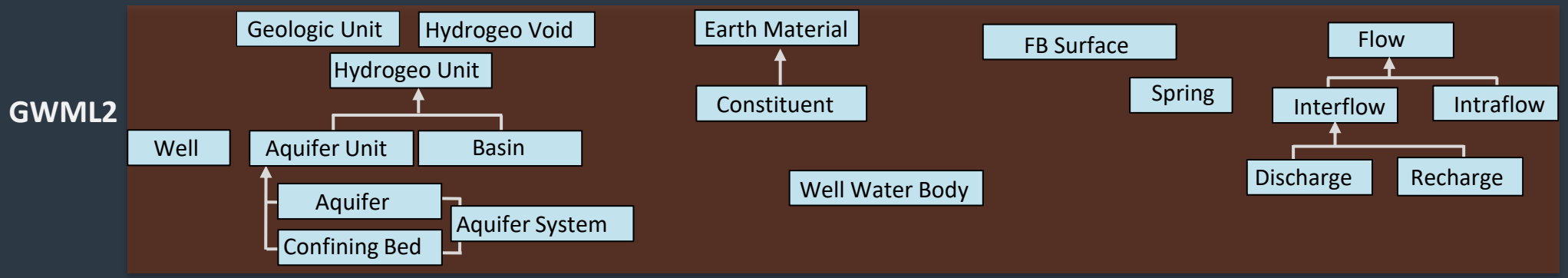


How is a *domain reference ontology* useful ?

… 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)



Torsten Hahmann & Shirly Stephen (2018) Using a hydro-reference ontology to provide improved computer-interpretable semantics for the groundwater markup language (GWML2), International Journal of Geographical Information Science, 32:6, 1138-1171, DOI: 10.1080/13658816.2018.1443751

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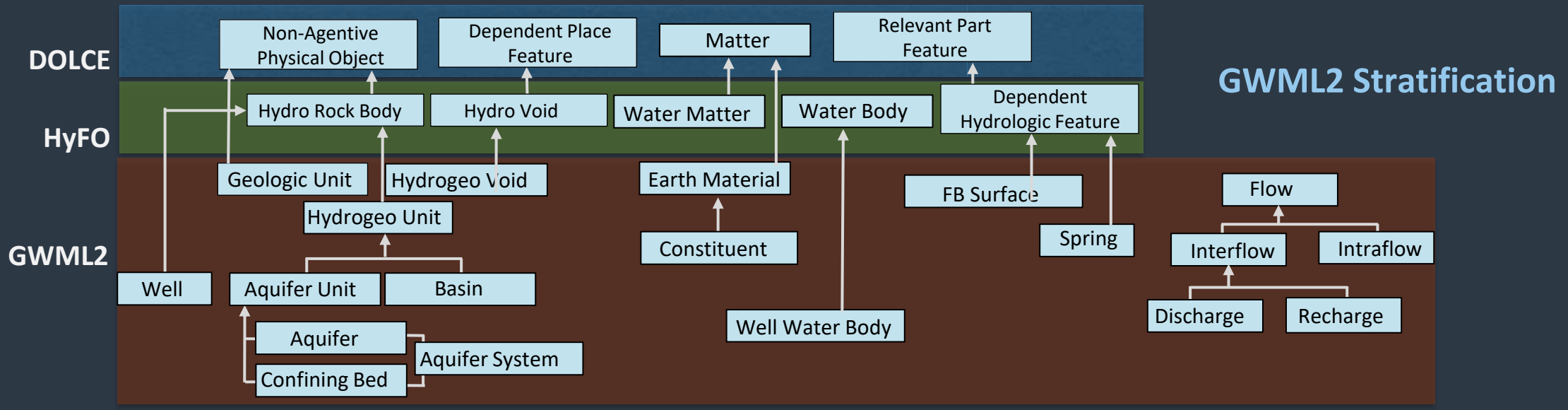

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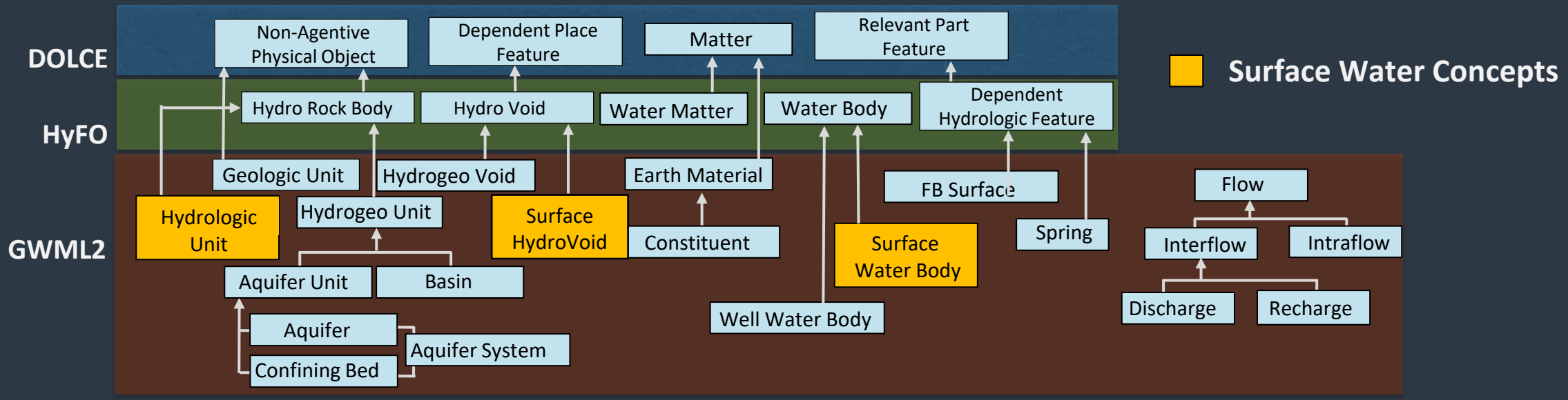
- ❑ Supports formal ontological analysis of existing water data standards (e.g., GWML2)
  - Axiomatic foundation for integrating existing water data standards via logical extension



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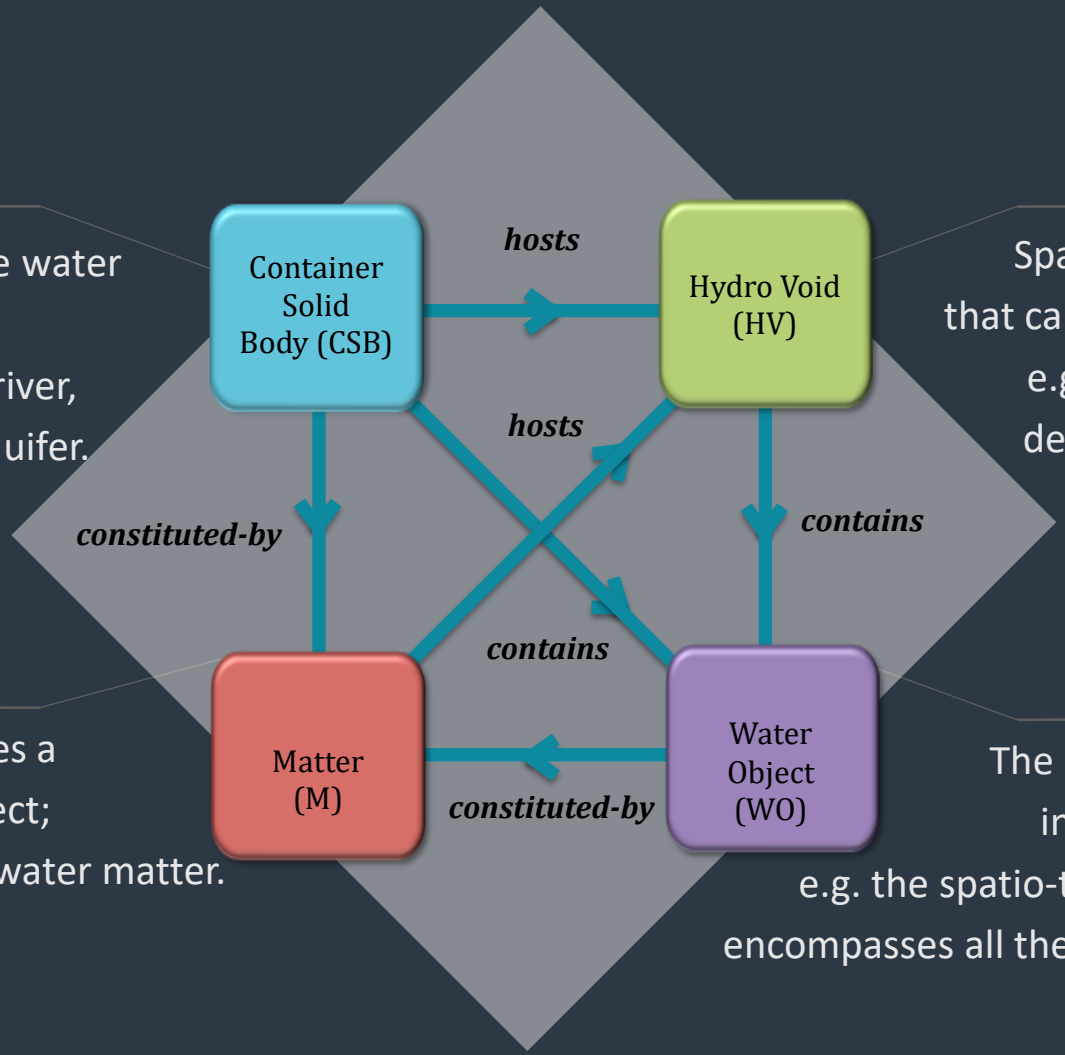
HyFO as Domain reference ontology



Container Object

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

Void

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

Matter

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

Water Object

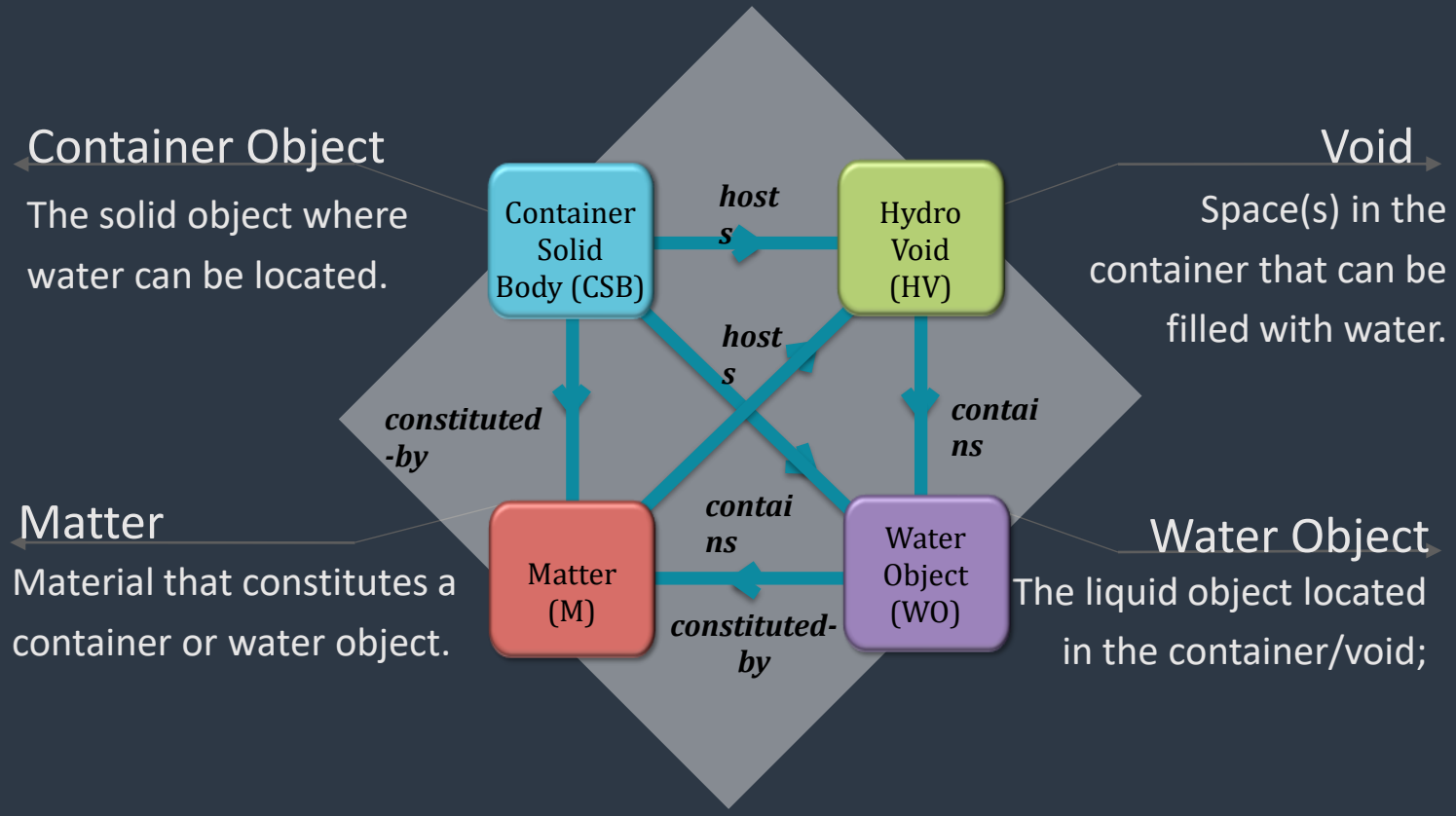
The liquid object located in the container/void;
e.g. the spatio-temporal object that encompasses all the water in an aquifer.

B. Brodaric and T. Hahmann: "Towards a Foundational Hydro Ontology for Water Data Interoperability." In: Proc. of the 11th Int. Conference on Hydroinformatics (HIC-2014). 2014.
B. Brodaric, T. Hahmann, M. Gruninger: "Water features and their parts" Applied Ontology 14(1), 1—42, 2019.

HyFO as Domain reference ontology

- 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



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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

Thank you!

- If you can, please join us for FOIS 2023: 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*