Multi-Perspective Ontology Alignment: Bridging Epistemic Differences in a Water Knowledge Case Study

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Today's Agenda

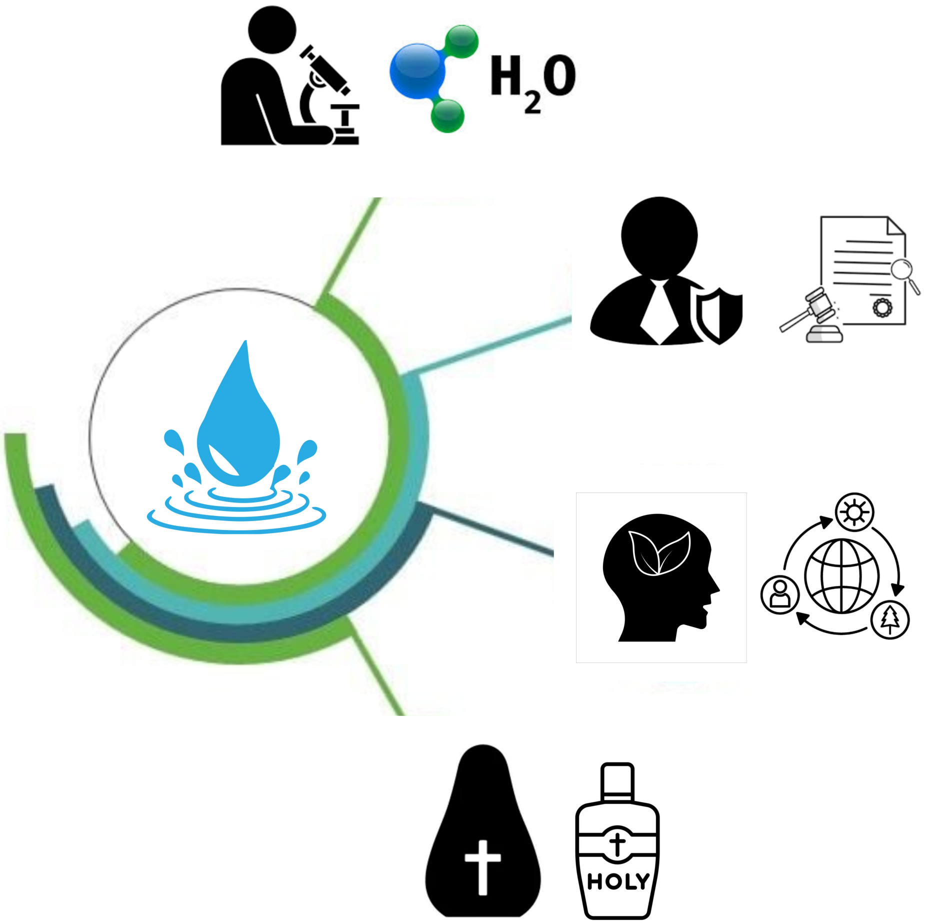
01	**Introduction & Motivation**
02	**Problem Statement**
03	**Existing Research**
04	**Baseline Trials**
05	**Conceptual Methodology**
06	**Conclusion**

01 Introduction & Motivation

Same phenomenon – different perspectives

- Meanings shift with context and perspective.
- Ontologies capture these choices → shaped by worldviews.
- Different communities create divergent ontologies for the same phenomenon.

01 Introduction & Motivation



There is no single definition of water.

Different communities describe water in divergent ways.

Each ontology encodes conceptual commitments, reflecting only one epistemic standpoint.

➔ For a chemist: H_2O, a molecular substance.

➔ For policymakers: a regulated resource linked to governance and rights.

➔ For ecologists: rivers, habitats, and sustainability.

➔ For communities: symbolic, part of rituals and cultural values.

Without bridging perspectives → fragmentation and limited intervention/ interdisciplinary understanding.

02

Problem Statement

- ➔ Existing ontologies capture single disciplinary perspectives.
- ➔ No single ontology can handle the full semantic breadth.
- ➔ Current ontology alignment methods often fail to represent perspectival diversity → focus mainly on lexical/semantic similarity.
- ➔ Bringing together water ontologies is time-consuming, expertise-intensive, and error-prone.
- ➔ No methodology exists to systematically **relate diverse water ontologies without suppressing their unique perspectives.**
- ➔ Need for general method to systematically identify, relate, and query diverse conceptualizations without forcing convergence.

How to connect different perspectives without erasing their differences?

03 Existing Research

Gentner's SMT

Gentner's structure-mapping theory / LISA [1]

- Aligning relational structure between two domains, not just surface features.
- One-to-one mapping, Focus on relational structure, not isolated terms.
- *Eg: "the atom is like the solar system"*

Kachroudi's Indirect Alignment

Algebraic framework [2]

- Link ontologies via an intermediate ontology, not just pairwise.
- Algebraic framework to formalize composition of alignments.
- $O_1 \leftrightarrow O_3 \leftrightarrow O_2$ then $O_1 \leftrightarrow O_2$

Álvarez's Standpoint EL

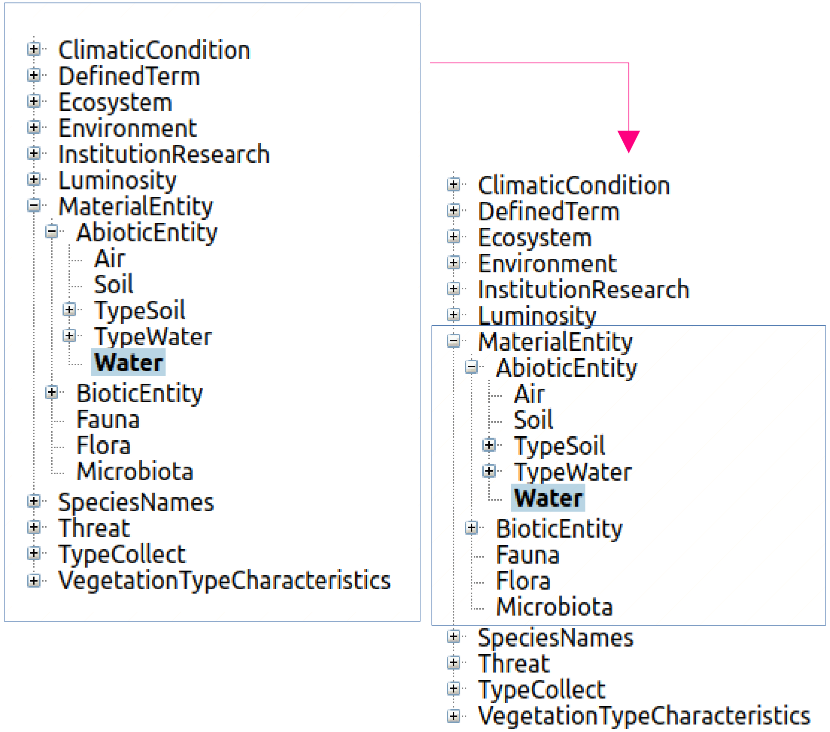
- Extends Description Logic (EL): axioms tagged with standpoints [3].
- Supports conflicting, hierarchical perspectives in a unified logic.
- Representation layer for multi-perspective knowledge without conflicting views.
- Preserves tractable reasoning (efficient and scalable).

Related Work: Approaches to Ontology Alignment

04 Baseline Trials

Ontology Survey, Selection, and Preprocessing

- Surveyed ontologies: 5 core water ontologies (hydrology, governance, monitoring, quality, interoperability).
- Extended search: 27 additional ontologies from BioPortal with “water” term.
- Extracted water-centric subgraphs: localized fragments centered on water (instead of full ontologies).
- Preprocessing: OWL format, automated ID extraction, loaded into Protégé.
- Standard alignment methods: produced mainly lexical matches, missing deeper cross-perspective relations.



Extraction of water-centric subgraphs rather than using complete ontologies in BioPortal. [4]

04 Baseline Trials

➔ Applied **LogMap** (lexical + logic-based reasoning):

Very few alignments (limited lexical overlap)

Generated unsatisfiable classes, no stable anchors.

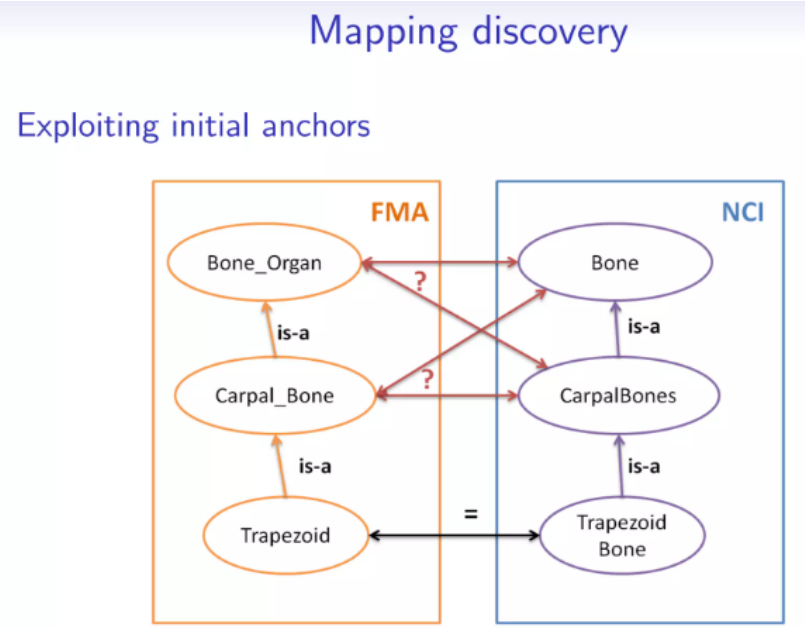
➔ Manual test (**Protégé + ELK/HermiT**):

conflicts: subclass inconsistencies, misaligned constraints, and overlapping hierarchies.

➔ **COMA++** (interactive tool):

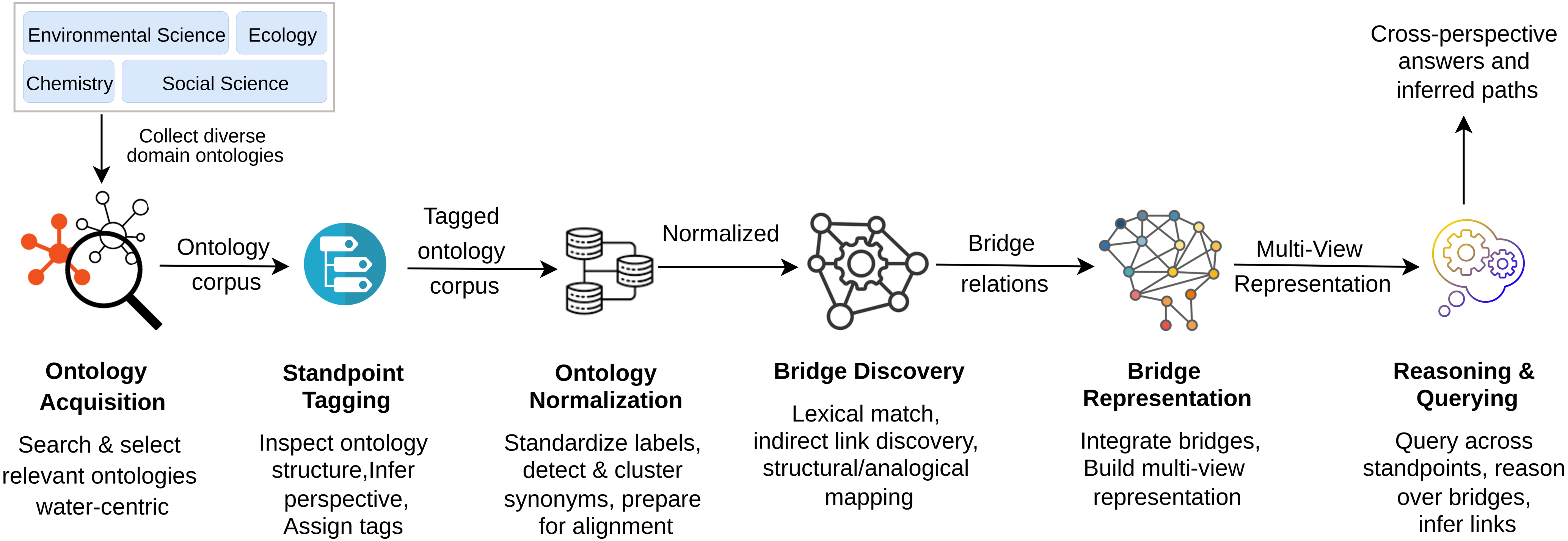
allowed to adjust alignments manually, partially reduce inconsistencies.

COMA 3.0 only supports schema standards such as OWL-Lite and XSD [6].



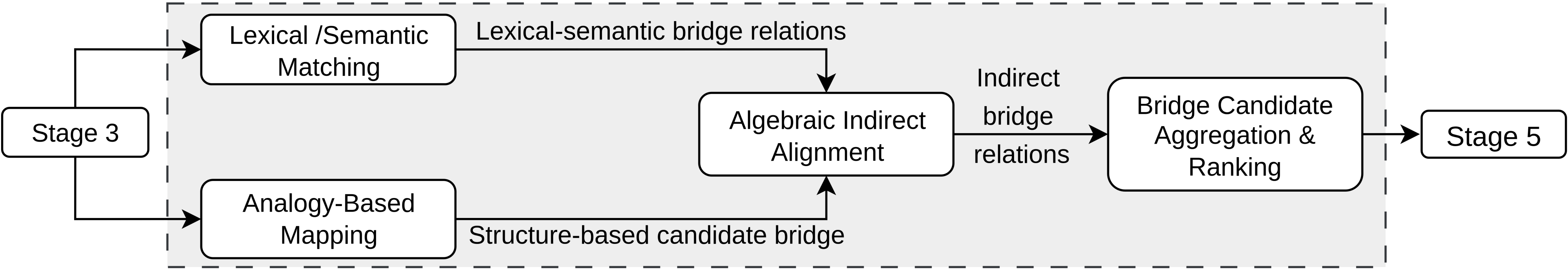
Mapping discovery stage in Logic-based and Scalable Ontology Matching (LogMap) [5]

05 Conceptual Methodology



Workflow of the proposed multi-perspective ontology alignment approach, showing the sequential stages and intermediate artifacts.

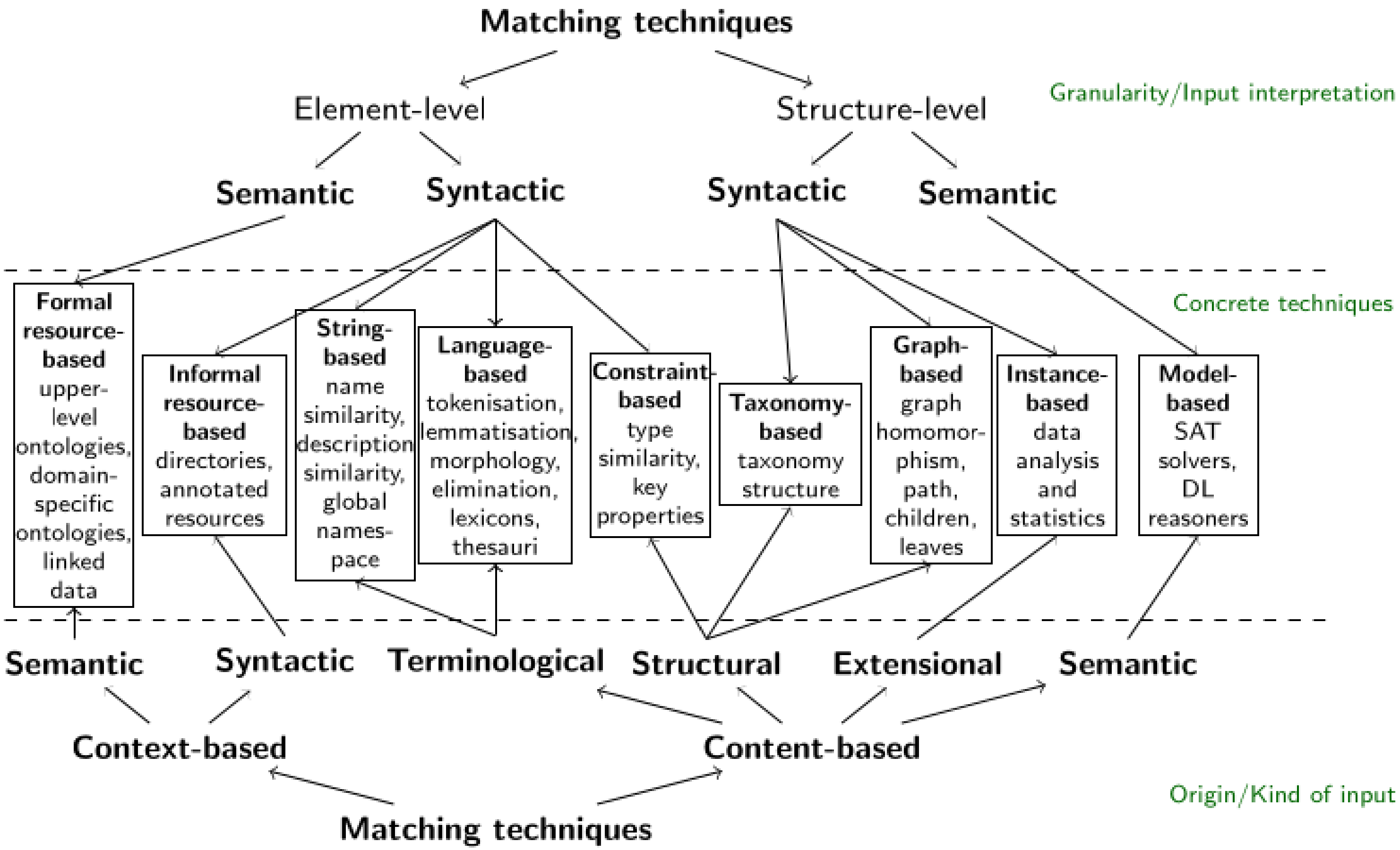
05 Conceptual Methodology



Workflow for conceptual bridge discovery across multiple perspectives.

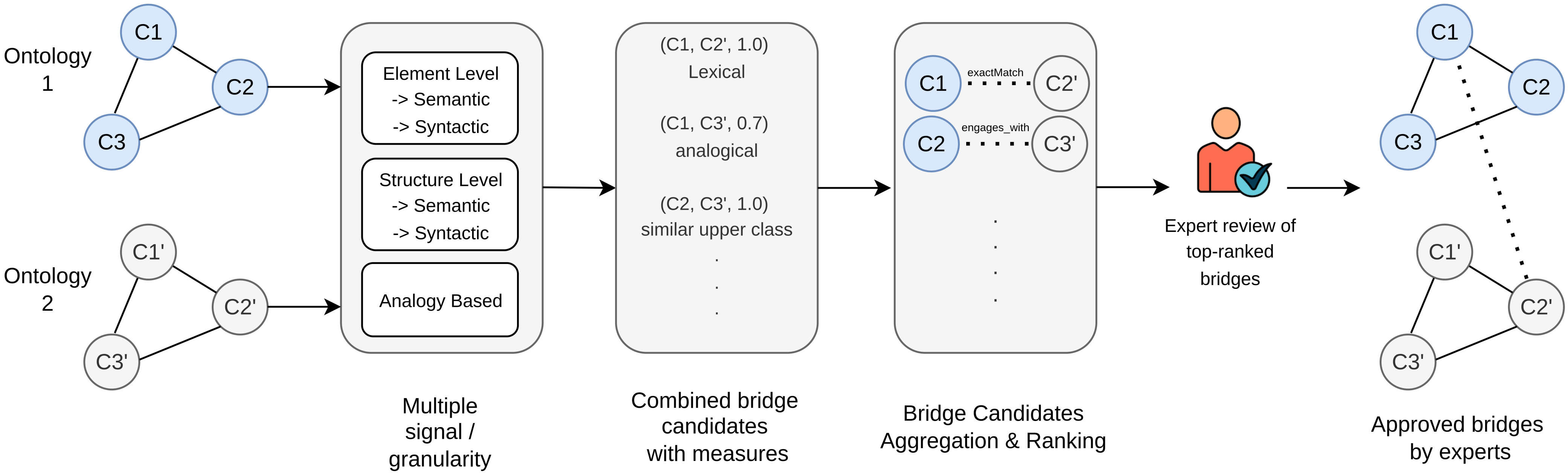
04

Conceptual Methodology



Ontology Matching Techniques Classified by Granularity and Signal Type [7]

05 Conceptual Methodology



Proposed Multi-Signal Ontology Bridging Pipeline.

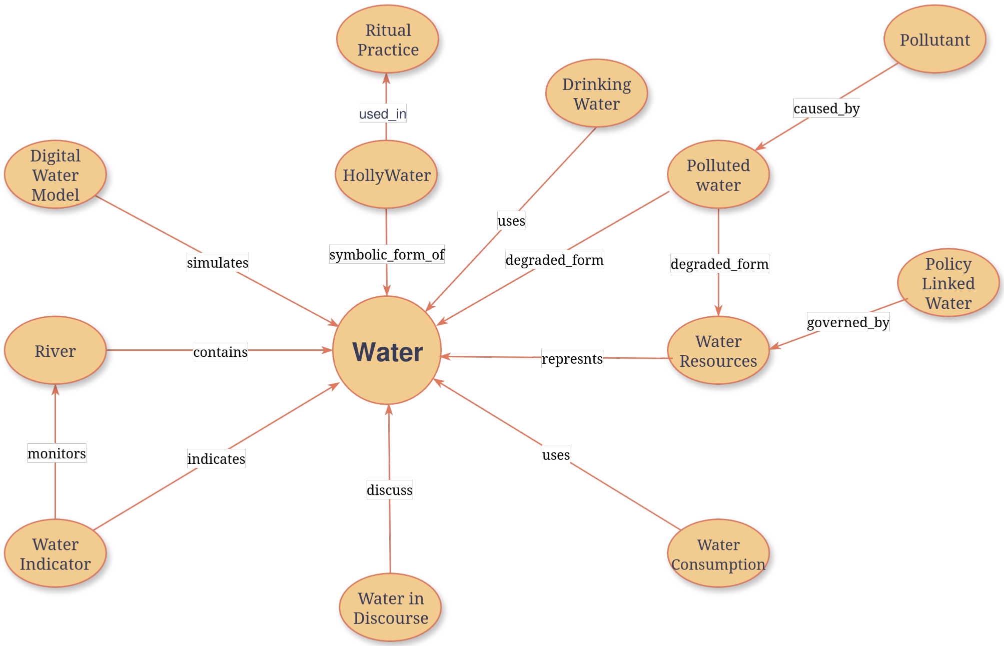


Figure 1: Shows the initial ontology modules, each from different disciplinary standpoints. Nodes like HolyWater, PolicyLinkedWater, or DigitalWaterModel represent how 'Water' is understood across domains.

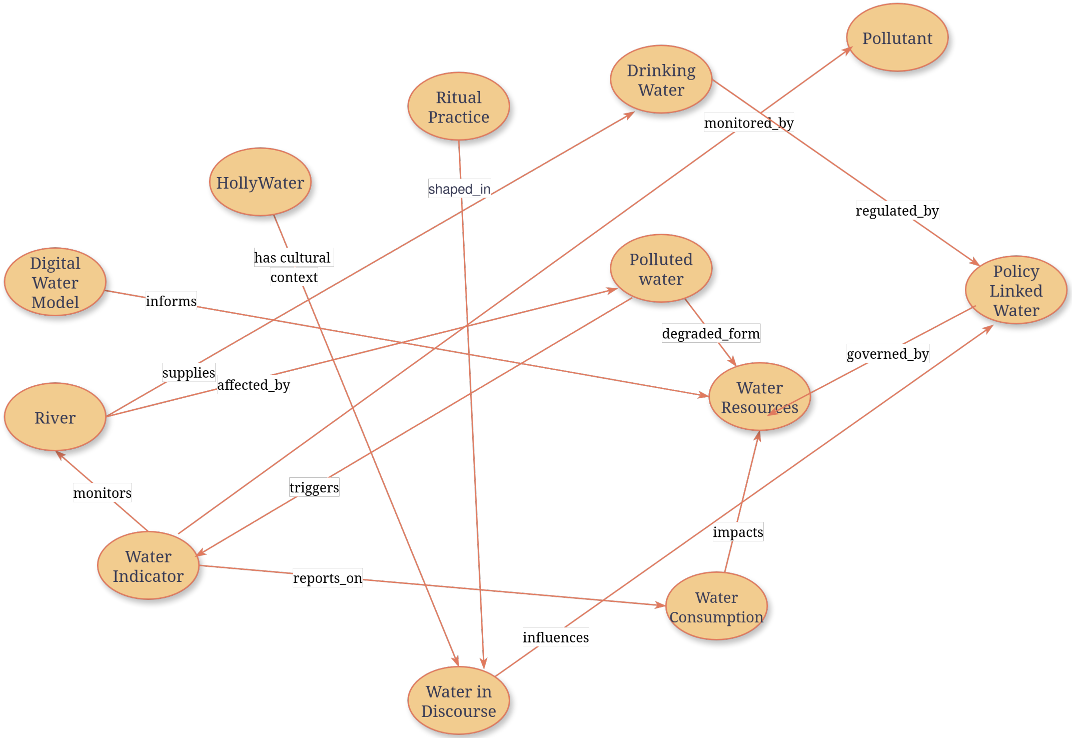


Figure 2: Illustrates the result of applying bridge discovery methodology. New edges represent relationships between concepts across different standpoints

As an outcome, the system will be able to address questions such as:

- How does cultural perception of water influence ritual use?
- Trace the impact of pollution on governance.

06 Conclusion

- ➔ Existing ontology alignment methods are insufficient for domains like water.
- ➔ They often fail to capture perspectival diversity, focusing mainly on lexical similarity.
- ➔ Our baseline trials (LogMap, Protégé reasoning, COMA++) show that standard methods are insufficient for complex scenarios.
- ➔ We developed a conceptual methodology for bridge discovery across multiple perspectives.
- ➔ Combines: standpoint tagging, cross-ontology normalization, bridge discovery, candidate scoring & expert validation, formal multi-view representation, and AI-agent support.
- ➔ Provides a formal multi-view representation to preserve perspectival differences.
- ➔ Supports cross-disciplinary queries and reasoning over diverse views.

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[4] https://bioportal.bioontology.org/

[5] Jiménez-Ruiz, E., & Cuenca Grau, B. (2011, October). Logmap: Logic-based and scalable ontology matching. In International Semantic Web Conference (pp. 273-288). Berlin, Heidelberg: Springer Berlin Heidelberg.

[6] https://dbs.uni-leipzig.de/research/projects/coma

[7] van Damme, P., Fernández-Breis, J. T., Benis, N., Miñarro-Gimenez, J. A., de Keizer, N. F., & Cornet, R. (2022). Performance assessment of ontology matching systems for FAIR data. Journal of Biomedical Semantics, 13(1), 19.

Thank you
for your Attention!